BUSINESS MODEL INNOVATION IN SMALL AND MEDIUM-SIZED ENTERPRISES: AN EXPLORATION OF KEY DRIVERS AND PERFORMANCE IMPLICATIONS

DORLETA IBARRA ZULUAGA

Supervisors:

Juan Ignacio Igartua

Jaione Ganzarain

MONDRAGON UNIBERTSITATEA

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Mondragon Unibertsitatea

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STATEMENT OF ORIGINALITY

Hereby I, Dorleta Ibarra Zuluaga, declare that this thesis is my original work of authorship, which I have elaborated on my own. All sources, references and literature used or extracted during the elaboration of this work are duly cited and listed in full reference to the proper source.

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LABURPENA

Enpresa txiki eta ertainak (ETEak) aberastasun eta enpleguaren sorrerarako eta garapen ekonomikorako giltzarria dira. Horrela, egungo ingurune aldakor, konplexu eta ezustekoan ETE-en lehiakortasuna mantendu eta indartzeko modu berriak nahiatezkoak dira haien biziraupenerako eta lurraldearen garapenerako. Testuinguru horretan, negozio ereduaren berrikuntza lehiarako abantail iturri berria bilakatu da, eta berritzeko modu tradizionalak osatu edota ordezkatu ditzake. Azken urteetan ikerketak hasi dira enpirikoki aztertzen nola berritu ditzaketen modu proaktiboan ETE-ek euren negozio ereduak testuinguruko erronketara egokitzeko. Hala ere, literatura oso zabala da eta ikerketa gehiago behar dira ETE-etan negozio ereduaren berrikuntza sustatzen duten faktore nagusien eta emaitzen ikuspegia orokorra lortzeko. Hori dela eta, ETE-en negozio ereduaren berrikuntza ikuspegi holistikotik aztertzea da tesiaren helburu nagusia. 78 ETEko lagin batetik abiatuta, ikerketak explorazio ikuspegia hartu, eta aurrerakari batzuek negozio ereduaren berrikuntzan duten eragina eta negozio ereduaren berrikuntzak enpresaren emaitzetan duen ondorioa aztertzen ditu. Negozio ereduaren berrikuntza beste berrikuntza mota batzuekin (produktua, zerbitzua, marketina, prozesua eta antolakuntza) ere alderatzen da. Ikerketak, metodo misto baten antzera, datuak galdetegi baten bitartez jaso, eta hiru metodo hauen bitartez ustiatu ziren: *partial least squares* ekuazio estrukturalen bidezko modelizazioa, *fuzzy-set* analisi kualitatibo konparatiboa, eta test estatistikoak. Emaitzek aditzera ematen dutenez, estrategia garatzeko, aukerak hautemateko eta esperimentatzeko gaitasunak dira ETE-en negozio ereduaren berrikuntzaren eragile nagusiak, eta kudeaketa orientazioa eta enpresaren berrikuntza kulturak dira, berriz, gaitasun horiek sustatzen dituztenak. Lankidetza gaitasunaren eragina negozio ereduen berrikuntzan, berriz, ez zen esanguratsua. Emaitzek adierazten dute, halaber, negozio ereduaren berrikuntzarako tresnen erabilerak negozio ereduaren berrikuntza errazten duela. Horrez gain, aurrekari horiek enpresaren portaeraren arabera (causal-effectual) bide desberdinetatik negozio eredua berritzera daramaten hainbat konfigurazio eraginkor iradokitzen dira. Gainera, badirudi negozio ereduaren berrikuntza enpresaren errendimenduaren hobekuntzarekin lotuta dagoela, eta negozio ereduaren abantailak, berriz, partzialki azaltzen du erlazio hori. Azkenik, egiaztatu zen negozio ereduarena berrikuntza mota ezberdina dela, baina beste berrikuntza mota batzuen osagarria. Hori guztia dela eta, ikerketa honek ETE-etan negozio ereduen berrikuntza hobeto ulertzen laguntzen du, eta aldi berean ETE-ei eta administrazio publikoei inplikazio praktikoak eskaintzen dizkie.

RESUMEN

La pequeña y mediana empresa (PYME) es clave para la creación de riqueza, generación de empleo y el desarrollo económico. Así, las nuevas formas de mantener y reforzar su competitividad en un entorno cada vez más cambiante, complejo e impredecible, son clave para su supervivencia y el desarrollo de la región. En este contexto, la innovación en el modelo de negocio emerge como una nueva fuente de ventaja competitiva que puede complementar o incluso sustituir las formas tradicionales de innovación. Recientemente, las investigaciones han comenzado a explorar empíricamente la forma en que las PYMEs pueden innovar proactivamente su modelo de negocio para adaptarlo a los desafíos del entorno. Sin embargo, la literatura es muy dispersa y es necesario seguir investigando para obtener una idea general de los principales impulsores y los resultados de la innovación en el modelo de negocio de las PYMEs. Por lo tanto, el principal objetivo de esta tesis es explorar la innovación en el modelo de negocio en las PYMEs desde una visión holística. En base a una muestra de 78 PYMEs, esta investigación adopta un enfoque exploratorio que aborda el efecto que ciertos antecedentes tienen en la innovación en el modelo de negocio, y el impacto que ésta tiene sobre los resultados organizacionales. También se compara la innovación en el modelo de negocio con otros tipos de innovación (producto, servicio, proceso, marketing, organización). La investigación se aborda mediante un enfoque de métodos mixtos que comprende un cuestionario y diferentes métodos de análisis de datos: modelización de ecuaciones estructurales por el método de mínimos cuadrados parciales, análisis cualitativo comparativo de conjuntos difusos y pruebas estadísticas. Los resultados sugieren que las capacidades de elaboración de estrategias, detección de oportunidades y experimentación son las principales impulsoras de la innovación en el modelo de negocio de las PYMEs, y que estas capacidades son promovidas por la orientación de la gestión y la cultura de innovación de la empresa. A su vez, la influencia de las capacidades de colaboración en la innovación en el modelo de negocio resultó no ser significativa. Los resultados también indican que el uso de herramientas para la innovación en el modelo de negocio facilita la innovación en el modelo de negocio. Al abordar el fenómeno desde una perspectiva configuracional, los resultados sugieren que las PYMEs combinan estos antecedentes siguiendo caminos diferentes, pero igualmente eficaces para innovar en el modelo de negocio; lo que refleja distintos comportamientos (causales y efectuales). Además, la innovación en el modelo de negocio parece estar relacionada con un rendimiento superior de la empresa, y la ventaja del modelo de negocio explica parcialmente esta relación. Por último, se muestra que la innovación en el modelo de negocio es una forma de innovación distinta, pero complementaria, que se interrelaciona con otros tipos de innovación. Esta investigación contribuye así a una mejor comprensión de la innovación en el modelo de negocio, al tiempo que proporciona implicaciones prácticas para las PYMEs y la administración pública.

ABSTRACT

Small and medium-sized enterprises (SMEs) are at the heart of a nation's wealth creation, employment generation and economic development. Hence, new ways to sustain and reinforce their competitiveness in today's fast-changing, complex and unpredictable environment become key for their survival and the development of the region. In this context, business model innovation is emerging as a new source of competitive advantage that can complement or even substitute for traditional forms of innovation. Recently, research has started to empirically explore how SMEs can proactively address business model innovation to adapt their business model to the environmental challenges. However, the literature is widely dispersed, and further research is needed to develop the big picture of the key drivers and outcomes of business model innovation in SMEs. The main goal of this thesis is therefore to explore business model innovation in SMEs from a holistic view. Based on a sample of 78 SMEs and using an exploratory approach, it examines the effects of certain antecedents on business model innovation, and the performance implications of business model innovation. Business model innovation is also compared with other forms of innovation (product, service, marketing, process and organisation). Research is conducted through a mixed-method approach comprising a questionnaire and different methods of data analysis: partial least squares structural equation modeling, fuzzy-sets qualitative comparative analysis, and statistical tests. The findings suggest that strategizing, sensing and experimenting capabilities are key drivers of business model innovation in SMEs, and these capabilities are promoted by the managerial orientation and the innovation culture of the firm. The influence of collaboration capabilities on business model innovation, in turn, was found non-significant. The results also indicate that the use of business model innovation tools facilitates business model innovation. Approaching the phenomenon from a configurational view, the results further suggest that SMEs combine the above-mentioned antecedents following different, equally effective paths to business model innovation, thereby reflecting distinct causation-effectuation behaviours. Additionally, business model innovation seem to be related to superior firm performance, and business model advantage partially explains this relationship. Lastly, it is shown that business model innovation is a distinct but complementary form of innovation that interrelates with business innovation (product, service, marketing, process and organisation). This investigation contributes therefore to a better understanding of business model innovation in SMEs, and the results have practical implications for SMEs and public administration.

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GLOSSARY OF ACRONYMS

ANOVA: Analysis of Variance
AVE: Average Variance Extracted
BCa: Bias Corrected and Accelerated
BM: Business Model
BMI: Business Model Innovation
BU: Business Unit
CB-SEM: Covariance Based Structural Equation Modeling
CR: Composite Reliability
CNAE: National Classification of Economic Activities
EFA: Exploratory Factor Analysis
EM: Expectation maximization
EU-28: European Union (EU) which consists a group of 28 countries
EUSTAT: Basque Institute of statistics
EVA: Equal Variances Assumed
EVNA: Equal Variances Not Assumed
FsQCA: Fuzzy sets Qualitative Comparative Analysis
HTMT: Heterotrait-monotrait ratio of correlations
HOC: Higher-Order Construct
ICT: Information and Communications Technologies
IT: Information Technology
KM: Knowledge Management
LM: naïve Linear Model
LOC: Lower-Order Construct
MAE: Mean Absolute Error
MCAR: Missing Completely At Random
ML: Maximum Likelihood
MVP: Minimum Viable Product
OECD: Organisation for Economic Co-operation and Development
OLS: Ordinary Least Squares
PESTLE: Political-Economic-Social-Technological-Legal-Environmental
PAF: Principal Axis Factoring
PCA: Principal component Analysis
PLS: Partial Least Squares
PLS-SEM: Partial Least Squares Structural Equation Modeling
PRI: Proportional Reduction in inconsistency
QCA: Qualitative Comparative Analysis
RMSE: Root Mean Squared Error
R&D: Research and Development
SEM: Structural Equation Modeling
SME: Small and Medium-sized Entreprise
SSE: Sum of the Squared prediction Errors
SSO: Sum of the Squared Observations
STOF: Service-Technology-Organisation-Financial
SWOT: Strengths-Weaknesses-Opportunities-Threats
TFR: Totally Fuzzy and Relative
VISOR: Value-Interface-Service platforms-Organising model-Revenue/costs
VIF: Variance Inflation Factor
VIP: Value-Information-Process
VRIO: Valuable-Rare-Inimitable-Organisational support
VSM: Value Stream Mapping

Chapter 1

Introduction

1. Introduction

Companies worldwide are operating in a complex, dynamic and unpredictable environment marked by rapid technological advances, competitive intensity, social changes and globalisation (Soto-Acosta et al., 2018). This situation forces firms[1] to innovate new ways of doing business to stay ahead of their competitors and make a profit (Pölzl, 2016).

The role of innovation as a major source of competitiveness, profitability and survival is well documented in the literature (Banbury y Mitchell, 1995; O'Regan, Ghobadian y Gallear, 2006; Porter, 1998; Roberts, 1999; Senge y Carstedt, 2001). However, whilst innovation can improve a company's competitiveness, nothing lasts forever (Breznik y D. Hisrich, 2014; Williams, 1992). According to Damanpour (1991), innovations are adopted in response to internal and external environmental changes or as preventive actions taken to influence the environment. Since the environment is in constant change, companies need to embrace innovations continually and manage their development of innovations successfully over time in order to survive, compete and prosper (Baregheh et al., 2009; Damanpour, 1991). Thus, innovation is closely linked to change, while the types of changes depend on the organisation's requirements, strategies, resources and capabilities (Tidd y Bessant, 2014).

Types of innovation have been commonly associated with new or improved products, processes, marketing activities and organisational forms (OECD/Eurostat, 2018). In recent years, however, a new form of innovation has emerged: namely, business model innovation, which is increasingly considered "the new competitive advantage" (Bashir and Verma, 2017, p. 7).

In the current business paradigm, companies like Dell (computer industry), Apple (music industry), Xiaomi (consumer electronics), Netflix (entertainment industry), Uber (transport industry), Airbnb (hospitality) and Southwest (airline industry), to list a few, have disrupted and even dominated their respective industries due to their unique business models**.** These companies show that the source of competitive advantage has changed. Their success does not lie in their products or services but rather in a singular business model which has allowed them to increase sales and achieve higher profit margins than their competitors (Bashir y Verma, 2017; Bereznoy, 2019; Hacklin et al., 2018).

In brief, a business model represents the business logic of a company, describing how it creates and delivers value to its customers, and how it captures value in return as profit (Osterwalder et al., 2005; Richardson, 2008; Teece, 2010).

[1] The words company, firm, enteprise and organisation will be used interchangeably throughout the document.

Therefore, business model innovation refers to changes in the business model that are purposively made to renew the firm's core business logic, expanding the scope of innovation beyond single products or services (Amit y Zott, 2012; Bouwman, Nikou, et al., 2018; Foss y Saebi, 2018; Schneider y Spieth, 2013).

In the face of globalisation, changing customer demand and market saturation, business model innovation allows firms to explore opportunities in new business areas and to reconfigure the way they create and deliver value to their customers (Casadesus-Masanell y Joan Enric Ricart, 2010; Pölzl, 2016). Thus, it facilitates the repositioning of the company, expanding its markets or building new ones (Kranich A. et al., 2017; Schneider y Spieth, 2013). Moreover, the digital transformation of the industries and the need for a more sustainable future are also challenging current business models (Bocken S. W.; Rana, P.; Evans, S. et al., 2014; Bouwman et al., 2019). Competitiveness is no longer based solely on adopting new technologies and optimising internal processes, but rather on rethinking the business model to provide more value while creating a strategic defence against competitors (Bereznoy, 2019; H Chesbrough, 2007). Additionally, in this context, potential competitors are not just established players in the market, as new entrants are changing the rules of the game with their new business models, shortening the life cycle of even successful established business models (Hock-Doepgen et al., 2020).

Furthermore, business model innovation can lead to a more sustainable competitive advantage than other innovations, since imitating a whole system of complex activities is more difficult than copying a single product, process or organisational method (Wittig et al., 2017). Similarly, business model innovation must be aligned with the company's long-term strategy, capabilities, resources and culture, making it more difficult for competitors to replicate it (Bucherer et al., 2012). Particularly in mature industries where options to innovate products and processes are scarce, business model innovation might provide a cost- and time-efficient opportunity to improve the firm's competitiveness (Clauss et al., 2020). Thereby, business model innovation sustains a significant improvement on competitive advantage (Schneider y Spieth, 2013) and thus can lead to superior firm performance (Foss y Saebi, 2017).

Considering these potential benefits, in the last two decades, the field of business model innovation has received increasing attention from both academics and practitioners (Foss y Saebi, 2018; Peric et al., 2017). Prior research has focused on defining, conceptualising and classifying the concept (Amit y Zott, 2012; Giesen, Berman, et al., 2007; Johnson et al., 2008; Markides, 2006). Some authors have described examples of successful business model innovation in large, well-known firms such as Ryanair (Casadesus-Masanell y Zhu, 2013), Nestle (Matzler, Bailom, et al., 2013) or Nokia (Aspara et al., 2013). Another research stream has focused on explaining the organisational and performance implications of business model innovation (Aspara et al., 2010; Cucculelli y Bettinelli, 2015; Zott y Amit, 2007).

1. Introduction

Factors that enable firms to proactively innovate their business model to face environmental challenges have been also addressed by academics (Hock-Doepgen et al., 2020; Mezger, 2014; Ricciardi et al., 2016; Voelpel et al., 2004). One emerging area gaining increasing attention in the business model innovation literature is business model tooling (Athanasopoulou y De Reuver, 2020; Bouwman et al., 2020; Schwarz y Legner, 2020).

Nonetheless, research on business model innovation is still widely dispersed: there is no unified definition of the term or well-founded theoretical base(Carayannis et al., 2014; Casadesus-Masanell y Zhu, 2013; Ghezzi y Cavallo, 2020; Pansuwong, 2020; Spieth et al., 2014; Zott et al., 2011). To date, relatively little is known about business model emergence, innovation and adoption and the implications of these changes on firm performance (Anwar, 2018; Foss y Saebi, 2018; Haggège et al., 2017). Moreover, business model innovation literature has largely kept a success-driven perspective on large firms, while research on small and medium-sized enterprises (SMEs) has only started to gain attention in recent years (Arbussa et al., 2017; Bouwman et al., 2019; Clauss et al., 2020; Lopez-Nicolas et al., 2020; Ricciardi et al., 2016).

As illustrated in Figure 1, a search in the Web of Science database for the topics business model, business model innovation and SME[2] in peer-reviewed journals and other sources published between 2000 and 2019 provides evidence for this statement. Figure 1 shows an increase in publications related to business model innovation (an average of 150 publications per year in the last five years), whereas research on business model innovation in SMEs seems to have started to gain momentum in the last three years, with an average of 10 publications per year.

This lack of studies is at least curious, considering that SMEs are recognised as a key driving force in a country's wealth creation, employment generation and economic development (Cosenz y Bivona, 2020; Pucihar et al., 2019; Scuotto et al., 2017). Moreover, SMEs are not small versions of large firms (Welsh y White, 1991). Man, Lau and Chan (2002) stated that "larger and smaller firms differ from each other in terms of their organisational structures, responses to the environment, managerial styles and, more importantly, the ways in which they compete with other firms" (pp. 128-129). Considering SMEs' specific characteristics, their innovativeness and value generation processes differ from those of larger companies, and therefore, business model approaches focused on large firms may not equally apply to SMEs (Cosenz y Bivona, 2020; Pierre y Fernandez, 2018).

[2] Source: Web of Science; citation indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC; Timespan: 2000-2019; searched terms in search field topic: "business model*" and "SME*" or "small and medium-sized enterprises"/ "business model innovation" and "SME*" or "small and medium-sized enterprises"/ "business model innovation" (January, 2020)

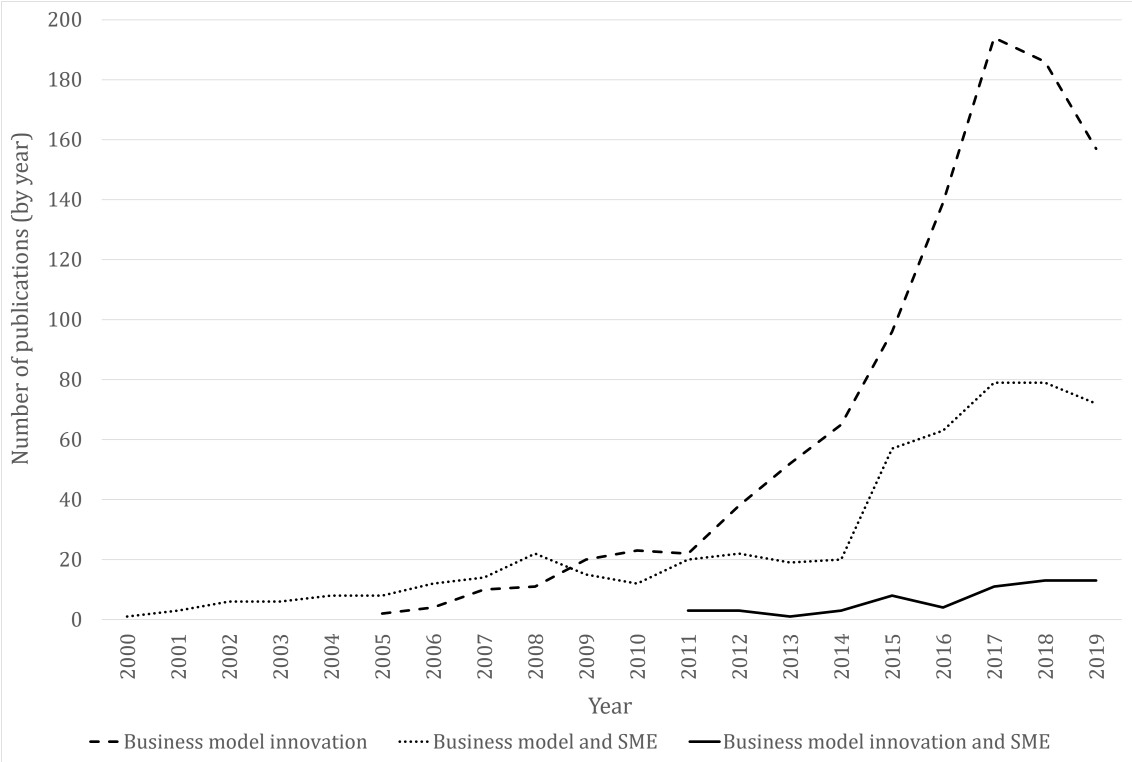

Figure 1 Business model and business model innovation articles in the context of SMEs in scholarly literature

As a result of this research gap, scholars have recently started to explore drivers and outcomes of business model innovation in SMEs (Bouwman et al., 2019; Futterer et al., 2018; Guo et al., 2017; Lopez-Nicolas et al., 2020; Pedersen et al., 2018). These studies offer evidence of the potential benefits that business model innovation can bring to SMEs in terms of innovativeness and firm performance. Additionally, some authors emphasise the relevance of applying tools to successfully accomplish business model innovation in SMEs (Cosenz y Bivona, 2020; Heikkilä, Bouwman, Heikkilä, Haaker, et al., 2016). However, how SMEs pursue business model innovation is still relatively unknown (Clauss et al., 2020; Foss y Saebi, 2018; Pucihar et al., 2019). In addition, most of the research is based on conceptualisations and case studies (Achtenhagen et al., 2013; Andreini y Bettinelli, 2017; Arbussa et al., 2017; Foss y Saebi, 2017; Pucihar et al., 2019; Ricciardi et al., 2016). In the face of these research approaches, contemporary academics are calling for more empirical research, larger samples, greater generalizability, replicability of results and a greater methodological sophistication (Clauss, 2017; Schneider y Spieth, 2013; Spieth et al., 2014; Zott et al., 2011). All this suggests that, despite the efforts and advances in research, it is still necessary to investigate how business model innovation develops and its relevance to SMEs' competitiveness.

1.1. Purpose of the research

In view of the potential benefits that business model innovation might bring to SMEs and the need for more research on this issue, the main goal of the present investigation is to gain a better holistic understanding of the business model innovation phenomenon in SMEs. For that purpose, four research questions are posited to explore different aspects of business model innovation to gain a more complete picture of its key drivers and performance implications.

Previous research on business model innovation has emphasised its role as a source of competitive advantage and superior firm performance, but an understanding of the impact of business model innovation on SMEs' competitiveness remains elusive due to the limited empirical evidence (Anwar, 2018; Foss y Saebi, 2017; Lopez-Nicolas et al., 2020). Therefore, the following research question is posed:

1) What effect does business model innovation have on SMEs' competitiveness?

The literature on business model innovation identifies various internal and external factors as potential key drivers of business model innovation, ranging from environmental shifts to internal firms capabilities (Foss y Saebi, 2017; Schneider y Spieth, 2013). However, understanding of how SMEs can systematically approach business model innovation to adapt their existing business model to environmental challenges remains unclear (Arbussa et al., 2017; Heikkilä, Bouwman, Pucihar, et al., 2018; Ricciardi et al., 2016). This leads to the second research question:

2) What drives business model innovation in SMEs?

In the last decade, several methods, techniques and tools have been developed to support business model innovation (Augenstein y Maedche, 2018; Bouwman et al., 2020). However, what tools are useful for SMEs and how they facilitate business model innovation is less understood (Heikkilä, Bouwman, Heikkilä, Haaker, et al., 2016; Trapp et al., 2018). To address this aspect, the following research question is presented:

3) Does the use of tools and techniques facilitate business model innovation in SMEs?

Finally, business model innovation is an emergent concept, without a universally accepted definition, and its boundaries with respect to other types of innovation, such as product, service, process, marketing and organisational, are still unclear (Snihur y Wiklund, 2019). The last research question is designed to shed light onto this issue:

4) What are the differences between business model innovation and other types of innovation?

1.2. Approach and scope of the study

Taking into account the current state of development of the business model innovation field and the research questions suggested in the previous section, this research addresses the study of business model innovation in SMEs by adopting an exploratory approach. The thesis uses a holistic framework supported by multiple theoretical underpinnings, which have allowed exploration of the phenomenon from different perspectives, including its potential drivers, its performance implications, the role of tools and the relationship of business model innovation to other forms of innovation.

The study uses a purposive sample of 267 SMEs from Gipuzkoa, which resolved into a final sample of 78 SMEs. The data is analysed using a two-step mixed method that combines partial least squares structural equation modeling (PLS-SEM) and a fuzzy-sets qualitative comparative analysis (fsQCA). Thus, both linear causality and complex causality (following a configurational approach) are addressed in exploring the relationships between business model innovation antecedents and outcomes. Moreover, the relationships between business model innovation and other forms of innovation are also explored using statistical tests (t-test for independent samples and chi-square test).

The research increases our knowledge of the phenomenon of business model innovation in SMEs, contributes to the development of the field and carries certain implications for both SMEs and policy makers. The results help to reveal the potential benefits of business model innovation and how to promote it.

1.3. Structure of the document

This document is organized into eight chapters (Table 1). The first chapter introduces the research. The second chapter reviews the literature on the business model innovation phenomenon, exploring prior research into business model innovation, its antecedents, its outcomes and business model innovation tools, with a particular focus on SMEs. Based on the literature review and the identified challenges, the third chapter presents the investigation's theoretical underpinnings, research framework and objectives. The fourth chapter describes the research methodology and design, develops the research hypotheses and propositions, and specifies the data collection and analysis methods. The fifth chapter presents the analysis and the results obtained, also encompassing the hypotheses and propositions tested. Discussion of the results are included in this chapter. The sixth chapter concludes the research with an explanation of the main contributions, theoretical and practical implications and research limitations, and it offers suggestions for further research. Chapter 7 lists bibliographic references, and Chapter 8 contains an appendix.

Table 1 Structure of the document

Chapter	Description
Chapter 1: Introduction	Introduces the research, the relevance and interest of the topic, the research purpose and main contributions.
Chapter 2: Literature review	Analyses and critically reviews the state of the art on business model innovation, particularly focusing on its antecedents, its outcomes and business model innovation tools in the context of SMEs.
Chapter 3: Theoretical approach, research framework and objectives	Presents the theoretical approach used in the research, the conceptual framework developed and the objectives specified to empirically investigate the research framework.
Chapter 4: Research methodology and design	Discusses the research methodology, including the philosophy, approach and plan to pursue the research objectives. It also presents the research hypotheses and propositions and describes the data collection and analysis methods.
Chapter 5: Analysis and results	Presents the results based on the analysis of collected data and discusses and interprets those results.
Chapter 6: Conclusions implications, limitations and further research	Highlights the main contributions of the thesis, its theoretical and practical implications, and the research limitations and suggests further research.
Chapter 7: References	Details the bibliographic references cited within the document.
Chapter 8: Appendix	Includes the appendix to better elucidate the content of the document (i.e. questionnaire, statistical results and code used for the analysis).

Chapter 2

Literature review

2. Literature review

This chapter analyses the state of the art in research into business model innovation in SMEs, exploring the theoretical underpinnings and main findings of prior work. As stated in the introduction, the main purpose of this thesis is to explore this phenomenon holistically. To this end, four research questions have been formulated to guide this review of the literature on business model innovation, its antecedents, its outcomes and business model innovation tools.

The literature review process consisted of two steps. The first step was to identify and study articles that systematically review the *business model* (Belussi et al., 2019; George y Bock, 2011; Massa et al., 2017; Morris et al., 2005; Peric et al., 2017; Perkmann et al., 2010; B Wirtz et al., 2016; Zott et al., 2010) and *business model innovation* literature (Andreini y Bettinelli, 2017; Foss y Saebi, 2017; Schneider y Spieth, 2013; Spieth et al., 2014). This review then employed a backward and forward snowball technique (Thomé et al., 2016) with the identified literature. The backward search entailed reviewing the key references cited in those articles, while the forward search identified additional sources that have cited the selected articles. The searches were carried out mainly in the Web of Science (https://www.webofknowledge.com/) and Scopus (https://www.scopus.com/) databases of scientific articles, with some additional use of search engines such as Google scholar (https://scholar.google.es/) and ResearchGate (https://www.researchgate.net/). This first step allowed the examination of definitions, concepts, frameworks, research models, and prior empirical research into business model innovation.

To ensure that relevant articles with an empirical approach on the topic of business model innovation in SMEs were included in the review, a second step entailed a systematic literature review of this issue that followed the main steps proposed by Becheikh et al. (2006). After the inclusion criteria were established, potential studies were located and selected. To be included, the articles had to do the following:

- Focus exclusively on established SMEs and business model innovation. Articles that referred to business models in the title but did not address the subject within the body of the article were excluded. Studies dedicated to other issues (e.g. newly created firms and start-ups, adoption of a technology or business model design guidelines) were not included.
- Describe an empirical study, either qualitative, quantitative or mixed.
- Be published in an English-language peer-reviewed journal. Due to the limited number of studies, conference proceedings were also retained.
- Limit the area under study to business and management.

To locate articles for the systematic literature review, two model databases from the field were selected: Scopus and the Web of Science. The keyword “business model*” was searched for within titles to ensure that the subject was treated as a main topic in the article and that the search would return not only *business model innovation* but also other terms commonly used to address business model innovation, such as *business model change* or *business model development*. To refine the search to focus on SMEs, the keywords "Small and medium-sized enterprises" OR "sme*" were searched for in the title, abstract or full text.

Of the 108 papers collected, 83 remained after duplicates had been removed. A first quick content check was conducted by reading titles and abstracts to determine whether the article content met the inclusion criteria mentioned above. Articles that did not meet the criteria were excluded. As a result of this process, 39 potential studies were included in the review. The list of selected articles can be seen in Appendix A.

It is worth mentioning that, among this final set of articles, eight of them pertain to the same project, titled “Envision. Empowering SME business model innovation” (Bouwman, Nikou, et al., 2018; Bouwman et al., 2019; Gatautis et al., 2019; Heikkilä, Bouwman, Heikkilä, Haaker, et al., 2016; Heikkilä, Bouwman y Heikkilä, 2018; Lopez-Nicolas et al., 2020; Marolt et al., 2016; Pucihar et al., 2019). This project, supported by European Community’s Horizon 2020 Program (2014–2020), explores how European SMEs conduct business model innovation and how it contributes to the growth of their enterprises. Given its relevance to the present research, the project report (Bouwman et al., 2015) was also included in this review.

Based on the four research questions that guide this literature review, this chapter is structured into four sections:

- The first section explores the business model innovation phenomenon from various angles, including definitions of business model, innovation and business model innovation; research contextualising business model innovation in established SMEs; and business model innovation research frameworks and models.
- In the second section, prior research into business model innovation antecedents and outcomes is analysed from multiple perspectives, with a particular focus on empirical research performed in the context of SMEs.
- The third section examines research into the business model innovation process, analysing the key practices and associated tools that facilitate this process.
- The last section summarizes the main findings and outlines the critical gaps identified in the literature, highlighting the suitability and relevance of this thesis work.

2.1. Business model innovation

In the last decade, the business model innovation phenomenon has received increasing attention from both academics and practitioners. Nevertheless, despite its relevance to competitive advantage and the research efforts undertaken, there is still no consensus about its definition, and research recognises the lack of construct clarity around business model innovation (Carayannis et al., 2014; Casadesus-Masanell y Zhu, 2013; Ghezzi y Cavallo, 2020; Pansuwong, 2020; B Wirtz et al., 2016; BW Wirtz et al., 2016; Zott et al., 2011).

A huge number of definitions, approaches and theoretical underpinnings can be found related to business model innovation (Andreini y Bettinelli, 2017; Arend, 2013; Belussi et al., 2019; Foss y Saebi, 2017; Ritter y Lettl, 2018). This may be a consequence of its dual nature, which brings together two concepts: namely, business models and innovation. On the one hand, much of the lack of clarity in the business model innovation construct can be attributed to the evolution of business model research itself, where the business model concept is still subject to criticism and lacks congruence in definition and conceptualisation (Massa et al., 2017; Spieth et al., 2014). On the other hand, innovation is considered a complex phenomenon that can be defined in multiple ways (Quintane et al., 2011). Consequently, business model innovation is open to different interpretations. Thus, this section seeks to delve into the understanding of business model innovation in the context of the present research and is structured as follows:

- The first subsection explores the emergence and development of business models and its related definitions, to adopt a definition for this research. It also explores the business model's similarities to and differences from strategy, a debate that has challenged the relevance of business model research until now.
- After this, business model innovation is defined and dimensionalised. To this end, the main theoretical approaches to innovation and its definitions are examined. Then, business model innovation definitions and dimensions are addressed. Finally, the relationship between traditional forms of innovation (i.e. product, service, process, marketing and organisation) and business model innovation is discussed.
- Next, business model innovation is explored in the context of established SMEs from various perspectives that include the kind, organisation, size and context of the firm.
- Finally, research frameworks and models for business model innovation in established companies found in the literature are examined with a view to developing an integrative approach to business model innovation, identifying main antecedents, outcomes and the relationships between them.

2.1.1. Business model: emergence, development and definition of the term

At an intuitive level, a business model describes an organisation and how that organisation works to achieve its goals (Massa et al., 2017). In this sense, every company has a business model, either explicitly or implicitly (Chesbrough y Rosenbloom, 2002; Teece, 2010). For instance, in their analysis of the evolution of business model patterns over time, Gassmann et al. (2014) postulated that *business model thinking* dates back to 1870. However, the first appearance of the term "business model" in an academic article did not occur until 1957 (Osterwalder et al., 2005), when Bellman et al. (1957) applied it to their research into the construction of business games for training purposes, to describe a simulation of the real world through a model. Three years later, in an article on the same subject, Jones (1960) wrote the first academic paper introducing the term "business model" in the title, even though the concept is not mentioned in the text itself, and its use in the title seems rather arbitrary (DaSilva y Trkman, 2014). Subsequently, the term can be found periodically in the literature, mainly in the field of information technology, and is understood as an operative activity for system modelling, Konczal (1975) being the only researcher suggesting the possibility of using business models as management tools (B Wirtz et al., 2016).

Thus, it was not until the mid-1990s that the term business model spread and began to be widely used, due to the establishment of the Internet and electronic commerce (Amit y Zott, 2001; Magretta, 2002; Osterwalder et al., 2005; Peric et al., 2017; Teece, 2010; B Wirtz et al., 2016). In fact, one of the first research streams that emerged in the field was focused on business models for e-business (B Wirtz et al., 2016; Zott et al., 2010).

Before the so-called dot-com era, all companies followed a similar logic when operating, which was typical of the industrial era: the company (and its suppliers) produced a product or service that was delivered to the customer and from which revenues were captured. Economies of scale were highly relevant, and value capturing was relatively simple (Teece, 2010). Thus, the advent of the internet and the development of information and communications technologies (ICTs) acted as a catalyst for experimentation and innovation with business models (e.g. Timmers, 1998; Afuah and Tucci, 2001; Amit and Zott, 2001), opening a new range of business opportunities through new value-creation logics unknown in recent business history (Massa y Tucci, 2014). Access to ever cheaper and more accessible technology increased business design choices, and industry boundaries gradually diminished (Osterwalder et al., 2005). Business logic was radically changed as firms started to conduct commercial transactions with their business partners and customers over the Internet, giving rise to the idea that traditional ways of doing business would become obsolete (Mahadevan, 2000; Merrifield, 2000).

In response, the business model moved from being an operative plan for creating a suitable information system to being seen as an abstract representation of the company's structure, making sense of these new forms of "doing business" (Magretta, 2002; B Wirtz et al., 2016). Moreover, it seemed to be the tool for explaining how innovative undertakings dealing with technology or any other unclear but potentially profitable concept, foreign to the logic of traditional industries, were realized in business terms (DaSilva y Trkman, 2014).

While early stages of business model literature were mostly technologically oriented and strongly related to e-business, the term was soon approached from other domains such as the economic, strategic, operational and organisational (Morris et al., 2005; B Wirtz et al., 2016), leading to a more generic conceptualisation of business models that could also be applied to other types of firms (Peric et al., 2017). Over subsequent years, business models spread to various fields such as marketing, technology and innovation management, strategic management and entrepreneurship (Andreini y Bettinelli, 2017; Belussi et al., 2019; Massa et al., 2017; Spieth et al., 2014; Zott et al., 2010). Consequently, at present, an overwhelming number of conceptualisations can be found in the literature, which vary depending on the approach, perspective and the roles assigned to the concept by the researchers (Peric et al., 2017; Spieth et al., 2014).

Regarding the approach adopted to define the term, business models have been referred to as a *statement* (Stewart y Zhao, 2000), *stories* (Magretta, 2002), an *architecture* (Dubosson-Torbay et al., 2002; Teece, 2010; Timmers, 1998), a *system* (Afuah y Tucci, 2001; Magretta, 2002), an *activity system* (Amit y Zott, 2012; Zott y Amit, 2007, 2008), a *structural template* (Amit y Zott, 2001), a *conceptual tool* (Osterwalder et al., 2005), a *method* (Afuah y Tucci, 2001), a *model* (Baden-Fuller y Morgan, 2010), a *framework* (Afuah, 2004; Richardson, 2008), an *abstraction* (Betz, 2002), an *approach* (Gambardella y McGahan, 2010), a *logic* (Casadesus-Masanell y Ricart, 2011; Chesbrough y Rosenbloom, 2002) and a *representation* (Geissdoerfer, Vladimirova y Evans, 2018; Morris et al., 2005; Perkmann et al., 2010; Shafer et al., 2005), to list a sample. In addition, the numerous definitions found in the literature illustrate a wide range of elements constituting the business model. For instance, in an attempt to identify key business model components from the literature, Clauss (2017) collected 73 semantically different elements.

Table 2 provides a selection of relevant definitions from the business model literature. These definitions show the different terms researchers use to refer to business models and that the semantics used to describe business model elements vary. However, almost all definitions are similar in two key aspects: the central role of value and the interlink among the elements explaining the business logic. Keywords referring to these aspects (terms applied, the role of value and linkages) are marked in italics.

Table 2 Review of business model definitions

Reference	Business model definition
Afuah and Tucci (2001)	"The *method* by which a firm builds and uses its resources to offer its customers better *value* than its competitors." (p. 3) "A *system* that is made up of components, *linkages* between components, and dynamics." (p. 4)
Dubosson-Torbay et al. (2002)	"The *architecture* of a firm and its network of partners for creating, marketing and delivering *value* and relationship capital to one or several segments of customers in order to generate profitable and sustainable revenue streams." (p. 7)
Magretta (2002)	"*Stories* that explain how enterprises work. A good business model answers Peter Drucker's age old questions: Who is the customer? And what does the *customer value*? It also answers the fundamental questions every manager must ask: How do we make money in this business? What is the underlying economic *logic* that explains how we can deliver value to customers at an appropriate cost?" (p. 4) "A system, how the pieces of a business fit together." (p. 6)
Seddon et al. (2004)	"An *outline* of the essential details of a firm's *value proposition* for its various stakeholders and the *activity system* the firm uses to *create and deliver value* to its customers." (p. 429)
Morris, Schindehutte and Allen (2005)	"Concise representation of how an *interrelated set of decision variables* in the areas of venture strategy, architecture, and economics are addressed to create sustainable competitive advantage in defined markets." (p. 727)
Osterwalder, Tucci and Pigneur (2005)	"A *conceptual tool* that contains *a set of elements and their relationships* and allows expressing the *business logic* of a specific firm. It is a description of the *value* a firm offers to one or several segments of customers and of the *architecture* of the firm and its network of partners for creating marketing, and delivering this *value* and relationship capital, to generate profitable and sustainable revenue streams." (pp. 17–18)
Shafer, Smith and Linder (2005)	"A *representation* of a firm's underlying *core logic* and strategic choices for creating and capturing *value* within a *value network*." (p. 202)
Casadesus-Masanell and Ricart (2007, 2010)	"(1) A *set of choices* and (2) the *set of consequences* arising from those choices." (2007, p. 3) "Refers to the *logic* of the firm, the way it operates and how it *creates value* for its stakeholders." (2010, p. 2)
Johnson et al. (2008)	"Consists of four *interlocking elements* that, taken together, *create and deliver value.*" (p. 60) These elements are customer *value proposition*, profit formula, key resources and key processes.
Richardson (2008)	"A *conceptual framework* that helps to link the firm's strategy, or theory of how to compete, to its activities, or execution of the strategy." (p. 135) The three major components of the framework are the *value proposition* (i.e. offering, target customer and basic strategy), the *value creation and delivery system* (resources and capabilities, organisation and position in the value network) and *value capture* (revenue sources and the economics of the business), which reflect the logic of strategic thinking about value.
Chesbrough (2010)	A "business model fulfils the following functions: articulates the *value proposition* (…), identifies a market segment (…), defines the structure of the *value chain* required to create and distribute the offering and complementary assets (…), details the revenue mechanism(s) (…), estimates the cost structure and profit potential (…), describes the position of the firm within the *value network* (…), and formulates the competitive strategy." (p. 355)
Doz and Kosonen (2010)	"Sets of *structured and interdependent* operational relationships between a firm and its customers, suppliers, complementors, partners and other stakeholders, and among its internal units and departments (functions, staff, operating units, etc.)." (p. 371) "Cognitive structures providing a theory of how to set boundaries to the firm, of how to *create value*, and how to organise its internal structure and governance." (p. 371)
Teece (2010)	"*Articulates the logic*, the data and other evidence that support a *value proposition* for the customer, and a viable structure of revenues and costs for the enterprise delivering that value." (p. 179) "Describes the design or *architecture* of the *value creation, delivery and capture mechanisms* employed." (p. 191)
Osterwalder and Pigneur (2010)	"Describes the rationale of how an organisation *creates, delivers, and captures value*." (p. 14) "A business model can best be described through nine basic building blocks that show the *logic* of how a company intends to make money. The nine blocks cover the four main areas of a business: customers, offer, infrastructure, and financial viability." (p. 15)
Amit and Zott (2012). *Updated from Amit and Zott (2001); Zott and Amit (2007, 2008)*	"A *system* of *interconnected and interdependent activities* that determines the way the firm 'does business' with its customers, partners and vendors." (p. 42) "A bundle of specific activities—an *activity system*—conducted to satisfy the perceived needs of the market, along with the specification of which parties (a company or its partners) conduct which activities, and how these activities are *linked* to each other." (p. 42)
Baden-Fuller and Haefliger (2013)	A "business model system as *a model* containing *cause and effect relationships.*" (p. 419) Business models can be classified based on a framework containing four dimensions: customers, customer engagement, *value delivery and linkages* and monetization.
Massa et al. (2017)	"A description of an organisation and *how that organisation functions in achieving its goals* (e.g., profitability, growth, social impact . . .)" (p. 73)
Saebi et al. (2017)	"The firm's *value proposition* and market segments, the structure of the *value chain* required for realizing the value proposition, the mechanisms of *value capture* that the firm deploys, and how these elements are *linked together in an architecture.*" (p. 567)
Geissdoerfer, Vladimirova and Evans (2018)	"Simplified *representations* of the *value proposition, value creation and delivery, and value capture* elements and the *interactions* between these elements within an organisational unit." (p. 402)

As for the idea of value, some authors define the business model using three main dimensions: value creation, value delivery and value capture (Baden-Fuller y Haefliger, 2013; Geissdoerfer, Vladimirova y Evans, 2018; Osterwalder y Pigneur, 2010; Richardson, 2008; Teece, 2010). These three dimensions embrace the key business model elements found in most of the definitions (Clauss, 2017; Foss y Saebi, 2018).

The value delivery dimension describes the solution the company offers to a given customer segment for which those customers are willing to pay, in terms of offer and market segment (Baden-Fuller y Haefliger, 2013; Chesbrough, 2010; Dubosson-Torbay et al., 2002; Magretta, 2002; Osterwalder et al., 2005; Richardson, 2008; Teece, 2010). Some authors also refer to this as the value proposition of the company (Geissdoerfer, Vladimirova y Evans, 2018; Osterwalder y Pigneur, 2010; Richardson, 2008; Saebi et al., 2017; Seddon et al., 2004).

The value creation dimension refers to how the company creates value for customers and usually encompasses the company's value chain, value network, processes, activities, resources and capabilities (Afuah y Tucci, 2001; Amit y Zott, 2012; Chesbrough, 2010; Doz y Kosonen, 2010; Morris et al., 2005; Osterwalder et al., 2005; Osterwalder y Pigneur, 2010; Saebi et al., 2017; Teece, 2010; Voelpel et al., 2004).

Finally, the value capture dimension commonly encompasses the costs associated with the creation and delivery of value as well as the revenue and profits that the company acquires in return (Baden-Fuller y Haefliger, 2013; Chesbrough, 2010; Dubosson-Torbay et al., 2002; Magretta, 2002; McGrath, 2010; Morris et al., 2005; Osterwalder et al., 2005; Richardson, 2008; Teece, 2010).

The second key aspect in most of these definitions is the linking of these elements in an architecture that explains the business logic of the firm (Afuah y Tucci, 2001; Amit y Zott, 2012; Baden-Fuller y Haefliger, 2013; Demil y Lecocq, 2010; Doz y Kosonen, 2010; Dubosson-Torbay et al., 2002; Geissdoerfer, Vladimirova y Evans, 2018; Magretta, 2002; Morris et al., 2005; Osterwalder et al., 2005; Saebi et al., 2017; Seddon et al., 2004; Teece, 2010; Winter y Szulanski, 2001).

In this regard, Teece (2010) offers a clear definition of a firm's business model as the "architecture of the value creation, delivery and capture mechanisms employed" (p. 191), a definition now widely accepted in the research community (Andreini y Bettinelli, 2017; Belussi et al., 2019; Foss y Saebi, 2018; B Wirtz et al., 2016). Similarly, Amit and Zott (2012) describe the business model as an activity system in which the notion of linkages and interdependencies among activities is usually highlighted.

This emphasis on the underlying architecture of business models is considered to provide the basis to dimensionalise business models and consequently business model innovation, paving the way for the study of causal relationships and the accumulation of theory (Foss y Saebi, 2018; Stieglitz et al., 2015). The idea of architecture, understood as a set of relations between elements in a system (Simon, 1996), allows these relations to be characterised in terms of directionality, strength and content (Foss y Saebi, 2018; Stieglitz et al., 2015).

Based on the various approaches in the literature and the two key aspects (value and architecture) and business model dimensions that are common to most of the definitions, this thesis adopts the following definition:

> *The business model articulates the business logic of value creation, delivery and capture and the architecture linking these dimensions.*

This definition is considered relevant to this thesis for the following reasons:

- First, it assumes that business models describe the business logic of the firm, and therefore, they reflect the managerial decisions on the value creation, delivery and capture mechanisms (Magretta, 2002; Osterwalder et al., 2005; Osterwalder y Pigneur, 2010; Richardson, 2008; Shafer et al., 2005; Teece, 2010). This issue is explicitly addressed in Casadesus-Masanell and Ricart's (2007, 2010) contributions, which refer to a business model as a set of choices on business model components made by the management and the consequences of those choices.
- Second, it provides a systemic view of how an organisation functions in achieving its goals: primarily, how it provides value to its customers and generates revenue in turn (Casadesus-Masanell y Joan Enric Ricart, 2010; Massa et al., 2017).
- Third, it stresses the underlying architecture of the value mechanism, suggesting that value creation, delivery and capture dimensions are linked and are interdependent (Amit y Zott, 2012; Teece, 2010).
- Fourth, by viewing a business model as an architecture, cause and effect relationships in the entire organisational system can be addressed (Baden-Fuller y Haefliger, 2013), and therefore this serves as a suitable definition for studies that address causal relationships empirically (Foss y Saebi, 2018; Stieglitz et al., 2015).
- Finally, this approach is in line with recent contributions that point to the convergence of business model definitions in terms of value creation, delivery and capture and the underlying architecture (Geissdoerfer, Vladimirova y Evans, 2018; Lopez-Nicolas et al., 2020; Saebi et al., 2017).

Business model and strategy

The definition adopted in this thesis builds on the strategy-oriented view of business models (Amit y Zott, 2012; Magretta, 2002; Teece, 2010; B Wirtz et al., 2016), which more than two decades ago opened a debate on the legitimacy of business models that continues today (Massa et al., 2017).

The description of business models as value creation and value capture mechanisms has challenged the assumptions of traditional theories in the strategy field on how value is created and captured. This has led several scholars to adopt contrary positions on the relevance of the term and to question whether it should be treated as a unit of analysis independent of strategy (B Wirtz et al., 2016).

Academics sceptical about the business model as a new construct argue that business models are nothing but "old wine in a new bottle" (Massa et al., 2017, p. 89). For them, business model literature limits itself to reframing questions, concerns and insights traditionally addressed in strategy research, adding little new knowledge to theory development (Foss y Saebi, 2018).

One of the most famous authors to criticise the term business model is Michael E. Porter (B Wirtz et al., 2016), who states that the business model is "murky at best" and "an invitation for faulty thinking and self-delusion" (Porter, 2001, p. 73). In Porter's (2001) words, the strategy describes "how all the elements of what a company does fit together" (p. 71). Comparing this definition with Magretta's (2002), who refers to the business model as "a system, how the pieces of a business fit together" (p. 6), both definitions seem indistinct. In addition, from the activity-system view of strategy, Porter (1996) stated the following:

> *Ultimately, all the differences between companies in cost or price derive from the hundreds of activities required to create, produce, sell, and deliver their products and services. . . . Cost is generated in performing activities. Similarly, differentiation arises from both the choice of activities and how they are performed. Activities, then, are the basic unit of competitive advantage. Overall companies' advantage or disadvantage results from all a company's activities, not only a few. (p. 62)*

Returning to Zott and Amit's (2007, 2008) work, they describe the business model as a bundle of specific activities (an activity system) that can be constructed around novelty and efficiency design themes. Novelty refers to the potential of introducing new activities, linking activities in original ways or establishing new ways of governing these activities in the business model. Efficiency, in turn, is related to enhancing transactions by reducing costs and thus providing greater value. By contrasting Zott and Amit's (2007, 2008) conceptualisation with Porter's (1996) view, a strong conceptual overlap between cost leadership and efficiency, differentiation leadership and novelty, and the notions of value capture and activity systems in both approaches make the business model look dispensable (Massa et al., 2017).

However, proponents of the business model claim that building business models addresses new research questions that traditional theories of value creation and capture under the concept of strategy have failed to answer (Massa et al., 2017; Meirelles, 2019). For instance, Massa et al. (2017) argue that business models enables to shift the focus from the firm side to the demand side. From their view, competitive advantage can be "multisourced" (Massa et al., 2017, p. 75), integrating also network effects, and prioritising experimentation over firm positioning and resources control.

Recent literature seems to accept that business model and strategy are different constructs (Ritter y Lettl, 2018). In this respect, scholars recognise the existence of an overlap and suggest the two are different constructs that are closely linked. Some authors describe the business model as a source of competitive advantage different from strategy and as strategy's extension and complement (Zott et al., 2011; Zott y Amit, 2008). For instance, Casadesus-Masanell and Joan E Ricart (2010) stress that every company has a business model but not every company has a strategy, and they further state that the business model is "a reflection of the firm's strategy" (p. 16). Chesbrough (2010) suggests that the business model "formulates the competitive strategy by which the innovating firm will gain and hold advantage over rivals" (p. 355). Similarly, Teece (2010) argues that business models need to meet the requirements of strategic analysis to make imitation by competitors difficult and thus be viable, even providing a competitive advantage.

Osterwalder and Pigneur (2002) adopt an operational approach, developing the *business logic triangle* framework and suggesting that the business model is the execution of the strategy, establishing the missing link between strategic planning and business processes in dynamic and competitive environments. This approach has been adopted by several authors (Al-Debei et al., 2008; Osterwalder et al., 2005; Osterwalder y Pigneur, 2002; Rachinger et al., 2019). As illustrated in Figure 2, Rachinger et al. (2019) include the firm's dynamic capabilities – that is, the ability to sense and seize opportunities and adapt the business model to environmental changes (Teece, 2017) – in Osterwalder and Pigneur's (2002) framework. They suggest the business model can be innovated as a result of the dynamic capabilities of the firm, on which business model design and operation depend.

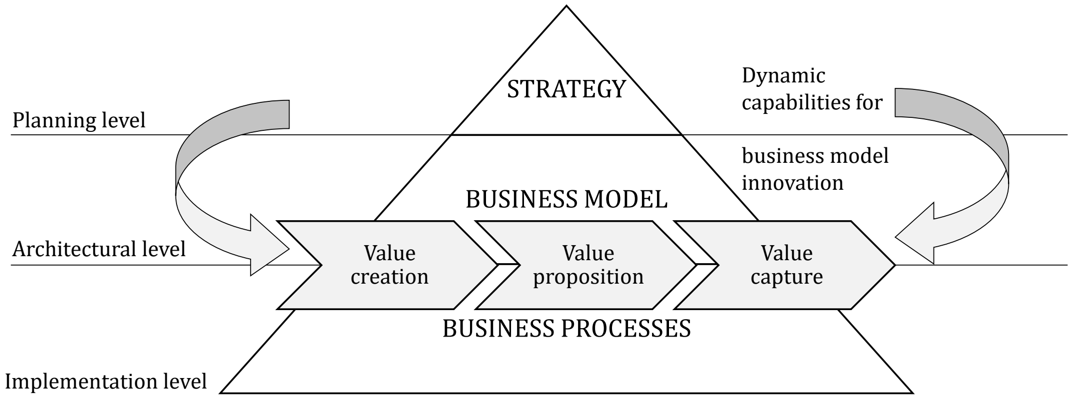

Figure 2 Business logic triangle.
Developed by Osterwalder and Pigneur (2002) and updated by Rachinger et al. (2019)

What Rachinger et al. (2019) suggest is in line with what DaSilva and Trkman (2014) were already advocating when they developed the framework shown in Figure 3. DaSilva and Trkman (2014) follow a different approach, focused on a strategic rather than operational perspective, with a distinction between strategy and the business model. They emphasize that the strategy reflects what an organisation intends to become, while a business model describes what the organisation actually is at any given time. In this view, strategy represents a company's long-term perspective, whereas the business model represents its short-term perspective (DaSilva y Trkman, 2014). They also suggest, as shown in Figure 3, that strategy and the business model are linked through those dynamic capabilities that are developed in the medium term.

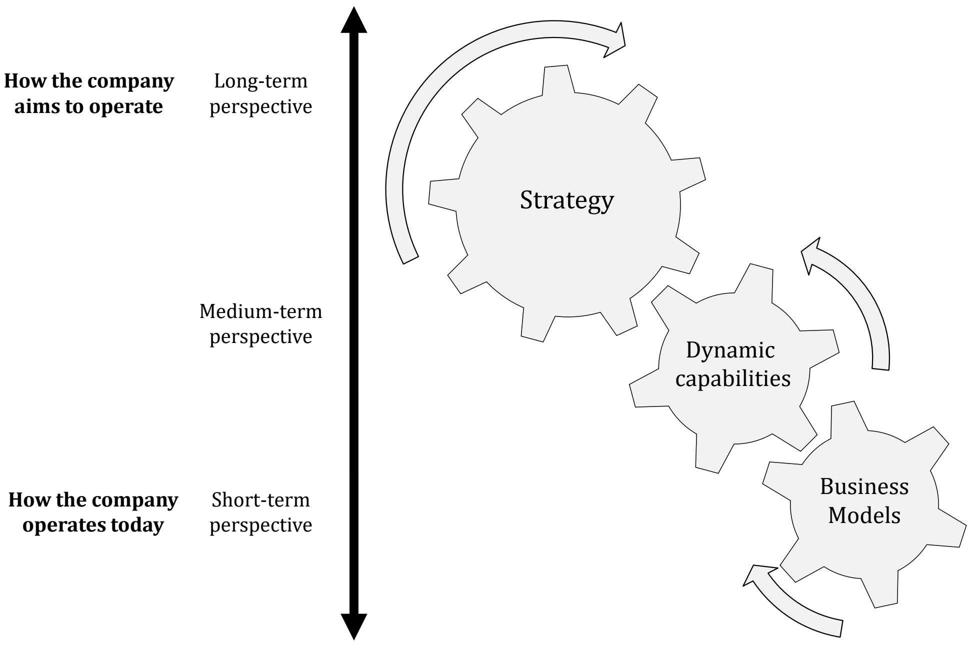

Figure 3 Strategy, dynamic capabilities and business models.
Adapted from Carlos M DaSilva and Trkman (2014)

Similarly, Teece (2018) emphasises that business strategy and dynamic capabilities combine to create and refine a defensible business model and guide organisational transformation. According to Teece, in some cases business strategy dictates the design of the business model, whereas in other cases, such as the introduction of a new technology, new business model opportunities may arise to which the business strategy must respond. While this may cause some conflict between the strategy and the business model, it is up to management to determine which of the two should change.

Finally, Taran et al. (2009) view strategy as "outside oriented", concerned with decisions about how to position the business and carry out the strategy, while the core business model is "inside oriented" and represents the implementation of the business strategy. Furthermore, as presented in Figure 4, they state that business strategy is implemented through a business model innovation process that results in the core business model, which allows the achievement of the business strategy.

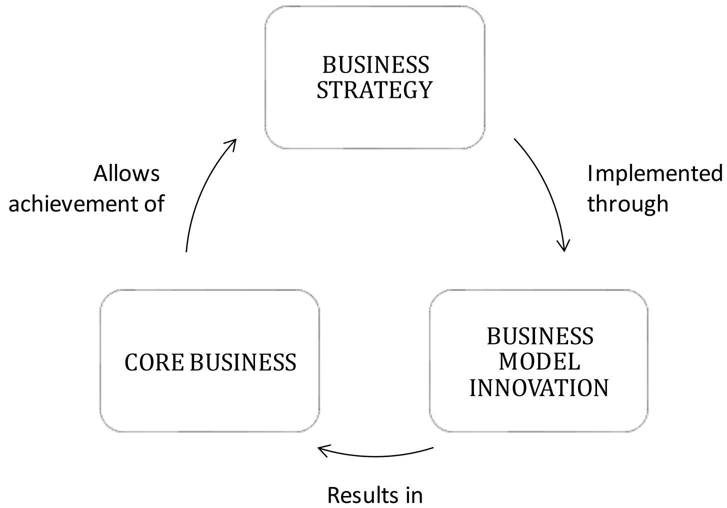

Figure 4 Core business, business model innovation and strategy. Adapted from Taran et al. (2009)

Thus the relationship between strategy and business model reviewed in this subsection can be summarized as follows:

- Business model and strategy are closely linked but they are considered different constructs (Ritter y Lettl, 2018).
- Every company has a business model, even if it does not have a defined strategy (Casadesus-Masanell y Joan E Ricart, 2010; DaSilva y Trkman, 2014).
- The strategy describes what the firm intends to become in the long term, whereas the business model represents the achievement of business strategy in the short term (DaSilva y Trkman, 2014; Taran et al., 2009).
- By detailing how the firm can avoid imitation by competitors and by outlining strategic choices, a firm's business model can become a source of competitive

advantage (Casadesus-Masanell y Joan E Ricart, 2010; Chesbrough, 2010; Teece, 2010; Zott et al., 2011; Zott y Amit, 2008).

- The link between the strategy and the business model tends to be represented using a dynamic view of interrelated concepts, where changes in strategy may alter the business model and vice versa (DaSilva y Trkman, 2014; Taran et al., 2009; Teece, 2017).
- Finally, from this dynamic view, the achievement of the strategy through the business model seems to be accomplished via a third element, which is the dynamic capabilities or business model innovation capabilities of the firm (DaSilva y Trkman, 2014; Rachinger et al., 2019; Taran et al., 2009; Teece, 2017).

2.1.2. Business model innovation: the innovation dimension of business models

Scholars have long considered the business model to be *static* (Ritter y Lettl, 2018). From this view, business models provide an overall picture of a company's operation, allowing typologies to be built and companies to be classified (Demil y Lecocq, 2010; Foss y Saebi, 2017). This view helps explain how an existing or future business model can generate profit and even provide guidance on how to outperform competitors (Spieth et al., 2014). Since business models address operational aspects, they also provide guidance and support for managers as they conceptualise the mechanism the firm will employ to create and capture value and as they manage these operations (Demil y Lecocq, 2010; Spieth et al., 2014). However, as stated in the previous subsection, the strategy-oriented perspective on business models has fostered a dynamic view of the concept. This has led to a new role for the business model as a means of addressing change and innovation in a company (Demil y Lecocq, 2010). In this role, business models can support the strategic development of the firm, the identification of new opportunities and the creation of sustainable competitive advantage (Andreini y Bettinelli, 2017; Spieth et al., 2014). Thus, the main premise behind this view is that business models are not static but rather are in a continuous state of change in terms of their components, relationships and structure (Andreini y Bettinelli, 2017; Demil y Lecocq, 2010).

Within this dynamic view, multiple approaches have been used to refer to changes in the business model, such as *business model reinvention* (Voelpel et al., 2004), *business model life cycle* (Morris et al., 2005), *business model evolution* (Demil y Lecocq, 2010), *business model erosion* (McGrath, 2010), *business model learning* (Teece, 2010), *business model transformation* (Aspara et al., 2013), *business model development* (Andries et al., 2013), *business model change* (Cavalcante, 2014; Osiyevskyy J. et al., 2015) and *business model adaptation* (Saebi et al., 2017).

One of the first explicit references to *business model innovation* is found in Mitchell and Coles's (2003) work titled "The ultimate competitive advantage of continuing business model innovation" (Foss y Saebi, 2017). The authors discuss how managers can purposively innovate their business model, through replacements and improvements, to achieve a sustainable competitive advantage and outperform their competitors.

Since Mitchell and Cole's work, a growing number of studies have focused on the innovation dimension of the business model (Foss y Saebi, 2017). Over the years, the term *business model innovation* seems to have prevailed over the other terms given above, laying the foundation for a new field of study. While business model innovation is an extension of the work on business models (Geissdoerfer, Vladimirova y Evans, 2018), it also incorporates questions that go beyond business model literature boundaries and approach the innovation management field, which studies how firms innovate (Naqshbandi y Kaur, 2015). Therefore, before addressing the definition of business model innovation as a whole, this section summarises key concepts of business innovation, with a view to understanding how business model innovation can be defined and dimensionalised.

Business innovation

Innovation is considered a complex phenomenon and has been defined in a variety of ways (Quintane et al., 2011). Since the term comes from the Latin *innovare*, which means "to make something new" (Bessant y Tidd, 2013), several authors have defined it as a process; see Table 3 (Bessant y Tidd, 2013; Farr y West, 1990; Garcia y Calantone, 2002; OECD/Eurostat, 2005; Taylor y Greve, 2006).

Viewing innovation as a process involves considering the outcome of the process: that is, the ways in which firms can innovate (Bessant y Tidd, 2013). Therefore, as demonstrated in Table 3, various authors have defined innovation by referring to the changes (i.e. outcomes) introduced by the firm (Boer y During, 2001; Levitt, 1960; OECD/Eurostat, 2005, 2018; Utterback, 1971). From this view, innovation commonly refers to changes in *things* (product/service innovation), changes in the ways in which *things* are created (process innovation), changes in the context in which things are introduced (market innovation) and changes in the underlying methods or business practices (organisational innovation). In addition, some definitions emphasise that innovation is about combining more than one form of innovation (Boer y During, 2001; OECD/Eurostat, 2018), since isolated innovations are very rare (Taran, Boer, et al., 2015).

These four types of innovation (product[3], process, marketing and organisation) are widely referred to in the literature and derive from Schumpeter's (1934) pioneering theory of economic development and new value creation, which is considered one of the first writings on innovation and a major influence on innovation research

[3] Product innovation also includes service mode.

(Heikkilä, Bouwman, Heikkilä, Haaker, et al., 2016; OECD/Eurostat, 2005; Taran, Boer, et al., 2015). In his work, he distinguishes five types of innovation: the introduction of new products into the market, new methods of production and distribution, new sources of supply, the opening of a new market and a change in the organisation or its management process.

Table 3 Innovation definitions

Reference	Innovation definition
Levitt (1960)	"Profit-building new and novel products, production processes, and marketing schemes." (p. 2)
Utterback (1971)	"An invention which has reached market introduction in the case of a new product, or first use in a production process, in the case of a process innovation." (p. 77)
Kimberly (1981)	"There are three stages of innovation: innovation as a process, innovation as a discrete item including, products, programs or services; and innovation as an attribute of organisations." (p. 108)
Drucker (1985)	"Innovation is the specific tool of entrepreneurs, the means by which they exploit change as an opportunity for a different business or service. It is capable of being presented as a discipline, capable of being learned, capable of being practised." (p. 19)
Farr and West (1990)	"The intentional introduction and application within a role, group, or organisation of ideas, processes, products or procedures, new to the relevant unit of adoption, designed to significantly benefit the individual, the group, organisation or wider society." (p. 9)
Porter (1990)	"Companies achieve competitive advantage through acts of innovation. They approach innovation in its broadest sense, including both new technologies and new ways of doing things." (p. 74)
Boer and During (2001)	"The creation of a new product-market-technology-organisation combination." (p. 84).
Garcia and Calantone (2002)	"An iterative process initiated by the perception of a new market and/or service opportunity for a technology-based invention which leads to development, production and marketing tasks striving for the commercial success of the invention." (p. 112)
Oslo Manual[4] 3th Edition (OECD/Eurostat, 2005)	"The implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations." (p. 46)
Taylor and Greve (2006)	"Both the creative development of novelty and its application to generation of a new product." (p. 724)
Bessant and Tidd (2013)	"A process of turning opportunity into new ideas and of putting these into widely used practice." (p. 35) "The process of turning ideas into reality and capturing value from them." (p. 38)
Oslo Manual. 4th Edition (OECD/Eurostat, 2018)	"A new or improved product or business process (or combination thereof) that differs significantly from the firm's previous products or business processes and that has been introduced on the market or brought into use by the firm." (p. 20)

Apart from the process-outcome approach, three more aspects are widely used to dimensionalise innovation: the degree of radicalness, the degree of novelty and the degree of complexity.

The *degree of radicalness* distinguishes incremental innovation from radical innovation and can also be found in Schumpeter's (1934) view of economic development. According to Schumpeter, economic development is driven by entrepreneurial or creative people looking for new combinations and ways of doing things, fostering innovation through a dynamic process that he called "creative destruction". This process suggests that new technologies replace old ones, causing the destruction of the structures of the economy and making old companies,

[4] The Oslo Manual is developed by the Organisation for Economic Co-operation and Development (OECD) together with EUROSTAT. It provides guidelines for collecting and interpreting data on innovation, and it can be considered one of the main references on innovation measurement in Europe.

products and occupations disappear, while new, better and more profitable ones replace them. In this respect, companies compete through innovation, which fosters the economic development of a country. In Schumpeter's view, innovation must be radical rather than incremental to continuously revolutionize the economic structure.

In more recent years, the distinction between incremental and radical innovation has been widely used under different nomenclatures (Naqshbandi y Kaur, 2015). In brief, incremental and radical innovation are applied to indicate "how new" a change is (Foss y Saebi, 2018; Taran, Boer, et al., 2015). Incremental innovation usually implies making small improvements based on existing knowledge. It is oriented to the short term and is used to make a company perform better than it has. Radical innovation, by contrast, is the ability to develop new knowledge and competences and may result in the cannibalization of existing products or ways of doing things (Bessant y Tidd, 2013; Naqshbandi y Kaur, 2015; Taran et al., 2009).

The *degree of novelty* measures "to whom" the innovation is new (Taran, Boer, et al., 2015). It relates to another relevant theory on the diffusion of innovations provided by Rogers (1983). This theory examines how innovation spreads and is adopted through certain channels over time by members of a social system (Naqshbandi y Kaur, 2015). In this sense, innovation can be new to the company, new to the market, new to the industry or new to the world (Foss y Saebi, 2017; Taran, Boer, et al., 2015).

The *degree of complexity*, dimensionalises innovation as components within larger systems (Bessant y Tidd, 2013). This approach was developed by Henderson and Clark (1990), who suggest that the knowledge required for product innovation is divided into two types: knowledge of the components and knowledge of the linkages between the components (architectural knowledge). The authors distinguish between modular innovation, which incorporates new knowledge into one or more components without changing the product architecture, and architectural innovation, which involves changes in the linkages between components while the core design of components remains unchanged (Naqshbandi y Kaur, 2015).

Business model innovation: definitions and approaches

In the following lines, the definitions and approaches of business model innovation are explored. Table 4 presents a selection of business model innovation definitions considered relevant to building the definition adopted in this research.

Table 4 Review of business model innovation definitions

Reference	Business model innovation definition
Mitchell and Coles (2004)	"We mean business model replacements that provide product or service offerings to customers and end users that were not previously available. We also refer to the process of developing these novel replacements as business model innovation." (p. 17)
Markides (2006)	"The discovery of a fundamentally different business model in an existing business." (p. 20)
Chesbrough (2007)	Business model innovation is to "advance [the] business model … from very basic (and not very valuable) models to far more advanced (and more valuable) models." (p. 15)
Giesen et al. (2007)	"We first identified three main types of business model innovation, which can be used alone or in combination: industry models (innovations in industry supply chain), revenue models (innovations in how companies generate value), and enterprise models (innovations in the role the structure of an enterprise plays in new or existing value chains). (p. 27)
Lindgardt et al. (2009)	"Innovation becomes BMI [business model innovation] when two or more elements of a business model are reinvented to deliver value in a new way." (p. 2)
Santos et al. (2009)	"Business model innovation … is a reconfiguration of activities in the existing business model of a firm that is new to the product/service market in which the firm competes." (p. 14)
Bock et al. (2010)	"New-to-the-firm changes in the design of organisational structures." (p. 10)
Johnson (2010)	"Seizing the white space requires new skills, new strengths, new ways to make money. It calls for the ability to innovate something more core than the core, to innovate the very theory of the business itself. I call that process business model innovation." (p. 13) "Business model innovation is an iterative journey." (p. 114)
Osterwalder and Pigneur (2010)	Business model innovation "is about challenging orthodoxies to design original models that meet unsatisfied, new, or hidden customer needs." (p. 136)
Amit and Zott (2012)	"Business model innovation can occur in a number of ways: 1. by adding novel activities …; 2. by linking activities in novel ways …; 3. by changing one or more parties that perform any of the activities …." (p. 44)
Bucherer et al. (2012)	"A process that deliberately changes the core elements of a firm and its business logic." (p. 184)
Rauter et al. (2012)	"An approach of changing the business model; therefore business model innovation is seen as the process itself and not as the result of the ongoing changes." (p. 10)
Abdelkafi et al. (2013)	"When the company modifies or improves at least one of the value dimensions [value proposition, communication, creation, delivery, capture]." (p. 13)
Björkdahl M. (2013)	"The implementation of a business model that is new to the firm." (p. 214) "Business model innovation is a new integrated logic of value creation and value capture, which can comprise a new combination of new and old products or services, market position, processes and other types of changes." (p. 215)
Frankenberger et al. (2013)	"A novel way of how to create and capture value, which is achieved through a change of one or multiple components in the business model." (p. 253)
Massa and Tucci (2013)	Business model innovation "may refer to (1) the design of novel BMs [business models] for newly formed organisations, or (2) the reconfiguration of existing BMs." (p. 424)
Matzler et al. (2013)	"Business model innovation results when a company increases customer value and simultaneously creates a new value creation and revenue model that allows the company to capture some of the value created in a new way." (p. 31)
Schneider and Spieth (2013)	"Business model innovation is defined as a conscious and significant change of at least one dimension of a firm's or a business units' business model [value offering, value creation architecture, revenue model logic]." (p. 13)
Khanagha et al. (2014)	"The redefinition of existing products or services and how they are provided to customers." "Business model innovation activities can range from incremental changes in individual components of business models, extension of the existing business model, introduction of parallel business models, right through to disruption of the business models, which may potentially entail replacing the existing model with a fundamentally different one." (p. 324)
Bouwman et al. (2015, 2018)	"A change in a company's business model that is new to the firm and results in observable changes in its practices towards customers and partners." (p. 1)
Foss and Saebi (2017)	"Designed, novel, and nontrivial changes to the key elements of a firm's business model and/or the architecture linking these elements." (p. 17)
Geissdoerfer, Vladimirova and Evans (2018)	"We define business model innovation as the conceptualisation and implementation of new business models. This can comprise the development of entirely new business models, the diversification into additional business models, the acquisition of new business models, or the transformation from one business model to another. The transformation can affect the entire business model or individual or a combination of its value proposition, value creation and delivery, and value capture elements, the interrelations between the elements, and the value network." (p. 405)

In addition, as illustrated in Figure 5, business model innovation can be conceptualised according to the four approaches previously listed (Foss y Saebi, 2017; Taran, Boer, et al., 2015).

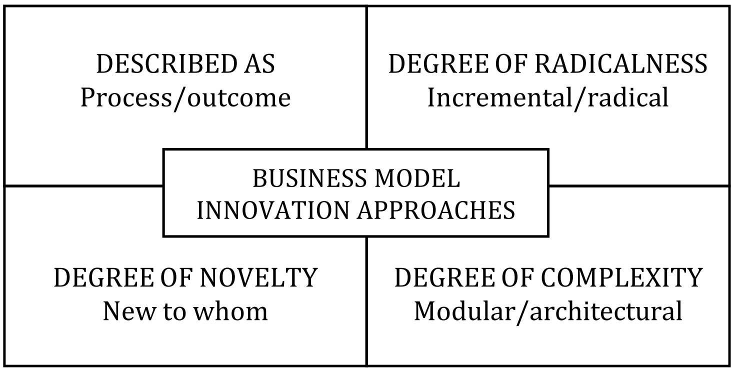

Figure 5 Business model innovation approaches.

The first approach concerns whether business model innovation is a process or the outcome of this process. Some authors define business model innovation as a process (Bucherer et al., 2012; Frankenberger et al., 2013; Johnson, 2010; Osterwalder y Pigneur, 2010; Rauter et al., 2012). In this view, business model innovation is a dynamic process that managers can implement through learning and experimentation (McGrath, 2010), trial and error (Sosna et al., 2010) or the development of certain activities through iterative stages (Frankenberger et al., 2013).

Other authors describe business model innovation as an outcome of this process, in the form of a change to an existing business model or the introduction of a new model (e.g. Bouwman et al., 2015, 2018; Foss and Saebi, 2017; Giesen et al., 2007; Massa and Tucci, 2013). Strategic management scholars tend to view business model innovation as the introduction of innovative ways to create and capture value (Amit y Zott, 2012), while entrepreneurship literature conceptualises it as a disruptive innovation introduced and developed to exploit new market opportunities (Andreini y Bettinelli, 2017; Osiyevskyy y Dewald, 2015).

Alternatively, in some cases it is understood as both process and outcome. For instance, Mitchell and Bruckner Coles (2004) define business model innovation as business model replacements (an outcome) and the process of "developing these novel replacements" (p. 17). Massa and Tucci (2013) understand business model innovation as an outcome and define two different processes that may lead to it: business model design (in the case of companies newly created) and business model reconfiguration (in the case of incumbent firms).

The second approach describes the degree of radicalness of business model innovation. In this view, business model innovation ranges from minor changes, such as extensions of or improvements to certain business model elements (i.e. incremental innovation) (Abdelkafi et al., 2013; HW Chesbrough, 2007), to significantly new developments of the business model, or radical innovation (Bouwman, Nikou, et al., 2018; Foss y Saebi, 2017; Markides, 2006; Schneider y Spieth, 2013). Other definitions consider both radical and incremental changes to the business model as business model innovation (Geissdoerfer, Vladimirova y Evans, 2018; Khanagha et al., 2014).

A third approach is the degree of novelty. Business model innovation definitions suggest various approaches when establishing whether it should be new to the firm, new to the market, new to the industry or new to the world (Foss y Saebi, 2017; Taran, Boer, et al., 2015). Some authors suggest business model innovation refers to models that are new to the firm but not necessarily to the market (Björkdahl y Holmén, 2013; Bock et al., 2010; Bouwman, Nikou, et al., 2018). Others suggest the model should be new to the market as well (Mitchell C. et al., 2004; Santos et al., 2009).

The last approach refers to the degree of complexity, which measures innovativeness in terms of the extent of modular changes – that is, a simple innovation in one element of the business model – or architectural changes – innovating all the business model dimensions (Taran, Chester Goduscheit, et al., 2015). Some definitions suggest business model innovation requires at least one value dimension to be changed (Abdelkafi et al., 2013). Other definitions indicate that one or more dimensions (Frankenberger et al., 2013), two or more elements (Lindgardt et al., 2009) or even all dimensions should be simultaneously changed (Matzler, Bailom, et al., 2013). Foss and Saebi (2017) pay particular attention to the degree of architectural and modular change within the business model, which, taken together with novelty (new to the firm or new to the industry), provides four typologies of business model innovation depending on the transformational process followed: evolutionary, focused, adaptive or complex. The evolutionary type includes voluntary and emergent changes in individual components of the business model that occur naturally over time. In the focused type, the company innovates within one area, such as targeting a new market segment ignored by its competition, and creates a new market without changing value creation, delivery or capture mechanisms. Adaptive business model innovation implies changes in the overall business model that are new to the firm but not necessarily new to industry. Finally, complex business model innovation involves changing the business model entirely and disrupting market conditions.

Business innovation and business model innovation

After reviewing the literature on innovation and business model innovation, a final concern is the ambiguity of the relationship between changes in business model components and business innovation forms: that is, product, process, marketing and organisation (Björkdahl y Holmén, 2013; HW Chesbrough, 2007; Khanagha et al., 2014; Markides, 2006; Mitchell C. et al., 2004).

Opinions vary on whether product, process and business model innovation can be performed simultaneously or must be separately (Snihur y Wiklund, 2019). On the one hand, some authors seem to integrate product, service or process innovation within business model innovation. For example, Mitchell and Bruckner Coles (2004) define business model innovation as "business model replacements that provide product or service offerings" (p. 17). Björkdahl M. (2013) suggests that business model innovation "can comprise a new combination of new and old products or services, market position, processes and other types of changes" (p. 215). Khanagha et al. (2014) in their turn describe it as "the redefinition of existing products or service and how they are provided to customers" (p. 324).

Furthermore, the latest edition of the *Oslo Manual 2018* (OECD/Eurostat, 2018), instead of providing a definition, simply refers to three types of business model innovations existing in companies: (1) a firm extends its business to include completely new types of products and markets the delivery of which requires new business processes; (2) a firm ceases its previous activities and enters into new types of products and markets that require new business processes; and (3) a firm changes the business model for its existing products: for example, it switches to a digital model with new business processes for production and delivery, and the product changes from a tangible good to a knowledge-capturing service. Thus, according to the *Oslo Manual 2018*, business model innovation seems to be a composite at the intersection of product, process, marketing and organisation innovation.

Based on these definitions, the differences between product, service, process, marketing and business model innovation are rather blurred. This is in line with Geissdoerfer, Vladimirova and Evans's (2018) findings. After reviewing business model innovation literature, they conclude that it is not clear what the threshold is to qualify changes in a company's activities as a change in business model elements. In other words, when the value proposition is innovated by introducing a new product or service, whether this is a product innovation or a business model innovation is not obvious.

On the other hand, various scholars differentiate between product innovation and business model innovation, arguing that business model innovation allows the creation of value for customers without resorting to product innovation (Markides, 2006) or that it can complement the value delivered through product or service innovation (Bohnsack et al., 2014). Francis and Bessant (2005) place business models together with organisational values and people management policies in the paradigm dimension of the four types of innovation: product, process, position and paradigm innovation. Chesbrough (2007) understands business models as a vehicle to commercialise new ideas and technologies. From this perspective, business model innovation captures the value of a technology-driven product or process innovation.

In the same vein, the researchers from the Envision Project (Bouwman et al., 2015) state that product, process, marketing and organisational innovation act as drivers of business model innovation, arguing that business model innovation refers to systemic and observable changes in the business logic itself. They state that "optimizations of processes, introduction of a new channel, or integrating new channels in a channel-mix, improvement of customer experience, or adjusting of pricing according to seasons, although valuable to an SME, are NOT considered to be a BM [business model] Innovation" (Bouwman et al., 2015, p. 9). In this sense, changing the business logic of the firm involves changing from product provider to service provider (servitization), transforming processes from physical to virtual ones, modifying the value chain or moving from pay per product to pay per use (Bouwman et al., 2015; Heikkilä, Bouwman, Heikkilä, Haaker, et al., 2016). From this point of view, product, process, marketing and organisational innovation are necessary for SMEs' competitiveness, yet distinct from business model innovation. Business model innovation revolves around the value creation, delivery and capture mechanisms that reflect the business logic of an SME, while product, process, marketing and organisational innovation can act as precursors of business model innovation.

Some authors have therefore analysed the similarities and differences between product, process and business model innovation (Bucherer et al., 2012; Snihur y Wiklund, 2019). Generally speaking, these contributions suggest that business model innovation enforces organisational restructuring more often than product innovation and requires greater involvement of management (Bucherer et al., 2012). Snihur and Wiklund (2019) argue that product innovation implies changes to a firm's marketing and sales activities, commonly started by the firm's research and development (R&D) department, whereas process innovation requires changes to the firm's production or service routines to streamline operations (upstream/middle in the value chain). Business model innovation, in turn, involves holistic changes to the firm's activity system.

Business model innovation in this thesis

As a result of the review conducted in this subsection, and based on the assumption that a business model *articulates the business logic of value creation, delivery and capture and the architecture linking these dimensions,* in this thesis, business model innovation is defined as follows:

> *Purposeful changes to the value delivery, value creation and value capture dimensions of a firm's business model and/or to the architecture linking them which are new to the firm and result in observable changes in its practices with customers and partners.*

This definition is considered relevant in the context of the present research for several reasons:

- First, it clarifies that *purposeful changes* have to be made to the existing business model for a change to be considered business model innovation, stressing that *managerial action* is required (Bouwman, Nikou, et al., 2018; Bucherer et al., 2012; Foss y Saebi, 2017; Schneider y Spieth, 2013). This implies that a firm initiates a business model innovation process and, as a result, deliberately changes its existing business model.
- Second, changes need to be *observable* to customers and partners, and therefore the definition excludes internal minor changes. Thus, internal improvements, while relevant for SMEs, are not considered business model innovation (Bouwman et al., 2015; Bouwman, Nikou, et al., 2018; Foss y Saebi, 2017).
- Third, as value creation, delivery and capture dimensions are linked within an architecture, *changes in one dimension will probably alter others* and/or the overall architecture of the business model (Bouwman et al., 2015; Bouwman, Nikou, et al., 2018; Foss y Saebi, 2017; Geissdoerfer, Vladimirova y Evans, 2018).
- Fourth, since the main focus of this study is to explore the relevance of business model innovation for SME competitiveness, it is assumed that business model innovation should be *new to the firm* but not necessarily new to the market or the world (Björkdahl y Holmén, 2013; Bock et al., 2010; Bouwman et al., 2015; Bouwman, Nikou, et al., 2018).
- Finally, as noted in the second point, business model innovation involves holistic changes to the firm and is therefore understood as *a new dimension* of innovation. Thus, it may be combined with product, process, marketing and organisational innovation but is distinct from them, presenting larger challenges and requiring greater management involvement (Bohnsack et al., 2014; Bouwman et al., 2015; Bouwman, Nikou, et al., 2018; Bucherer et al., 2012; Snihur y Wiklund, 2019).

2.1.3. Business model innovation in established small and medium-sized enterprises (SMEs)

Business model innovation can be analysed at various levels of abstraction: individual, team, product, business, firm, network or industry (Andreini y Bettinelli, 2017; B Wirtz et al., 2016). In addition, it is subject to organisational, strategic, temporal and environmental conditions (Casadesus-Masanell y Joan Enric Ricart, 2010; Cavalcante et al., 2011; Geissdoerfer, Vladimirova y Evans, 2018; Guo et al., 2018; Pati et al., 2018; Saebi, 2014; Zott y Amit, 2007, 2008). Consequently, the formulation of the business model innovation construct in one specific context may not apply equally in a different one, since it is contingent on contextual conditions (Foss y Saebi, 2018; Suddaby, 2010).

The contingency theory emphasizes that the structure and strategy of a company varies according to its contextual situation (Chandler, 1962). From this view, there is no one optimal strategy for all companies, since strategic choices are altered according to certain factors, known as contingency factors (Donaldson, 1996; Zott and Amit, 2008). In this regard, an organisation does not achieve effectiveness by following a unique and exclusive organisational structure; that is to say, there is no single form of organisational structure that is best suited for achieving organisational goals (Burns y Stalker, 1961; Child, 1975; Lawrence y Lorsch, 1967; Martins y Rialp, 2013). Therefore, firms can be configured in different ways and develop the optimal organisational structures that best fit their environment (Chapman, 1997; Lawrence y Lorsch, 1967), with any given strategic choice not necessarily being equally effective in other conditions (Beliaeva, 2019).

Hence, delineating the contextual circumstances of the business model innovation construct contributes to a better understanding of the phenomenon and is essential for construct clarity before developing any studies (Foss y Saebi, 2018; Suddaby, 2010). This thesis aims to address business model innovation in established Basque SMEs. Thus, business model innovation is explored at the firm level. In addition, some contingent factors relevant in this context – namely, a company's being newly created or established, a firm's structure or size, or the regional environment (Beliaeva et al., 2020) – are considered in analysing and determining the scope conditions of business model innovation within this thesis.

Newly created versus established firms

Prior research suggests the need to differentiate between newly created and established firms when exploring business model innovation, given that they engage in different types of business model innovation (Cavalcante et al., 2011; Cortimiglia et al., 2016; Geissdoerfer, Vladimirova y Evans, 2018; Massa y Tucci, 2014; Schneider y Spieth, 2013).

In the case of start-ups or newly created companies, business model innovation occurs in a setting in which there is no previous business model and a new business model is created (Geissdoerfer et al., 2018). In this context, business model innovation deals with the transition from business ideas to the implementation of a business model and the creation of a new venture (Cavalcante et al., 2011). In the case of established firms, business model innovation takes place in the context of an existing business model which is changed for another one (Geissdoerfer et al., 2018).

With this in mind, various authors distinguish between new *business model design* and existing *business model reconfiguration* or *development* (Cortimiglia et al., 2016; Massa y Tucci, 2014; Schneider y Spieth, 2013). This distinction is relevant, since newly created firms and established firms will address business model innovation following different processes. Although both processes may lead to business model innovation, each requires different capabilities and involves different challenges.

For instance, business model design implies entrepreneurial activity to explore and exploit opportunities (Schneider y Spieth, 2013) and to design and test new business model ideas, activity which is usually conducted along less well-defined paths than it is in established firms (Cortimiglia et al., 2016).

In turn, business model reconfiguration is not limited to the development of new business ideas; instead it requires managers to face a systemic reconfiguration of the firm's existing key human, physical and capital resources and capabilities (Cavalcante et al., 2011; Clauss et al., 2020; Cortimiglia et al., 2016; Hock et al., 2016; Massa y Tucci, 2014; Schneider y Spieth, 2013). Business model reconfiguration implies complicated investment decisions, acquisition or removal of resources and competences, organisational commitment and dealing with possible conflicts between new and old business models (Chesbrough, 2010; Sosna et al., 2010; Velu y Stiles, 2013). Furthermore, business model innovation in established firms requires overcoming certain structural or cognitive challenges (Bohnsack et al., 2014; Cavalcante et al., 2011; Chesbrough, 2010; Chesbrough y Rosenbloom, 2002; Massa y Tucci, 2014). Structural barriers are potential conflicts with existing assets and business models, as the complexity involved in reconfiguring them can create inertia to maintain the status quo (Huang et al., 2013; Massa y Tucci, 2014). Cognitive barriers involve the inability of managers to understand the potential of new business opportunities that do not fit with the current business model (Massa y Tucci, 2014). Managerial actions are affected by path dependencies, existing and past trajectories of the company that limit the propensity to embrace change, especially when those trajectories led to success (Bohnsack et al., 2014; Chesbrough y Rosenbloom, 2002). In addition, the dominant logic of the firm, which is established and rooted in the procedures and principles carried out to date by the company, affect the manner in which managers conceptualise and make decisions about their business model (Cavalcante et al., 2011; Chesbrough, 2010).

In this sense, managers are often reluctant to make radical changes that force them to change their own mental models and logic (Cavalcante et al., 2011; Khanagha et al., 2014). Therefore, unlike in newly created firms or start-ups, which are free from these barriers, in incumbent firms the need to examine the link between business model innovation and the resource-structure-dominant logic of the company becomes critical (Cortimiglia et al., 2016). Thus, dynamic capabilities enabling a firm's agility, flexibility and continuous adaptation, together with managerial commitment, innovative culture and behavioural change, seem to be of paramount importance (Bock et al., 2012; Doz y Kosonen, 2010; Hock et al., 2016; Retegi, 2006; Santos et al., 2009; Voelpel et al., 2004).

In addition to differentiating between new business model design and reconfiguration of an existing business model, some authors further explore the types of business model innovation that can be found in incumbent firms. For example, Geissdoerfer, Vladimirova and Evans (2018) suggest two types: business model diversification (in which the current business model remains and an additional business model is created) and business model acquisition (in which an additional business model is identified, acquired and integrated). Cavalcante, Kesting and Ulhøi (2011) explore the paths towards business model innovation that are based on the business model lifecycle. They suggest that once companies have established their business model, over time the business model will be (1) extended, by adding new processes or improving existing ones; (2) revised, by replacing existing processes with new ones; and finally (3) terminated, by abandoning core processes and closing the company or the business unit.

The structure of the firm

Another relevant aspect that has generated debate among scholars is the way established companies organise business models and how this organisation affects business model innovation. One of the main issues concerns the fact that one company can operate with more than one business model at the same time (Kim et al., 2015; Sabatier V.; Rousselle, T. et al., 2010). Various authors studying business models and business model innovation have addressed this issue, providing different opinions about the management of simultaneous business models and the effect of having multiple business units within an organisation (Aspara et al., 2011; Johnson, 2010, 2019; Snihur y Tarzijan, 2018; Trapp et al., 2018).

Business units represent individual components of an organisation and are characterised by being responsible for one or more product markets, often operated by a single management (Chandler, 1962; Martin y Eisenhardt, 2010). Many established companies operate with more than one business unit, and each of these units may operate with one or more business models (Snihur y Tarzijan, 2018). In this sense, one company can have not so much a single business model but rather a collection of business models.

From the viewpoint of Aspara et al. (2011), a business unit should operate just one business model. Johnson (2010, 2019) thinks the same way, arguing that it is almost impossible for a business unit to adopt and operate with more than one business model at a time while performing well under all models. According to Johnson, when a business model comes to an end, its business unit will also disappear, giving way to the creation of new units with new models. On the contrary, Markides and Oyon (2010) posit that companies can succeed in the market by simultaneously exploiting two business models without separating them into two business units. Similarly, other authors argue that operating a business model portfolio improves the medium-term viability and future development of a company (Kim et al., 2015; Sabatier V.; Rousselle, T. et al., 2010). Furthermore, authors from the Envision Project (Bouwman et al., 2015) state that a firm can have multiple business models and support multiple business logics, depending on the product or service market combinations and market segmentation.

Aware of the these two opposing opinions, Trapp, Voigt and Brem (2018) suggest that there are three main ways to integrate business model innovation in established firms. The first way is to integrate a new business model by creating a new additional business unit and legal entity. This option emphasises that a firm can have more than one business unit, each unit operating with one business model. The second option is to reconfigure the business model of an existing business unit, leading to a new unit with an innovated business model, as suggested by Johnson (2010, 2019). Finally, in line with Markides and Oyon (2010), the third option refers to integrating the new business model within an existing business unit, with the new model adding to the established business model. This implies that the new business model may share activities and functions with the overall organisation or the other business models within the unit. Nonetheless, the unit's revenues and cost structure would be assigned to its business model.

Another contribution that sheds light on the relationship between the number of business units and business models is Snihur and Tarzijan's (2018). They explore the complexity of operating with different business models and business units at different levels. These authors indicate that, while business units are generally based on a specific product market in a particular geographic area, business models reflect how particular products or services are provided through a specific activity system (Zott y Amit, 2010). As shown in Table 5 they propose four possible scenarios, depending on the number of business units and business models within the firm. In general, the authors suggest that large companies may combine multiple business models and multiple business units. Due to their smaller size, however, SMEs are typically placed in the scenario of a single business model and a single business unit.

Table 5 BU- and BM-based organisations.
Adapted from Snihur and Tarzijan (2018)

<table>
<tr><th></th><th></th><th colspan="2">Business Model (BM)</th></tr>
<tr><th></th><th></th><th>Single</th><th>Multiple</th></tr>
<tr><th rowspan="2">Business Unit (BU)</th><th>Multiple</th><td>Single-BM, multiple-BU organisation
Example: BUs organized by country or by product market, exploiting the same BM.</td><td>Multiple-BM, multiple-BU organisation
Example: BUs and BMs can overlap or not. Different product markets with several BMs. Different BMs in different BUs by country.</td></tr>
<tr><th>Single</th><td>Single-BM, single-BU organisation
Example: A firm exploiting one BM in one BU, often the case for small and medium enterprises.</td><td>Multiple-BM, single-BU organisation
Example: Firms organized using the BM logic instead of the BU logic. Exploiting two BMs (equipment and solutions) in the same product market.</td></tr>
</table>

The size of the firm

Several authors have stressed the differences in specific characteristics between SMEs and larger firms (Cosenz y Bivona, 2020; Damanpour, 2010; O'Regan, Ghobadian y Gallear, 2006; Pierre y Fernandez, 2018; Terziovski, 2010). These contributions highlight how certain features usually related to SMEs affect their innovation capacity and value creation processes. These features are as follows:

- Resource scarcity
- Network integration
- Flatter and more flexible structures
- Great potential for innovation
- Reactive to environmental changes and legislative reforms
- Informal and unstructured strategy design and innovation processes
- Manager/owner influence
- High expertise in a small range of products and/or services
- Niche market orientation

Unlike larger firms, SMEs generally have fewer financial resources, limited time, smaller or non-existent R&D facilities, fewer technical capabilities and difficulties in recruiting multidisciplinary skilled employees (Berends et al., 2014; Leithold et al., 2016). This lack of resources makes innovation activities particularly challenging for SMEs. When the resources needed for innovation cannot be developed internally, SMEs need to access them externally. Therefore, network integration capabilities, which allow SMEs to develop partnerships and collaborations, are usually emphasized as a key determinant for both the innovation capability and the survival of SMEs, since they allow them to benefit from external sources of knowledge and resources (Lee, Shin, Park, et al., 2012; Pierre y Fernandez, 2018; Rezazadeh, 2017).

While the strengths of large companies are mainly material – that is, advantages related to economies of scale and the availability of financial and technological resources (Vossen, 1998) – it is often said that SMEs have "behavioural advantages" in terms of flexibility and rapid decision-making (European Commission, 2019). In this respect, past research claimed that SMEs can compensate for resource scarcity by relying on the strengths associated with their size, such as a climate that is more receptive to change, procedures that are less bureaucratic and structures that are more flexible and adaptable (Damanpour, 2010). Their flatter hierarchies facilitate intra-firm communication, the sharing of mental models, the detection of errors and the ability to learning from those errors, enabling SMEs to respond rapidly to both competitors' movements and changing market conditions, promoting SME's innovativeness (Cosenz y Bivona, 2020; García-Morales et al., 2007). The more flexible structures and routines of SMEs allow them to absorb new strategic directions and innovations, facilitating the improvement of current or future strategic capabilities (Aguilar-Fernandez y Ramon Otegi-Olaso, 2018; Widya-Hasuti et al., 2018). In addition, managers are closer to operational levels, and thus decision-making processes are more dynamic, which can speed up the reconfiguration of a business model (Cosenz y Bivona, 2020). However, SMEs have less-structured approaches to innovation, usually reacting to external challenges rather than proactively addressing them (Olazaran et al., 2009). The lack of processes or methods to properly assess the costs of the innovation projects or the time-to-market can hinder innovation management, leading to less efficient innovation activities (Pierre y Fernandez, 2018).

Typically, due to their small size, SMEs have overlap between managers, leaders and owners (Nicholas et al., 2011). Therefore, innovative activity is strongly influenced by the owner-manager (Arbussa et al., 2017; Garcia y Calantone, 2002), while strategy design is often an informal and unstructured process driven by the experience and individual intuition of this person (Cosenz y Bivona, 2020). This accelerates the decision-making process, which in turn tends to be dominated by the owner-manager's traits and personality (Gherardini et al., 2017). Moreover, some authors suggest that innovation activities in SMEs are mainly driven by the owner-manager's vision (O'Regan, Ghobadian y Gallear, 2006; O'Regan, Ghobadian y Sims, 2006). Consequently, an SME's behaviour and culture is usually dominated by these subjective approaches (i.e. personal beliefs, feelings, experiences or common sense), which affect critical decisional processes such as the prioritization of innovation projects (Gherardini et al., 2017).

In addition, SMEs compete mainly based on high levels of expertise, often based on specific technical or handcraft skills. These skills constitute the core competencies of the company and can provide a competitive advantage by affecting critical success factors of a market sector, such as delivery time, product quality or design (Cosenz y Bivona, 2020). Thereby, the strategic priorities and objectives apply mainly to design and production quality, delivery speed, flexibility and openness to include new customer expectations (Cagliano et al., 2001; Cosenz y Bivona, 2020). This specialisation also tends to focus on offering a small range of products or services and on a particular niche market, which makes the firm's revenue streams limited and strongly dependent on those market segments (Child et al., 2017).

Regional environment

This study focuses on established SMEs in Gipuzkoa (Basque Region, Spain). Thus, current environmental dynamics (Saebi, 2014) and regional innovation policies (Alcalde-Heras et al., 2019; Holl y Rama, 2016) are likely to be some of the contingency factors that affect a manager's strategic intentions related to innovation.

Basque SMEs are supported by the Regional innovation system and its innovation policies that promote R&D corporate activities, clusters, and private technology centres, which address regional companies' needs, especially those of SMEs (Alcalde-Heras et al., 2019; Holl y Rama, 2016; Sanz-Menéndez y Cruz-Castro, 2005). This ecosystem of innovation is characterised by the development of high-tech industries (González-Bravo et al., 2018). In recent years, innovation policies have focused on great challenges such as Industry 4.0, digital transformation and sustainability as main strategic priorities for maintaining Basque firms' competitiveness, and these strategic priorities affect business model innovation (Orkestra, 2019).

As a result, the Regional Innovation Scoreboard (Hollanders et al., 2019) indicates that the Basque Region has improved its performance in innovation over the last 8 years (79.8% higher than the EU-28 average improvement), being one of the regions with the highest levels of innovation in Spain. According to the Basque Institute of Statistics (Eustat, 2019), the scores for SMEs in product or process innovations, SMEs innovating in-house, and sales of new-to-market and new-to-firm innovations by SMEs, are higher in the Basque Region than in the EU-28.

Nonetheless, although statistics show that Basque SMEs are relative strong in technological innovation – that is, product and process (Hollanders et al., 2019) – non-technological innovation (marketing and organisational innovation) is a critical area for improvement. Furthermore, the combination of the two types of innovation is weak. Thus, despite the relevance business model innovation is acquiring in the new competitive landscape, SMEs' innovation efforts seem to be geared foremost to product and process innovation and to a lesser extent to other forms of innovation that could include business model innovation. Nevertheless, this assumption is hard to verify since to date business model innovation is not measured by the Regional Innovation Scoreboard, which measures other forms of innovation (product, process, marketing and organisational innovation).

In addition, the regional environment may affect business model innovation in Basque SMEs, since they face an environment of uncertainty that may be constraining their approach to innovation. The results in the latest report submitted by Orkestra (2019) on the competitiveness of the Basque Region highlight that the internal circumstances of Basque companies, such as financial restructuring, along with external challenges (e.g. international commerce policies, digitalisation, ageing or climate change) are accentuating the environmental uncertainties faced by Basque SMEs. Furthermore, a certain aversion to risk can be observed, with companies adopting a conservative profile in their financial strategy and type of innovation (Orkestra, 2019).

Summary

As has been explained, four main aspects (i.e. newly created versus established firm, the structure of the firm, the size of the firm and the regional environment) allow to delineate the scope of the business model innovation construct in the context of this research. Thus, to explore business model innovation, certain key issues need to be considered:

- Business model innovation requires the reconfiguration of an existing business model, which implies a series of management decisions regarding investments, resources, and capabilities that can be affected by the dominant logic of the company and, especially in the case of SMEs, by the mental models of managers (Arbussa et al., 2017). Emphasis should be place on the managerial, behavioural and organisational elements that enable SMEs to reconfigure their existing business model while overcoming related barriers (Bock et al., 2012; Cavalcante et al., 2011; Chesbrough, 2010; Doz y Kosonen, 2010; Massa y Tucci, 2014; Voelpel et al., 2004).

- How SMEs integrate new business models into their structures seems to be an important issue that can affect business model innovation. The review shows that, although opinions on the subject are mixed, most SMEs may operate with one business unit and a single business model only because their limited size and resources prevent them from successfully deploying two business models at the same time (Aspara et al., 2011; Johnson, 2010, 2019; Snihur y Tarzijan, 2018).
- Moreover, SMEs' specific attributes, such as resource scarcity, flexibility and their manager's influence, are considered to both hinder and foster an SME's innovation capabilities and could affect business model innovation (Arbussa et al., 2017; Berends et al., 2014; Child et al., 2017; Cosenz y Bivona, 2020; Pierre y Fernandez, 2018).
- In addition, the Region's environmental contingencies, such as the innovation approach and current competitive uncertainties, could alter the innovation focus and efforts of Basque SMEs, causing them to follow different paths towards business model innovation.

2.1.4. Business model innovation frameworks

Having defined and explored business model innovation in the context of established SMEs, this section now discusses the main frameworks identified in the literature and academic research. Frameworks enable an understanding of the structure and relationship between elements within a system, in this case business model innovation (Shehabuddeen et al., 1999). This subsection presents the frameworks identified during the review, and discusses relevant factors related to business model innovation and possible relationships among them.

In Mahadevan's (2004) framework (Figure 6), business model innovation is presented as a repetitive process forced by the diffusion of innovation over time. Building on the Schumpeterian view of innovation-driven competition, the author suggests that the business model innovation cycle in established firms is driven by contextual factors (i.e. technology, competition, customer needs or regulatory and economic issues). Homogeneity among business models lead to a reduction in value for companies, forcing them to seek new opportunities. Reconfiguring business models creates a disequilibrium in the environment that makes customers perceive the added value. Choices made to innovate business model components (i.e. target customers, value proposition and value delivery system) will enable a competitive advantage to be sustained over time, allowing the company to routinize business model innovation. However, competitive advantage will not last forever, and the context will once again force a new cycle of innovation.

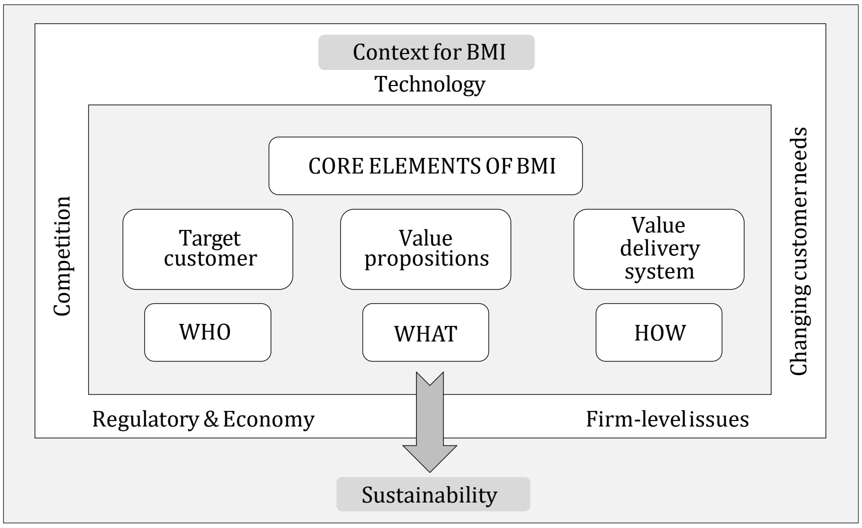

Figure 6 A framework for business model innovation.
Adapted from Mahadevan (2004)

The next framework, displayed in Figure 7, was developed by Voelpel et al. (2004), who also stress the influence of environmental dynamics on incumbent firms but adopt a different approach, focusing on the internal capabilities of the firm.

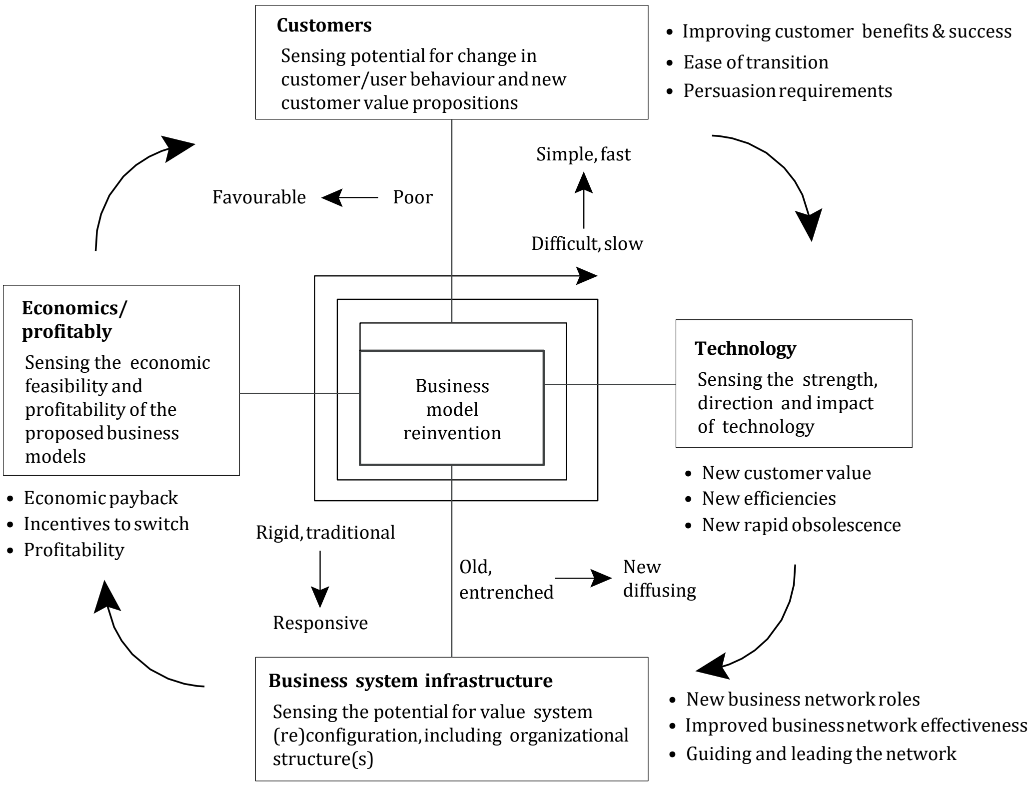

Figure 7 The wheel of business model reinvention.
Adapted from Voelpel et al. (2004)

The framework is represented as a wheel to illustrate the systemic flow among the four pillars enabling business model reinvention: customer sensing, technology sensing, business system infrastructure sensing, and economic or profitability sensing capabilities. The main premise is that established firms which are continuously making sense of environmental dynamics and opportunity gaps are more likely to reconfigure their value proposition, value chain and value networks. The proposed framework favours the fit between a business model and a fast-changing environment, and consequently the way firms can achieve a sustainable competitive advantage.

In line with Voelpel et al. (2004) on the relevance of internal capabilities in adapting to the external environment, various authors propose frameworks based on the dynamic capabilities view theory to address business model innovation. The dynamic capabilities view stresses the increasingly short-lived nature of any competitive advantage in a changing, dynamic and turbulent environment (Schneider y Spieth, 2013), postulating that a firm's competitive advantage resides in its ability to alter its resource base to continuously adapt to change (Breznik y D. Hisrich, 2014).

According to Teece et al. (1997), the precursors of this theory, dynamic capabilities reflect "the firm's ability to integrate, build and reconfigure internal and external competences to address rapidly changing environments" (Teece et al., 1997, p. 516). Teece (2007) later developed a framework disaggregating the dynamic capabilities in three dimensions: sensing, seizing and reconfiguring capabilities. *Sensing capability* is the ability to recognise changes and detect opportunities and threats. *Seizing capability* is the ability to act on identified opportunities and capture value from them. Finally, *reconfiguring capabilities* relate to the orchestration and renewal of the company's resources and competencies. These three main dimensions are underpinned by a set of microfoundations in the form of different skills, processes, procedures, organisational structures, decision rules and disciplines.

Teece (2017) recently integrated the business model concept in his dynamic capabilities framework (Figure 8), arguing that business model innovation is enabled by the dynamic capabilities of the firm.

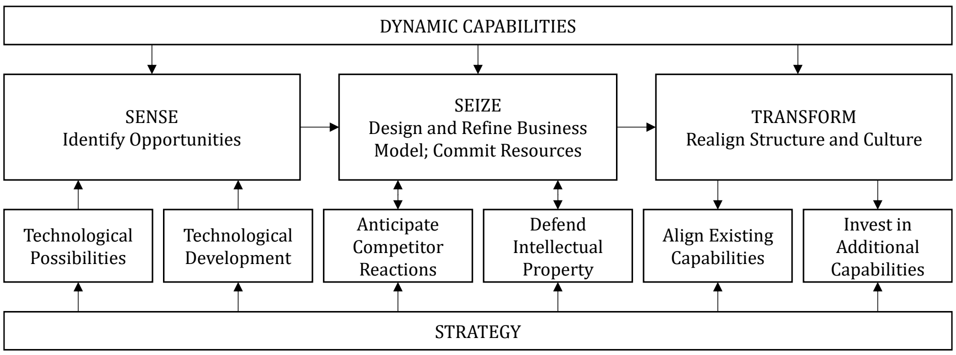

Figure 8 Dynamic capabilities, business models and strategy.
Adapted from Teece (2017)

In a procedural sequence of three steps (sense, seize and transform), management first needs to sense customers with unmet needs, sense technological options and be familiar with different business models to identify business model innovation opportunities. To seize these opportunities, a firm needs to redesign and refine the existing business model, committing the necessary resources for that purpose. Consequently, the organisational structure and culture need to be realigned so organisational transformation can be achieved.

Additionally, various scholars have adapted the dynamic capabilities framework (Teece, 2007) to explore how sensing, seizing and reconfiguring capabilities relate to business model innovation (Čirjevskis, 2019; Inigo et al., 2017; Mezger, 2014; Vicente et al., 2018).

As illustrated in Figure 9, Mezger (2014) conceptualises business model innovation as a distinct dynamic capability that can be disaggregated into three core dimensions: (1) capabilities for identifying an opportunity for a new business model, (2) capabilities for designing a new business model to address such an opportunity, and (3) capabilities for implementing the new business model.

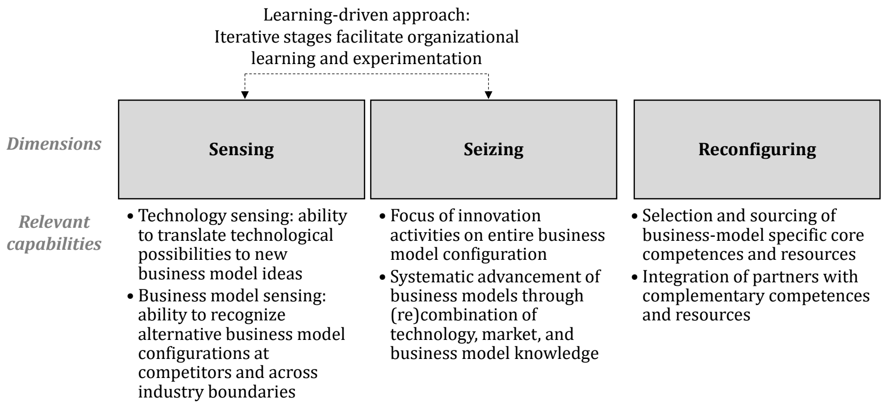

Figure 9 A capability-based conceptualisation of business model innovation. Adapted from Mezger (2014)

The framework is based on the findings of six cases studies in the publishing industry of firms that were affected by technological changes, and is thus oriented towards a technological approach. Mezger (2014) highlights as sensing capability the ability to translate technological possibilities into new business model ideas and recognize alternative business models used by competitors or across industry boundaries. Seizing capability entails deploying market, technology and business model knowledge to develop and test new business model configurations. Reconfiguring capability involves building new competences, integrating partners with complementary competences and resources, and implementing organisational renewal. Moreover, as represented in Figure 9, "systematic business model innovation is an iterative cycle between idea generation (sensing), development and testing, and testing of new business model configurations (both seizing)" (Mezger, 2014, p. 13), that fosters organisational learning and experimentation (McGrath, 2010; Sosna et al., 2010).

Figure 10 shows the framework developed by Inigo et al. (2017), who examine the organisational processes of business model innovation for sustainability in established Basque companies. In general, they find that companies sensing capabilities opt for networking with stakeholders, anticipating and proactively identifying environmental challenges, while looking into new technologies. Seizing capabilities implies integrating new technologies, methodologies and partners and co-creating with customers. Reconfiguring abilities, in turn, involve distributing knowledge management, managing collective decision-making and governance, promoting innovation teams and even generating spin-offs. Moreover, they find that depending on the approach to business model innovation (i.e. introduction of incremental changes or implementation of disruptive changes), companies develop different sense, seize and reconfiguration capabilities.

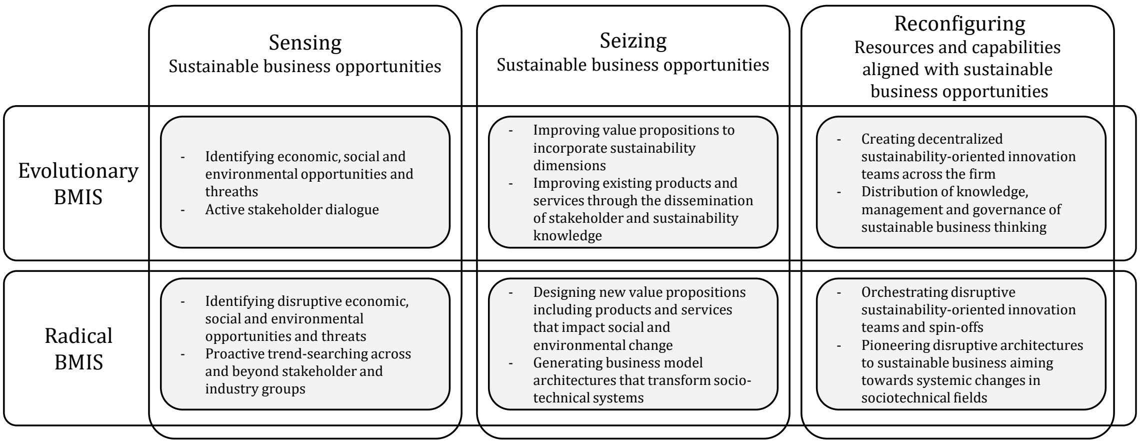

Figure 10 Business model innovation for sustainability.
Adapted from Inigo et al. (2017)

Based on four cases studies of SMEs in the IT sector, Vicente et al. (2018) developed the framework shown in Figure 11. They highlight the managers' experience along with developing market knowledge and gaining information from customer needs as key sensing capabilities. Seizing capabilities are reflected in a manager's ability to manage resources, search for information and create trusted relationships among personnel. Finally, as reconfiguring capabilities they emphasize the relevance of involving external agents in innovation processes and investing in information sharing with partnerships. In brief, they found that companies that developed higher levels of dynamic capabilities (i.e. sensing, seizing and reconfiguring capabilities) changed their business model in a more efficient way than firms that did not develop them.

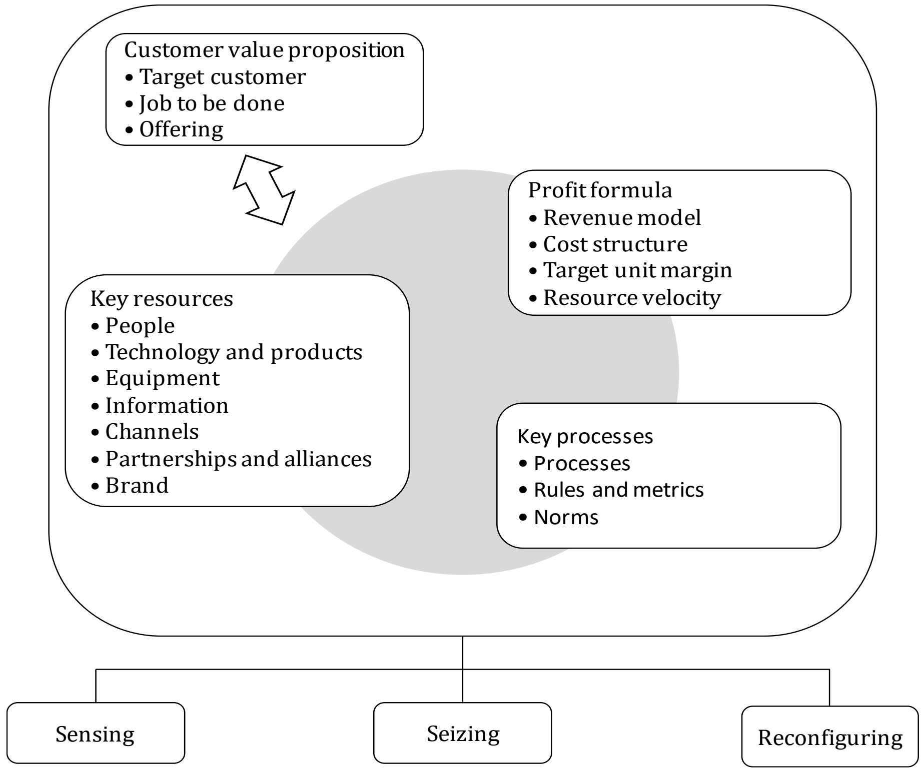

Figure 11 Dynamic capabilities in the development of business model innovation. Adapted from Vicente et al. (2018)

The last adaptation of Teece's framework found during the review is the one proposed by Čirjevskis (2019), who explores the influence of dynamic capabilities on business model innovation in mergers and acquisitions of technology-advanced firms.

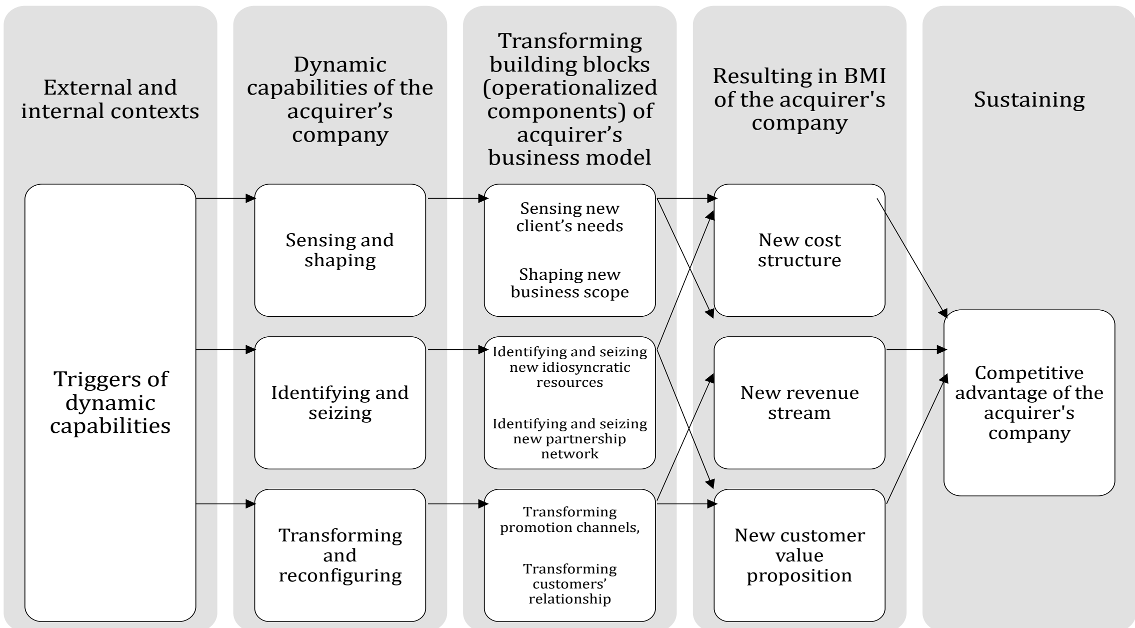

Figure 12 Dynamic capabilities as drivers of business model innovation (BMI). Adapted from Čirjevskis (2019)

As shown in Figure 12 this framework differs from those mentioned above (Figure 8, Figure 9, Figure 10 and Figure 11), presenting a sequence of conditions that go from triggers of dynamic capabilities (left) to a firm's competitive advantage (right). In discussing dynamic capabilities driving business model innovation, Čirjevskis (2019) suggests the following key capabilities: sensing new customer segments, new business scopes and new activities; seizing new resources and partnerships; and reconfiguring customer relationships and promoting new channels. Moreover, the author shows that the intersection of sensing, seizing and transforming capabilities can result in the generation of new value propositions, efficient cost structures and new revenue streams, thereby having a positive effect on both business model innovation and competitive advantage.

Teece's understanding of dynamic capabilities has been widely disseminated in the literature, with several authors developing their own interpretation and approaches on dynamic capabilities (Barreto, 2010; Schilke et al., 2018; Zahra et al., 2006). Furthermore, the dynamic capabilities concept is considered abstract by some authors, who state that it is not clear what dynamic capabilities really are nor how they can be conceptualised and measured (Achtenhagen et al., 2013; Danneels, 2008; Roaldsen, 2014; Schilke et al., 2018). Thus, some authors build their own approach when developing business model innovation frameworks based on the dynamic capabilities view.

In one such example, Achtenhagen et al. (2013) suggest the framework displayed in Figure 13. This framework, based on the findings from a research program on continuously growing firms, suggests that SMEs require three critical capabilities to successfully innovate their business model and achieve sustained value creation: (1) creating, identifying, experimenting with and exploiting new business opportunities; (2) using resources in a balanced way; and (3) achieving coherence between active leadership, culture and employee commitment. Activities related to the first critical capability include gaining relevant information about technological developments, markets and competitors; monitoring changes; providing freedom for and encouraging the exploration of new ideas; and accepting mistakes and encouraging learning from them. Activities for using resources and capabilities in a balanced way relate to choosing how to allocate resources, ensuring a steady cash flow, reinvesting profits, cooperating with partners, investing in R&D, developing new products and improving the brand's full potential through various marketing approaches. Activities focused on achieving coherence between active leadership, culture and employee commitment imply showing loyalty and commitment to employees, exerting a visible leadership style, fostering employee motivation, encouraging the search for innovative ideas and creating an open communication climate. These critical capabilities combine with an SME's strategizing actions to change the established business model to sustained value creation.

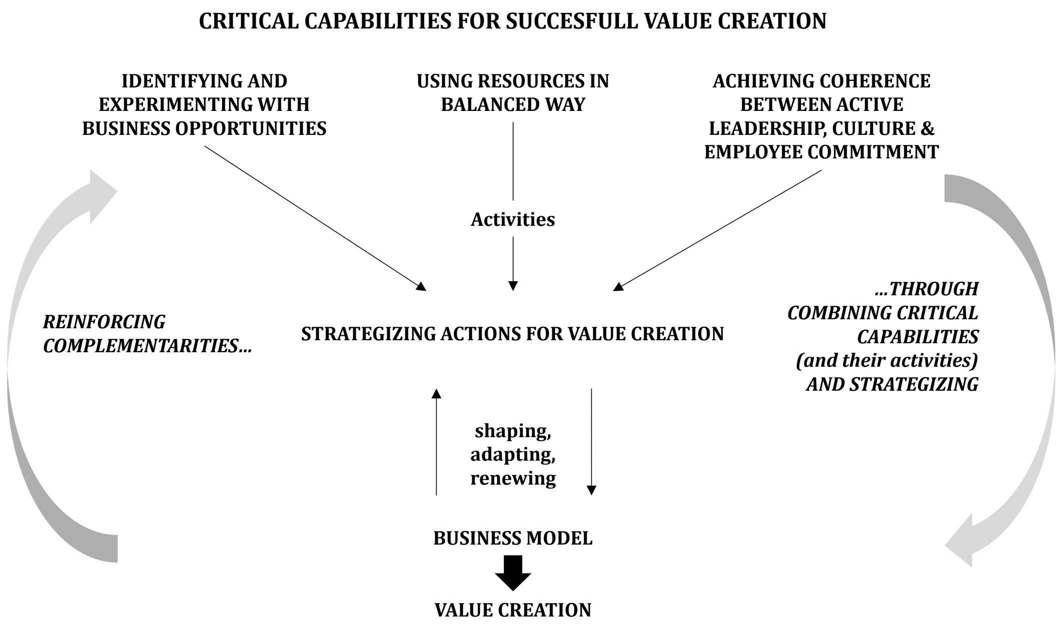

Figure 13 An integrative framework for achieving business model change.
Adapted from Achtenhagen et al. (2013)

Following a different approach, Cavalcante (2014) explored through four case studies the effects of managers' initiatives on business model innovation in the context of an emergent technology. Based on the findings, he suggests a process-based framework of business model change with two main stages: a pre-stage and the business model change stage (Figure 14).

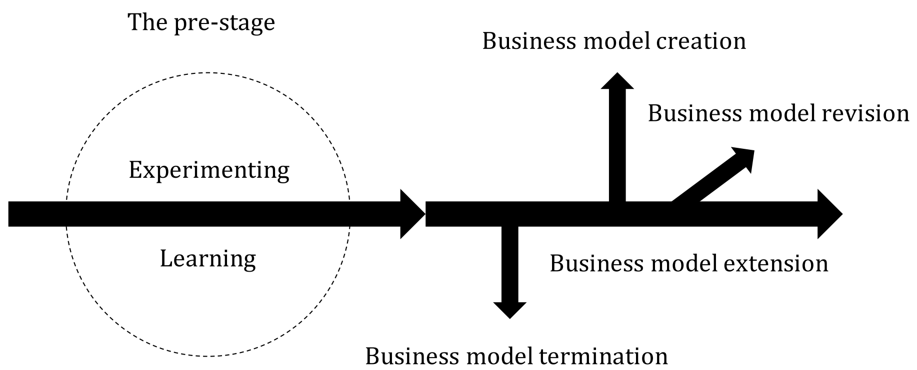

Figure 14 Business model innovation pre-stage.
Adapted from Cavalcante (2014)

Understanding organisational processes as key mechanisms for change and viewing dynamic capabilities as a set of organisational processes designed to create value for firms (Eisenhardt y Martin, 2000), the pre-stage of the framework illustrates experimenting and learning as key capabilities that will enable a manager's initiatives to succeed in the face of challenges, resulting in potential business model changes. Thus, continuous experimentation (researching technical challenges, giving demonstrations, making prototypes and engaging in new practices) and learning (acquiring new knowledge, discussing new ideas and networking with partners) foster a firm's abilities to successfully implement business model innovation in the long term. Moreover, this approach is in line with that of Mezger (2014), who also suggests that sensing and seizing capabilities facilitate organisational learning and experimentation (Figure 9).

In the last of the frameworks that are based on the dynamic capabilities view, Ricciardi et al. (2016) propose a framework focused on organisational dynamisms to achieve business model innovation in turbulent environments. As presented in Figure 15, organisational dynamism comprises three pairs of ambidexterity- or vacillation-based paradoxical management phenomena (engagement in exploitation-exploration, cooperation-competition and institutional conformity-agency) and resilient dynamic capabilities.

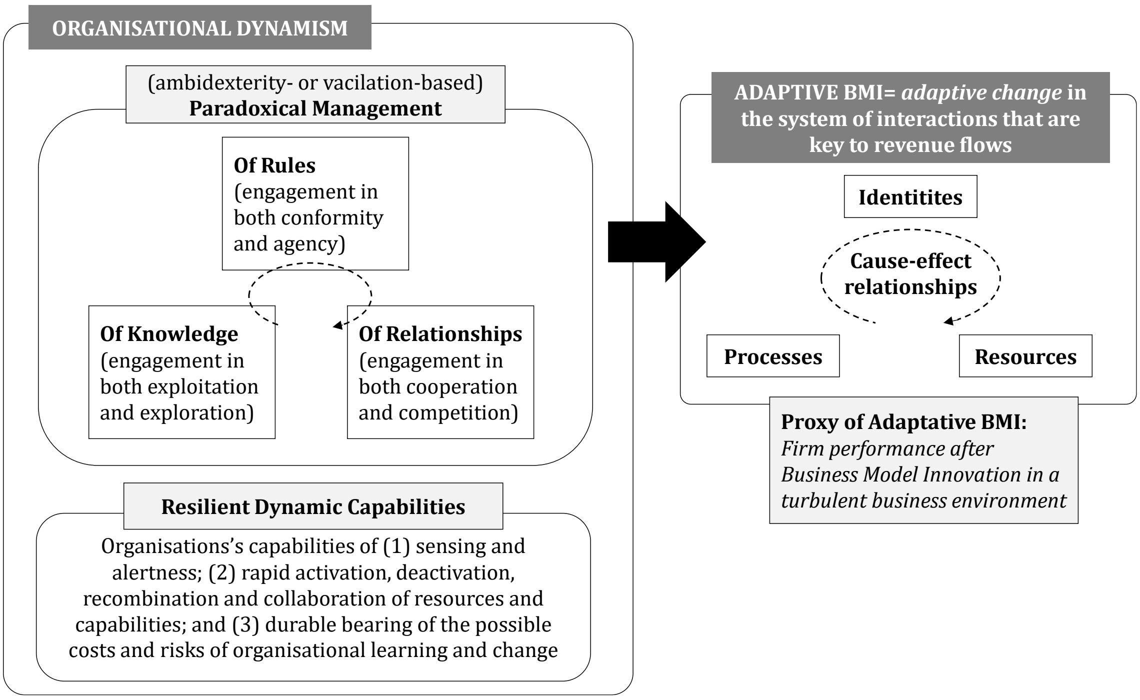

Figure 15 Organisational dynamism enables adaptive business model innovation (BMI). Adapted from Ricciardi et al. (2016)

The resilient dynamic capabilities are the firm's resources and capabilities that (1) enable sensing and alertness; (2) allow rapid reconfiguration of and collaboration around practices, resources and capabilities; and (3) support change, trial and error and improvisation by controlling the related costs and risks. Based on qualitative comparative analysis of data from 35 Italian SMEs, Ricciardi et al. (2016) found that SMEs with high resilient dynamic capabilities displayed high levels of adaptive business model innovation, while SMEs with lower resilient dynamic capabilities did not. In addition, resilient dynamic capabilities combine with the paradoxical dimensions suggested in the framework, which, although logically opposed, strongly intertwine in enabling adaptive business model innovation. Collaborative business networking emerges as a key management practice for adaptive business model innovation in all the cases explored.

Moving on to a broader approach to business model innovation, Figure 16 presents the framework developed by Halecker, Bickmann and Hölzle (2014). The authors, based on a theoretical review and multiple case studies, explored the causes that lead to the success or failure of business model innovation in established firms. In learning from failure, they identified thirteen potential business model innovation drivers, divided into factual and social dimensions. The factual dimension is characterized by its application orientation, while the social dimension refers to characteristics, capabilities, interpersonal dependencies or networks at the individual or team level. This framework includes some drivers not addressed in previous frameworks, such as innovation strategy, innovation culture and innovation process. Their inclusion provides a new angle for exploring the role of organisational factors fostering business model innovation beyond the external factors and firm capabilities mentioned in the previous frameworks.

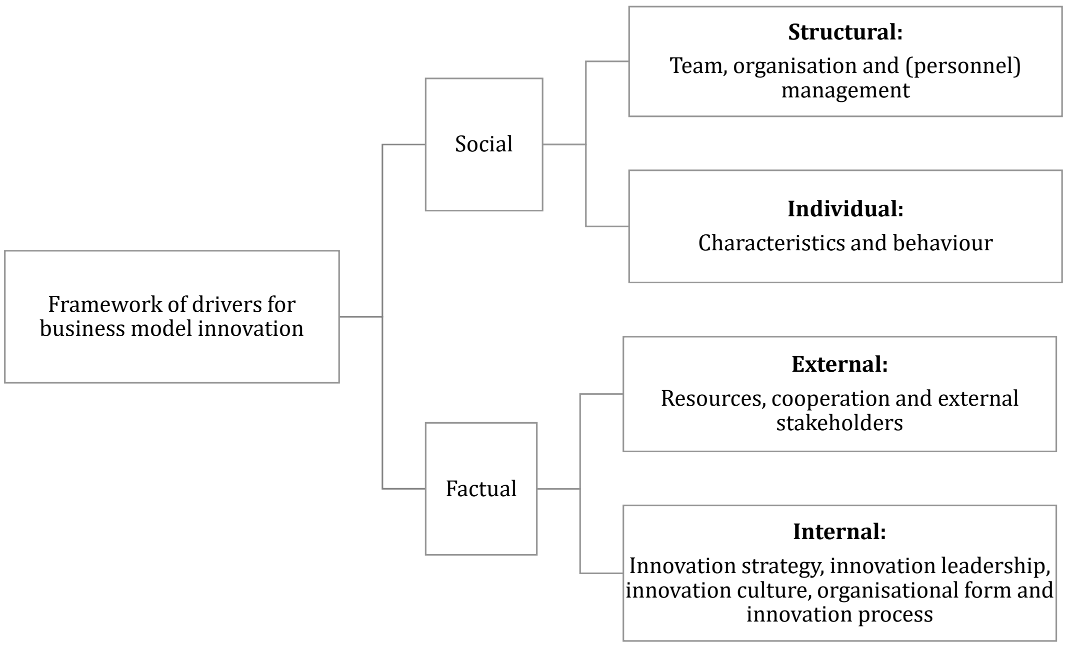

Figure 16 Framework of drivers for business model innovation.
Adapted from Halecker, Bickmann and Hölzle (2014)

Finally, the framework developed by Wirtz and Daiser (2017) is one of the few integrative frameworks found in the review (Figure 17) that unifies different perspectives from previous approaches (Giesen, J. Berman, et al., 2007; Mahadevan, 2004; Malhotra, 2000; Voelpel et al., 2004; Yang et al., 2014). The framework brings together several factors commonly treated separately, such as environmental dimensions, business model innovation dimensions, techniques and tools, knowledge management and sense-making, business model innovation intensity and business model innovation results. Broadly speaking, Wirtz and Daiser (2017) put special emphasis on the "knowledge management and sense-making" and "techniques and tools" dimensions, which they contend have been underexplored in prior business model innovation frameworks. With this in mind, the authors highlight the importance of having the relevant knowledge about internal and external factors and the required skills to sense and identify business model opportunities and change drivers. Furthermore, they suggest that the "knowledge management and sense-making" and "techniques and tools" dimensions represent the interface between environmental factors and the central dimensions of business model innovation. Thus, they link in some way the approaches of Mahadevan (2004) and Voelpel et al. (2004) (Figure 6 and Figure 7). In addition, Wirtz and Daiser's (2017) framework includes four business model innovation outcomes: the degree of novelty of the business model innovation (moderate or radical), business model innovation sustainability, competitive advantage, and value creation and capture. Compared to frameworks analysed previously, this approach provides a more holistic view of critical aspects of business model innovation.

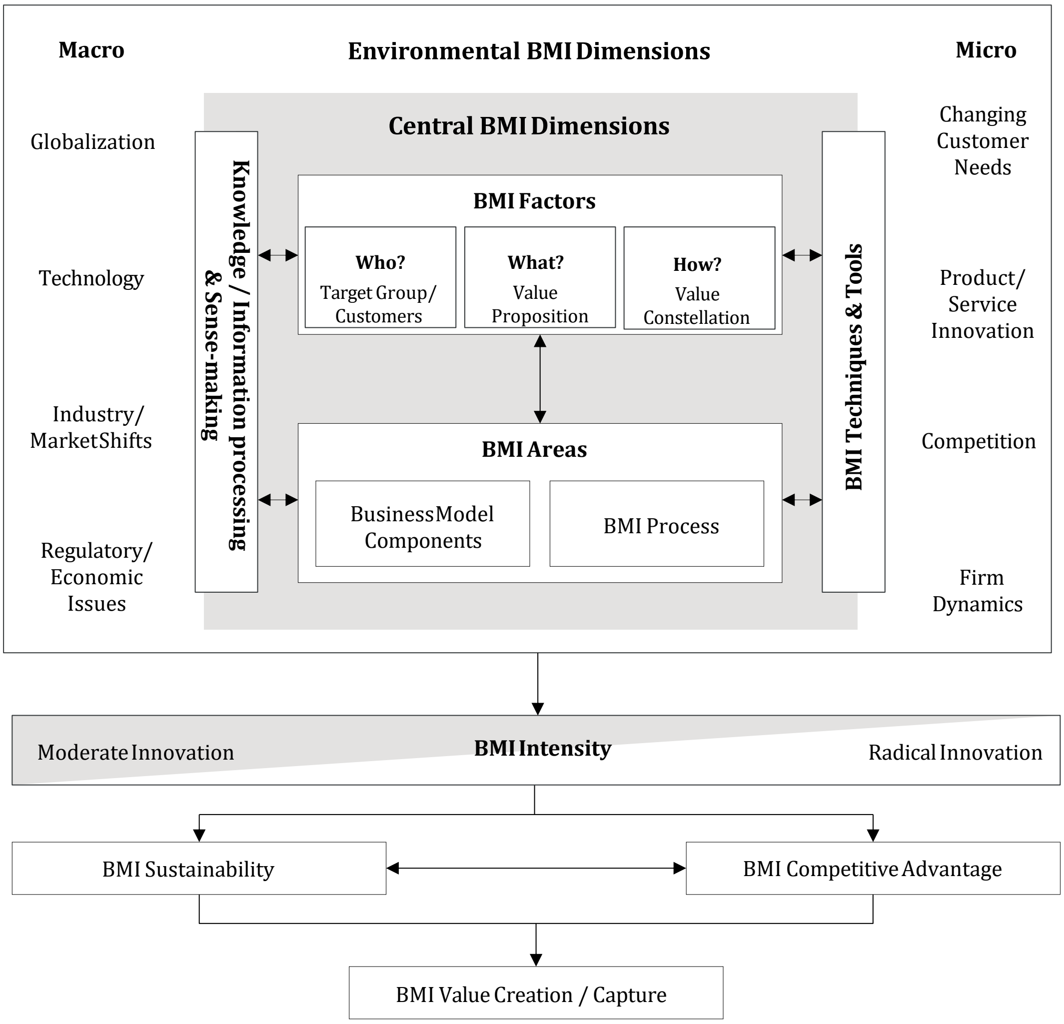

Figure 17 The integrative business model innovation (BMI) framework. Adapted from Wirtz and Daiser (2017)

As discussed, various approaches have been considered for frameworks to explain business model innovation. Some frameworks put the emphasis on the role of external factors driving business model innovation (Figure 6), while others focus on a firm's internal capabilities (Figure 7,Figure 8, Figure 9, Figure 10, Figure 11 and Figure 14). Several frameworks represent business model innovation as a set of dynamic capabilities related through a procedural approach – that is, sense, seize and reconfigure (Figure 8, Figure 9, Figure 10 and Figure 11) – some of them highlighting organisational learning and experimentation (Figure 9 and Figure 14) as the basis of this process. Other frameworks represent dynamic capabilities as antecedents of business model innovation (Figure 12, Figure 13 and Figure 15). Moreover, various frameworks provide a more integrative approach (Figure 16 and Figure 17), including business model innovation drivers at different abstraction levels (firm or individual) and those comprising external and internal drivers within the same framework. In this vein, the framework developed by Wirtz and Daiser (2017) seems to be the most integrative one (Figure 17), since it also involves business model innovation outcomes. To summarise these thoughts, Table 6 highlights by category the main factors identified within the analysed frameworks.

Table 6 Main factors identified in business model innovation frameworks

Categories	Main factors	References
External factors	Business environment	Mahadevan (2004), Wirtz and Daiser (2017)
Dynamic capabilities	Sensing capabilities	Voelpel et al. (2004), Achtenhagen et al. (2013), Cavalcante (2014), Mezger (2014), Ricciardi et al. (2016), Inigo et al. (2017), Teece (2017), Vicente et al. (2018), Čirjevskis (2019), Wirtz and Daiser (2017)
	Seizing, experimenting and learning capabilities	Achtenhagen et al. (2013), Cavalcante (2014), Mezger (2014), Ricciardi et al. (2016), Inigo et al. (2017), Teece (2017), Vicente et al. (2018), Čirjevskis (2019)
	Collaborating with external partners	Achtenhagen et al. (2013), Cavalcante (2014), Halecker et al. (2014), Mezger (2014), Ricciardi et al. (2016), Inigo et al. (2017), Vicente et al. (2018)
	Reconfiguring capabilities: competencies and resources	Achtenhagen et al. (2013), Mezger (2014), Inigo et al. (2017), Teece (2017), Vicente et al. (2018), Čirjevskis (2019)
	Managing commitment, leadership and culture	Achtenhagen et al. (2013), Halecker et al. (2014), Inigo et al. (2017), Teece (2017), Vicente et al. (2018)
Organisational factors	Managing organisational ambidexterity	Ricciardi et al. (2016)
	Innovation strategy	Halecker et al. (2014)
	Innovation culture	Halecker et al. (2014)
	Organisational structure	Halecker et al. (2014)
Business model innovation process	Process	Halecker et al. (2014), Wirtz and Daiser (2017)
	Tools and techniques	Halecker et al. (2014), Wirtz and Daiser (2017)
Individuals-teams	Characteristics/behaviours	Halecker et al. (2014)
Outcomes	Sustainability/competitive advantage	Wirtz and Daiser (2017)
	Innovation intensity	Wirtz and Daiser (2017)
	Value creation/capture	Wirtz and Daiser (2017)

All in all, the frameworks reviewed suggest that business model innovation is driven by both external and internal factors. In addition, the drivers differ in nature (i.e. resources, capabilities and behaviours) and might be placed at different levels (i.e. network, firm, team or individual; see Table 6). As can be seen in the table, the categories organisational factors, business model innovation process, individuals/teams and business model innovation outcomes are missing in most of the frameworks explored.

Several of the frameworks are based on the dynamic capabilities view theory (Achtenhagen et al., 2013; Cavalcante, 2014; Čirjevskis, 2019; Inigo et al., 2017; Mezger, 2014; Ricciardi et al., 2016; Teece, 2017; Vicente et al., 2018), a theory which suggests that the deployment of certain internal capabilities can help established firms adapt their existing business models to meet environmental challenges. While the approach details differ from one author to another, most of the frameworks encompass the firm's ability to detect market, technological and new business model opportunities and threats (Achtenhagen et al., 2013; Cavalcante, 2014; Čirjevskis, 2019; Inigo et al., 2017; Mezger, 2014; Ricciardi et al., 2016; Teece, 2017; Vicente et al., 2018; Voelpel et al., 2004). Additionally, the ability to deploy, seize and exploit new knowledge is also stressed in various frameworks, highlighting continuous learning and experimentation as key capabilities (Achtenhagen et al., 2013; Cavalcante, 2014; Čirjevskis, 2019; Inigo et al., 2017; Mezger, 2014; Ricciardi et al., 2016; Teece, 2017; Vicente et al., 2018). In addition, managing and integrating existent or new resources and the need for collaboration and partnerships are often mentioned (Achtenhagen et al., 2013; Cavalcante, 2014; Halecker et al., 2014; Inigo et al., 2017; Mezger, 2014; Ricciardi et al., 2016; Vicente et al., 2018). Moreover, issues related to reconfiguring resources and capabilities (Achtenhagen et al., 2013; Mezger, 2014; Teece, 2017) and managing commitment, leadership and culture (Achtenhagen et al., 2013; Halecker et al., 2014; Inigo et al., 2017; Teece, 2017) are also included. Other factors such as innovation strategy, innovation culture, organisational form (Halecker et al., 2014), and the relevance of business model innovation process and related tools and techniques (Halecker et al., 2014; Wirtz y Daiser, 2017) are also mentioned.

As for business model innovation outcomes, although a firm's sustainable competitive advantage is stressed by various authors (Mahadevan, 2004; Voelpel et al., 2004; Wirtz y Daiser, 2017), only Wirtz and Daiser's (2017) framework illustrate it (Figure 17), together with business model innovation intensity and value creation/capture, which refers to a firm's returns.

2.1.5. Business model innovation research models

Having defined business model innovation and studied the main frameworks found in the literature, this section now addresses research models relevant to this thesis. While frameworks enable an understanding of the structure of a system such as business model innovation, research models support the comprehension of the dynamic interactions, such as causal relationships, between the elements of the system (Shehabuddeen et al., 1999). Therefore, reviewed research models are discussed in this subsection as a means to explore how business model innovation relates to its antecedents and outcomes. Using research models, relevant factors can be analysed and possible causal relationships among those factors can be identified.

The research models discussed below provide a view of the diversity of research problems and explanatory functions associated with the business model innovation construct. For example, some authors propose simple models in which business model innovation is defined as an antecedent (independent variable) linked to organisational results (Table 7). Among these research models, some include additional variables as moderators or mediators in the relationship between business model innovation and its performance (Brettel et al., 2012; Pati et al., 2018).

Table 7 Business model innovation (BMI) as an antecedent

Reference	Research focus	Outcomes
Brettel et al. (2012)	The performance effects of efficiency-centred and novelty-centred business model design in entrepreneurial firms and the moderating role of organisational life-cycle stage and investment	- Firm performance* ** Organisational life-cycle stage and investment moderate the relationship between BMI and performance*
Anwar (2018)	The importance of BMI in SME performance and the mediating role of competitive advantage	- Firm performance - Competitive advantage
Pati et al. (2018)	The performance effects of efficiency-centred and novelty-centred business model design in SMEs and the moderating role of firm age and environmental dynamism/munificence	- Performance* ** Firm age and environmental dynamism/munificence moderate the relationship between BMI and performance*
Bouwman et al. (2019)	[Envision Project] BMI practices improving the performance of digitalising SMEs	- Firm performance - Innovativeness

Other authors, mainly focused on exploring what drives business model innovation, define business model innovation as an outcome (dependent variable) and develop their research models to explore the effects that certain factors have on it (Table 8).

Table 8 Business model innovation (BMI) as an outcome

Reference	Research focus	Antecedents
Torkkeli et al. (2015)	The effect of the decision-making logics on BMI in SMEs	- Causation - Effectuation(experimentation and organisational flexibility)
Hock et al. (2016)	The impact of organisational culture on firm's BMI capabilities	- Capabilities for BMI - Cultural values as antecedents of BMI
(Liu et al., 2017)	BMI drivers in the context of a technological shift	- Entrepreneurial cognition (attitude to technology innovation)* - Business environment ** Entrepreneurial cognition moderates the relationship between business environment and BMI*
Anwar et al. (2019)	Manager's personality and BMI in SMEs	- Extroversion - Agreeableness - Conscientiousness - Openness to experience - Neuroticism
Kiani, Ahmad and Gillani (2019)	Service innovation capabilities as the precursor to BMI	- Service innovation capabilities - Service innovation success* * *Service innovation success mediates between innovation capabilities and BMI* * *Knowledge management practices moderate the relationships*
S. Liao et al. (2019)	Relationships and configurational paths of open innovation and organisational agility to BMI in SMEs	- Strategic resource (open innovation) - Dynamic capabilities (organisational agility) - Combinations of open innovation and organisational agility
Hock-Doepgen et al. (2020)	Knowledge management capabilities leading to BMI	- Internal knowledge management capabilities - External knowledge management capabilities - Combinations of knowledge management capabilities ** Organisational risk-taking tolerance moderates the relationship between knowledge management capabilities and BMI*

Again, in some models moderation and mediation relationships are suggested between business model innovation and its drivers (Hock-Doepgen et al., 2020; Kiani et al., 2019; Liu et al., 2017). Moreover, some authors approached business model innovation antecedents as both independent and combined factors leading to business model innovation (Hock-Doepgen et al., 2020; Liao et al., 2019).

A third approach addresses business model innovation in relation to both its antecedents and its outcomes within the same research model. Thus, business model innovation has a dual relationship, as both independent and dependent variable in the sequence of variables that compose the model (Hair et al., 2016). It is independent because it predicts certain outcomes, yet at the same time it is dependent, as it is predicted by antecedent variables. Thus, this approach provides a more integrated view of the causal relationships among business model innovation, its antecedents and outcomes (Table 9).

Table 9 Business model innovation (BMI) as an intermediate variable

Reference	Research focus	Antecedents	Outcomes
Huang et al. (2013)	How open innovation can be effective in changing organisational inertia to create BMI and improve firm performance	- Organisational inertia - Open innovation* * *Open innovation mediates between organisational inertia and both firm performance and BMI*	- Firm performance
Bouwman et al. (2015)	Envision Project: Understanding BMI in European SMEs	- External drivers - Internal drivers	- Innovativeness - Firm performance
Foss and Saebi (2017)	Conceptual research model for future BMI research	- External drivers - Internal drivers * *A set of macro-, firm- and micro-level moderators influence the relationship between antecedents and outcomes with BMI*	- Financial performance - Innovativeness - Cost reduction
Bashir and Verma (2018)	Conceptual model of internal factors and consequences of BMI	- Organisational structure - Organisational culture - Organisational inertia - Leadership - Technology	- Strategic flexibility - Firm competitiveness - Competitive advantage
Pedersen et al. (2018)	Explore the relationship between BMI, corporate sustainability and organisational values in fashion SMEs	- Organisational values	- Financial performance - Corporate sustainability
Bouwman et al. (2018)	[Envision Project] Business model experimentation and its effect on innovativeness and performance in European SMEs forced by digital technologies	- Innovation activity - Strategy - Technology turbulence - Competitive intensity	- Firm performance - Innovativeness
Gatautis et al. (2019)	[Envision Project] BMI drivers, practices and outcomes in Lithuanian SMEs	- BMI drivers (innovation activities, strategic orientation, market, technology turbulence and competitive intensity)	- Firm performance - Innovativeness
Pucihar et al. (2019)	[Envision Project] Drivers and outcomes of BMI in Slovenian SMEs.	- Innovativeness - Business environment - Information technology	- Firm performance
Lopez-Nicolas et al. (2020)	[Envision Project] Gender differences and business model experimentation in European SMEs	- Internal drivers (innovation activities) - External drivers (changes in customer demand and technological uncertainty)	- Business model experimentation capabilities - Firm performance

A fourth approach to research models also reflects the dual relationship of the business model innovation construct to its antecedents and outcomes, providing an integrated view of the phenomenon while additionally suggesting that business model innovation acts as a mediating variable between some predictors and the performance outcomes (Table 10).

Table 10 Business model innovation (BMI) as a mediation variable

Reference	Research focus	Antecedents	Outcomes	BMI as a mediator
Hai Guo et al. (2017)	The mediating effect of BMI between opportunity recognition and SME performance	- Opportunity recognition	- Performance	- BMI mediates the relationship between opportunity recognition and firm performance
Asemokha et al. (2019)	BMI and entrepreneurial orientation relationships in SMEs	- Entrepreneurial orientation	- International performance	- BMI mediates between entrepreneurial orientation and firm performance
Clauss et al. (2019)	Strategic agility, BMI, and firm performance	- Strategic agility (strategic sensitivity, collective commitment and resource fluidity)	- Performance	- Environmental turbulence moderates the relationship between strategic agility and BMI - BMI mediates between strategic agility and performance

Based on the insights from previously analysed frameworks and given the interests of this thesis, some of these research models deserve special attention. These models, which represent possible causal relationships between antecedents and outcomes of business model innovation from an integrative view, are described below.

The first one is the model proposed by Foss and Saebi (2017), which is displayed in Figure 18. The authors bring together the gaps identified in an extensive literature review and connect them by establishing relationships between them. Thus, they model the antecedents, business model innovation and its outcomes in a linear sequence that is moderated by certain factors. The antecedents refer to external and internal changes and a firm's dynamic capabilities that are prerequisites for business model innovation. The authors dimensionalise business model innovation based on its scope (modular or architectural changes in the business model) and novelty (new to the firm or new to the industry). The outcomes capture the results of business model innovation, such as firm innovativeness, cost reduction or financial performance. Additionally, the authors suggest the introduction of other variables as moderators. They divide moderator variables into three groups: macro-level, firm-level and micro-level. Macro-level moderators are elements that are external to the firm. Firm-level moderators capture capabilities and characteristics of the firm, while micro-level moderators comprise characteristics, skills and behaviours at the individual level. The authors highlight the following theories as being especially relevant in the development of the model: complexity theory, complementarity theory, innovation theory, dynamic capabilities theory and open innovation theory (Foss y Saebi, 2017).

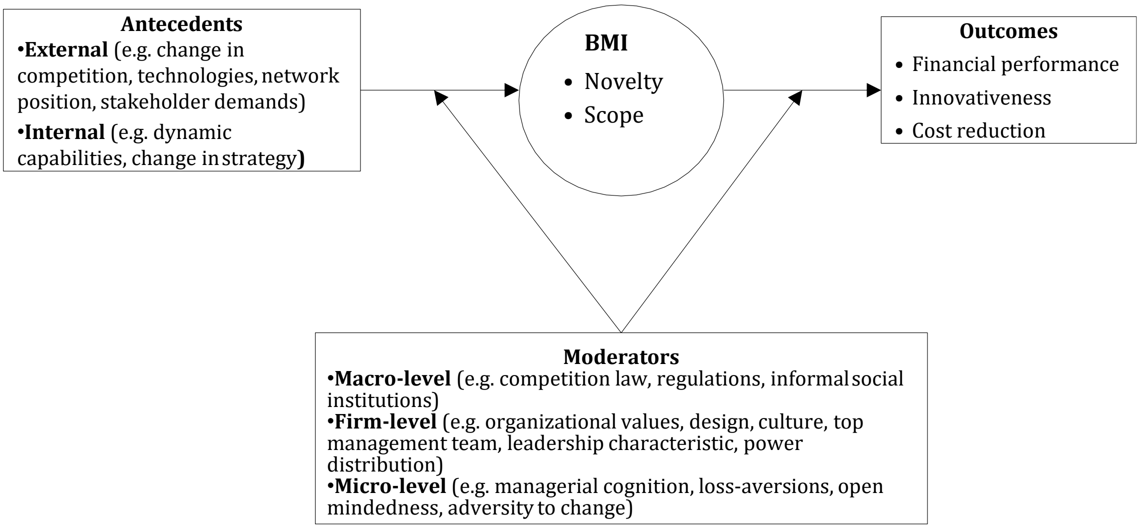

Figure 18 Research model for business model innovation.
Adapted from Foss and Saebi (2017)

The second relevant research model is the one provided by Bashir and Verma (2018), who also develop a model encompassing the findings of their literature review. As illustrated in Figure 19, the model also represents a lineal sequence in which business model innovation predicts a firm's strategic flexibility, competitiveness and competitive advantage by means of a set of internal factors. Bashir and Verma (2018) particularly focus on organisational internal factors as antecedents of business model innovation, including organisational structure, organisational culture, organisational inertia, leadership and technology. In addition, firm size and experience are defined as moderators.

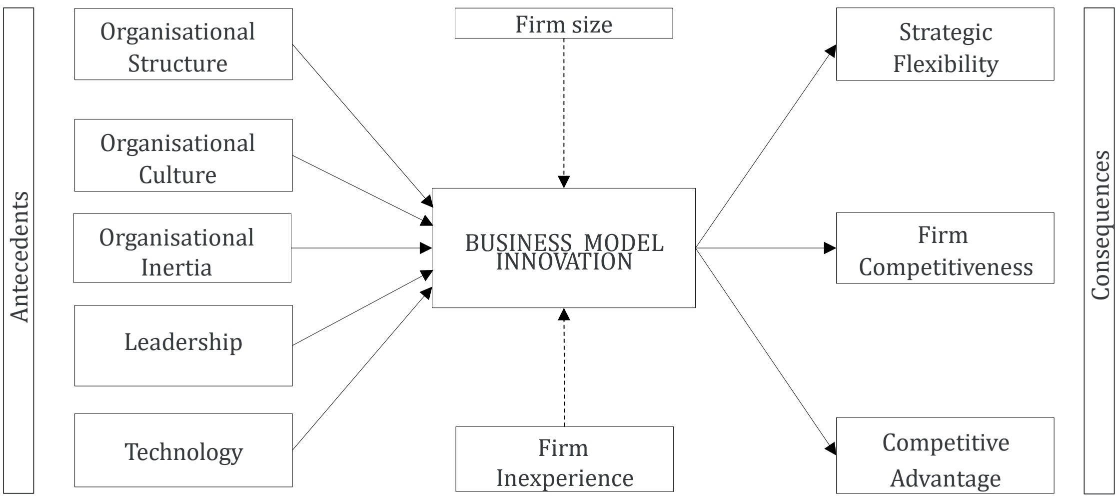

Figure 19 Internal factors and consequences of business model innovation.
Adapted from Bashir and Verma (2018)

A third research model, developed for the Envision Project (Bouwman et al., 2015), is illustrated in Figure 20. This basic conceptual model was developed to explore business model innovation in European SMEs. The authors built the model based on a meta-analysis of existing empirical research.

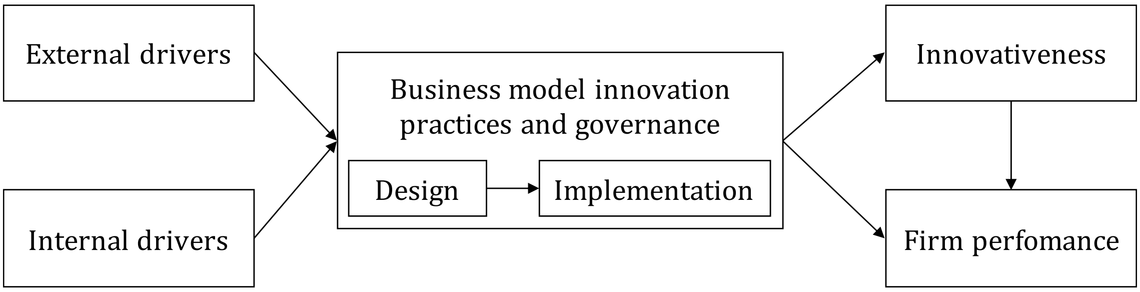

Figure 20 Basic conceptual model of main effects of Envision Project. Adapted from Bouwman et al. (2015)

In brief, the Envision Project (Bouwman et al., 2015) focuses on ontologies, tools and the use of platforms during business model innovation while also aiming to reveal how SMEs innovate their business model under digitalisation. Thus, the research model and related variables revolve around business model innovation practices and governance, with a focus on technological issues. The researchers of the project suggests that business model innovation practices and governance can be driven by external and internal factors (Table 11). Business model innovation practices and governance integrate two constructs: design and implementation. Design includes practices and tools related to the business model innovation process, while implementation refers to the strategy implementation practices to change the business logic and operational model. Finally, the model includes business performance and innovativeness as the outcomes of business model innovation practices and governance.

Based on this research model (Figure 20) and using different variables (Table 11), researchers on the project adapted the model to different contexts and research purposes (Bouwman, Nikou et al., 2018; Bouwman et al., 2019; Gatautis et al., 2019; Heikkilä, Bouwman, Heikkilä, Haaker et al., 2016; Heikkilä, Bouwman and Heikkilä, 2018; Lopez-Nicolas et al., 2020; Marjeta Marolt et al., 2016; Pucihar et al., 2019).

Table 11 Variables suggested to measure the basic conceptual model of the Envision Project

Variables	Measurement variables
External business model drivers	Product, service innovation, market innovation, organisational innovation, strategy and knowledge management
Internal business model drivers	Environmental dynamism, competitive intensity, regulatory changes, technology push, competitor behaviour, market trends
Design	Design/exploration, analyses and testing, implementation (exploitation/replication); familiarity with and use of ontologies and tools; involvement of eco-system partners; co-creation focal firm and customers
Implementation	Relation strategy-business model, usage of enterprise architecture tooling, operating model (process analyses levels)
Outcomes	Innovativeness, financial performance *Additional variables suggested: market performance, time to market performance, customer performance, technical performance, observed components changed in the business model, perception of business model change by entrepreneur, disruptiveness of the business model innovation (new to the world; new to the firm)*

In addition to the three integrative research models addressed above (Figure 18, Figure 19 and Figure 20), two additional models have been identified. The first one is the research model developed by Anwar (2018), which, unlike the models presented so far, includes both competitive advantage and firm performance as the main outcomes of business model innovation (Figure 21). Moreover, this model proposes that competitive advantage mediates the relationship between business model innovation and firm performance. This approach is in line with one of the conclusions obtained through the review of business model innovation frameworks in subsection 2.1.4, which suggested that business model innovation could be a source of sustainable competitive advantage and that firm performance would be attained once competitive advantage is achieved (Mahadevan, 2004; Voelpel et al., 2004; Wirtz y Daiser, 2017).

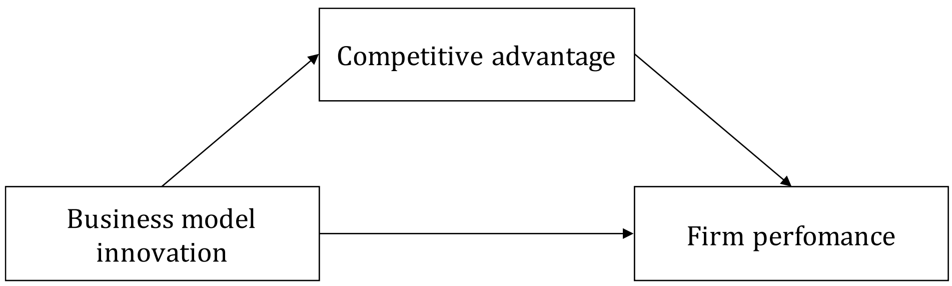

Figure 21 Business model innovation, competitive advantage and firm performance. Adapted from Anwar (2018)

The second research model is presented in Figure 22. This model by Hock et al. (2016) differs in its approach from other models analysed: instead of simply exploring how certain capabilities might influence business model innovation, the authors also focus on the role of organisational values in fostering those capabilities. As has been reviewed, both capabilities and organisational culture are referenced in business model innovation frameworks as important antecedents of business model innovation (Achtenhagen et al., 2013; Cavalcante, 2014; Čirjevskis, 2019; Halecker et al., 2014; Inigo et al., 2017; Mezger, 2014; Ricciardi et al., 2016; Teece, 2017; Vicente et al., 2018; Voelpel et al., 2004; Wirtz y Daiser, 2017). However, to the best of the author's knowledge, this is one of the few research models found in the literature that provides a view on how organisational culture and dynamic capabilities link with business model innovation.

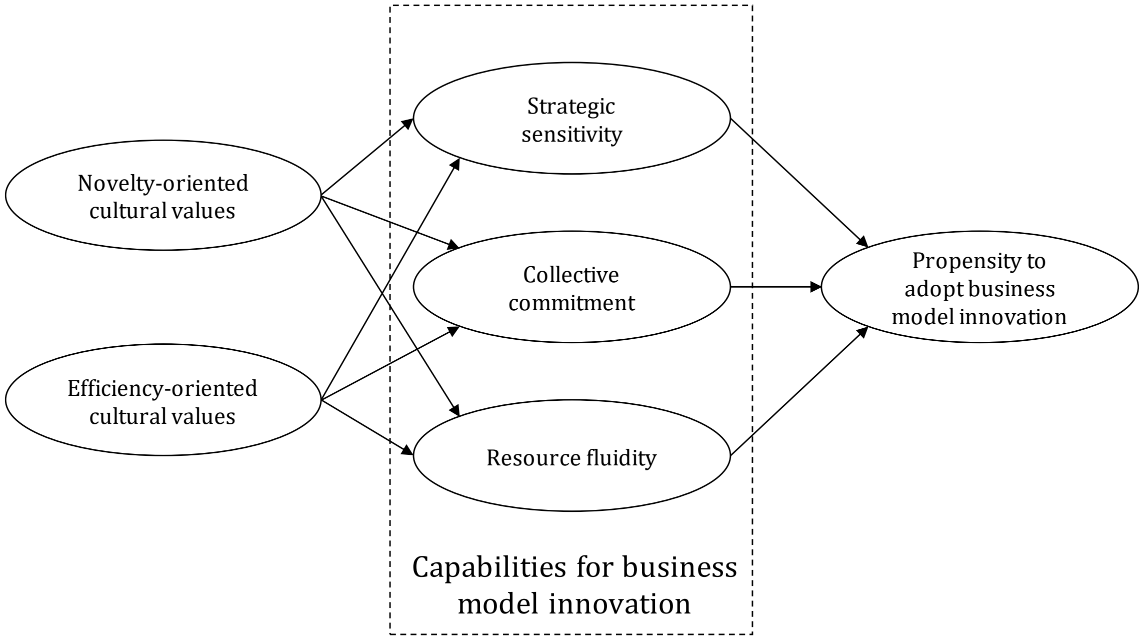

Figure 22 Organisational culture, capabilities and business model innovation. Adapted from Hock et al. (2016)

From the review of research models analysed it can be concluded that approaches to integrating both antecedents and outcomes of business model innovation all suggest similar sequences among variables (Figure 18, Figure 19 and Figure 20), whereas the constructs under study vary significantly (Table 9, Table 10).

As to business model innovation outcomes, research models usually define firm performance (Asemokha et al., 2019; Bouwman et al., 2019; Brettel et al., 2012; Clauss et al., 2019; Guo et al., 2017; Huang et al., 2013; Pati et al., 2018; Pucci, Nosi, Zanni, et al., 2017) and innovativeness (Bouwman et al., 2015; Bouwman, Nikou et al., 2018; Foss and Saebi, 2017; Gatautis et al., 2019) as the main consequences of business model innovation. Some models also suggest that business model innovation is a predictor of a firm's competitive advantage (Anwar, 2018; Bashir y Verma, 2019), whereas few studies address the mediator role of competitive advantage between business model innovation and firm performance (Anwar, 2018). To a lesser extent, various models suggest other kinds of outcomes, such as experimentation capabilities (Lopez-Nicolas et al., 2020), strategic flexibility (Bashir y Verma, 2019) and corporate sustainability (Pedersen et al., 2018).

In the case of antecedents, the diversity of approaches adopted is even greater than it is for outcomes. Some authors include environmental factors such as technological, competitive or demand changes in their models (Bouwman et al., 2015; Bouwman, Nikou, et al., 2018; Foss y Saebi, 2017; Gatautis et al., 2019; Lopez-Nicolas et al., 2020; Pucihar et al., 2019). Others define dynamic capabilities as main drivers of business model innovation in the form of overall capabilities (Foss y Saebi, 2017; Kiani et al., 2019; Pucci, Nosi, Zanni, et al., 2017) or focus on specific aspects, such as knowledge management (Hock-Doepgen et al., 2020) or strategic agility (Clauss et al., 2019; Hock et al., 2016). All in all, organisational factors as predictors of business model innovation range from open innovation practices (Huang et al., 2013; Liao et al., 2019), innovation activity (Bouwman, Nikou, et al., 2018; Gatautis et al., 2019; Kiani et al., 2019; Lopez-Nicolas et al., 2020), decision-making logics (Torkkeli et al., 2015) and organisational inertia (Bashir y Verma, 2019; Huang et al., 2013) to organisational culture, values and innovativeness (Bashir y Verma, 2019; Hock et al., 2016; Pedersen et al., 2018; Pucihar et al., 2019). Finally, some authors focus on the relationship between individual behaviour and business model innovation (Anwar et al., 2019; Asemokha et al., 2019; Guo et al., 2017; Liu et al., 2017). Nonetheless, few studies integrate antecedents from different nature in the same model, and the ones that propose such an approach are conceptual models (Bashir y Verma, 2019; Foss y Saebi, 2017) or are based on the same research project (Bouwman et al., 2015; Bouwman, Nikou et al., 2018; Gatautis et al., 2019; Lopez-Nicolas et al., 2020; Pucihar et al., 2019).

2.2. Business model innovation antecedents and outcomes

Having examined business model innovation definitions, frameworks and models, in this section the chapter deepens the analysis of business model innovation antecedents and outcomes. To this end, prior empirical research is addressed, paying special attention to studies focused on established SMEs.

As concluded in the previous sections, prior research has indicated several antecedents that may act as inhibitors or drivers of business model innovation. Varying in nature, these are placed at different firm levels (i.e. at individuals level or at organisational level) and can be external or internal to the firm. These antecedents can be clustered into four main groups: (1) environmental factors, (2) capabilities for business model innovation, (3) organisational factors and (4) individual/team factors. In addition, previous sections have explored business model innovation outcomes and concluded that competitive advantage and firm performance are the outcomes most often referred to in research frameworks and models. The effects of these factors within business model innovation have been analysed, and new factors have been identified.

This section first addresses business model innovation antecedents in these four groups and then explores the performance implications of business model innovation in the context of SMEs. The section ends with a review of the main research purposes, approaches, methods and findings of business model innovation research in SMEs.

2.2.1. Environmental factors

Environmental factors are external changes that may influence the propensity for business model innovation. Scholars agree that firms that grow fastest are the ones that take advantage of structural changes in the business landscape to compete differently by innovating their business models (Casadesus-Masanell y Joan Enric Ricart, 2010). These changes are commonly associated with alterations in regulation, competition, customer demand or technological development (Bouwman, Nikou, et al., 2018; de Reuver et al., 2009; Pateli G. M., 2005; Pucihar et al., 2019; Wirtz et al., 2010). Due to increasing technological uncertainty, some authors focus on the effects of ICT developments, digitalisation or the Industry 4.0 phenomenon in business model innovation (Berman et al., 2012; Bouwman et al., 2019; Gatautis et al., 2019; Mueller et al., 2018). Other authors highlight the following as potential drivers for business model innovation: stakeholder demands (Ferreira et al., 2013; Miller et al., 2014), national culture (Dalby et al., 2014) and sustainability (Inigo et al., 2017; Kiron et al., 2013).

As for established companies, Giesen et al. (2010) suggests three environmental conditions that these firms should consider when rethinking their existing business model. The first is economic downturns, during which companies might find new ways to gain cost and flexibility advantages. The second is exploiting ongoing industry transformation, since disruptive changes such as new technological developments or digitalisation provide new business opportunities. The third is identifying changes in customer needs in order to develop new value propositions and pricing models to fit new customer preferences.

While the relevance of environmental drivers for business model innovation is often stressed, quantitative research offers mixed results on whether environmental drivers are relevant. For instance, To et al. (2019) identify five business context factors that shape business model innovation: business eco-networks; the business actors; behavioural orientation; mastery of technology, rules and governance; and business complexity. They found that mastery of technology and business complexity were particularly critical, leading to strong fostering or inhibition effects on business model innovation in science and service business start-ups. By contrast, researchers with the Envision Project found that the correlation between competitive intensity (Bouwman, Nikou, et al., 2018) or technological uncertainty (Pucihar et al., 2019) and business model experimentation was not supported in European SMEs. Recently, Lopez-Nicolas et al. (2020) have shown that internal drivers (innovation and business strategy) have more influence than external ones (customer demand and technological uncertainty) on business model experimentation and performance.

As shown in the previous section, a changing environment may bring both opportunities and threats. However, business model innovation will further depend on a firm and its individuals' capabilities, willingness and proactiveness in continuously adapting the established business model to those changes (Achtenhagen et al., 2013; Mezger, 2014; Ricciardi et al., 2016; Saebi et al., 2017; Voelpel et al., 2004). Indeed, according to Mueller et al. (2018), some SMEs find external pressures and internal motivations strongly interlinked when driving business model innovation in the context of Industry 4.0. Thus, the following subsections address the internal factors that may drive business model innovation.

2.2.2. Capabilities for business model innovation

Among internal factors enabling business model innovation, the dynamic capabilities view theory is gaining increasing attention in the literature (Clauss et al., 2019; Hock-Doepgen et al., 2020; Liao et al., 2019; Schoemaker et al., 2018; Teece, 2017; Vicente et al., 2018). This section explores prior findings on dynamic capabilities, strategic agility and learning and experimentation capabilities as major streams identified in empirical research that adopts a dynamic capabilities view of business model innovation.

Dynamic capabilities

Business model innovation frameworks have identified various approaches to dynamic capabilities for business model innovation (Achtenhagen et al., 2013; Cavalcante, 2014; Čirjevskis, 2019; Inigo et al., 2017; Ricciardi et al., 2016; Vicente et al., 2018). These contributions, mostly based on case studies, suggest that business model innovation is facilitated by a set of capabilities, including those for sensing and seizing opportunities, experimenting and learning, collaborating and reconfiguring resources and competences (Achtenhagen et al., 2013; Čirjevskis, 2019; Inigo et al., 2017; Mezger, 2014; Vicente et al., 2018). Furthermore, some scholars have found that firms follow different paths towards business model innovation that may require different dynamic capabilities (Inigo et al., 2017; Ricciardi et al., 2016). Some have also suggested that SMEs with higher levels of dynamic capabilities achieve higher levels of business model innovation, while SMEs with lower levels of dynamic capabilities do not (Ricciardi et al., 2016; Vicente et al., 2018). In line with this, Roaldsen (2014) suggests that SMEs from the food industry possessing specific capabilities (intra-management cooperation routines, collective learning, advantage-seeking capability, trust-advancing capability and operational process updating) are more likely to succeed in experimenting with and changing the way they create and develop value.

In addition, three quantitative studies were identified that explore the relationship between dynamic capabilities and business model innovation. For instance, Pucci, Nosi and Zanni (2017) explore the relationship between firm capabilities, business model design and performance in SMEs. Pucci, Nosi and Zanni (2017) define four capabilities: absorptive capability, marketing capability, managerial capability and relational capability. Absorptive capability is the ability developed by the firm over time to recognise the value of new external knowledge and to assimilate and exploit it for commercial ends. Marketing capability is the exploitation of a firm's resources to detect market needs, enable product differentiation and develop customer cooperation. Managerial capabilities comprise a firm's ability to manage its financial resources, people and operations effectively. Finally, relational capability refers to abilities to develop external relationships to support innovation and learning. Their study shows that the adoption of a particular business model was positively associated with the distinctive capabilities possessed by the SME.

A second study, developed by Kiani, Ahmad and Gillani's (2019), focuses on the factors that affect business model innovation in the mobile banking sector of Pakistan. The authors define a set of innovation capabilities based on Janssen and den Hertog (2016) and Janssen, Castaldi and Alexiev (2016): sensing customer needs, sensing technological options, conceptualisation, co-producing and orchestrating, scaling and stretching. *Sensing customer needs* refers to the set of resources and routines organisations have to empathically understand customers and sense their (potential) needs, while *sensing technological options* refers to the resources and capabilities a firm has to scan the organisational context for promising technologies and technology providers. *Conceptualising* encompasses the ability to generate new ideas and transform these rough ideas into viable value propositions and business models. *Co-producing and orchestrating* refers to companies' ability to both manage innovation across their boundaries and engage in network ecosystems to facilitate business model innovation. Finally, *scaling and stretching* refers to the ability to disseminate new business concepts throughout the organisation, creating a consistent set of experiences, solutions and brand associations in a way that it fits the overall firm strategy and is seen as logical from the perspective of customers and potential customers (Janssen y den Hertog, 2016). In their study, Kiani et al. (2019) demonstrate that this set of five innovation capabilities had a positive and significant impact on business model innovation.

The third study was recently conducted by Hock-Doepgen et al. (2020). These researchers explore what knowledge management capabilities SMEs should develop to achieve business model innovation following both a dynamic capabilities approach and a configurational approach. They consider knowledge management as a key microfoundation of sensing capabilities (Teece, 2007), and they further argue that new knowledge has been largely recognised as a driver of the innovation process. In this sense, they argue that the ability to acquire new knowledge and to apply it at the right time is relevant for business model innovation. They define both internal and external knowledge management capabilities, the former addressing the culture, structure and technology of the firm, and the latter measuring the acquisition, conversion and application process. From the findings obtained through a combination of multivariate and qualitative comparative analyses, they conclude that external knowledge management capabilities are core conditions in obtaining a high level of business model innovation. In addition, they found that SMEs follow different configurational paths towards business model innovation and that knowledge management capabilities that might drive business model innovation in one firm are not necessarily successful at driving business model innovation in another.

Strategic agility

Among empirical research that adopts a dynamic capabilities view to explore business model innovation antecedents, some researchers particularly address the role of a firm's strategic agility.

Strategic agility is about remaining agile and flexible, staying open to new ideas, being always willing to re-evaluate past choices and being willing and able to change direction in the face of new developments (Doz y Kosonen, 2008). It guides leadership actions for accelerating business model renewal and overcoming business model rigidities that result from organisational inertia (i.e. previously learned routines that defend the status quo), thereby making successful business model innovation more likely (Doz y Kosonen, 2010). Doz and Kosonen (2010) state that strategic agility is thoughtful and purposive interplay among three meta-capabilities – strategic sensitivity, leadership unity and resource fluidity – which are the result of a set of management practices developed and refined over time.

Strategic sensitivity is defined as "the sharpness of perception of, and the intensity of awareness and attention to, strategic developments". Leadership unity is "the ability of the top team to make bold, fast decisions, without being bogged down in top-level 'win-lose' politics". Resource fluidity is "the internal capability to reconfigure capabilities and redeploy resources rapidly" (Doz y Kosonen, 2010). These capabilities are interdependent and provide the required infrastructure for change. The authors suggest a set of practical and actionable steps based on these three meta-capabilities that can help CEOs and corporate leadership teams to encourage the adoption of new business models.

Doz and Kosonen's (2010) conceptualisation of strategic agility through three meta-capabilities was later adopted by other scholars, such as Arbussa et al. (2017), who explore the influence of strategic agility on business model innovation in the context of SMEs. Based on a case study, they found that an SME's specific characteristics facilitate resource fluidity and leadership unity, while strategic sensitivity is less natural and more critical for SMEs. They believe this could be related to an SME's size and lack of specialist staff for strategic planning, forecasting and innovation.

Furthermore, they suggest that because of resource scarcity, SMEs seem to develop a key fourth capability: resourcefulness. This ability helps a firm overcome size limitations through motivation, competence development, and goal alignment of a firm's employees and customer-specific knowledge, all of which allow SMEs to customise their offer while economising their resources.

Using quantitative research, Hock et al. (2016) operationalised the three meta-capabilities that comprise strategic agility to explore their effect on the propensity to develop business model innovation; they found a positive relationship. Subsequently, Clauss et al. (2019) used the strategic agility construct developed by Hock et al. (2016) to explore the relationship between strategic agility and business model innovation, confirming the positive relationships between the three meta-capabilities (strategic sensitivity, leadership unity, and resource fluidity) and the three dimensions of business model innovation (value proposition, value creation, and value capture innovations). In addition, they conclude that strategically agile firms operating in turbulent environments are more likely to adopt business model innovation.

These contributions suggest that strategic agility may be relevant for business model innovation, with strategic sensitivity a critical meta-capability for SMEs. Moreover, comparing strategic agility's three meta-capabilities with the literature on dynamic capabilities, some common characteristics can be appreciated, such as the relevance of detecting and seizing from environmental and internal changes, the importance of leadership and the ability to reallocate resources (Hock et al., 2016; Teece, 2007). Furthermore, some authors refer to the three strategic agility meta-capabilities as business model innovation capabilities (Hock et al., 2016) that reflect a company's ability to reconfigure its existing resources and capabilities, thereby facilitating business model innovation (Clauss et al., 2019). Thus, although strategic agility was introduced as a concept distinct from dynamic capabilities, some authors view it as a dynamic capability that allows a firm to purposively and rapidly adapt to environmental changes as a driver of business model innovation (Clauss et al., 2019; Hock et al., 2016).

Finally, Battistella et al. (2017) introduced a different approach to explore the influence of critical capabilities on business model reconfiguration. After identifying a set of 52 capabilities for strategic agility in the literature, Battistella et al. (2017) grouped them into three types of capabilities that enable business model innovation: strategy innovation capabilities, resource capitalisation capabilities and networking capabilities.

Strategy innovation capabilities help firms to anticipate and look for strategy innovation (e.g. seizing and sensing opportunities) and to realise strategy innovation (e.g. experimentation, innovativeness or reconfiguration of resources). *Resource capitalisation capabilities* merge a firm's abilities to acquire, develop, and deploy resources and to capitalise on them. Finally, *networking capabilities* capture the firm's abilities related to collaboration, integration and coordination of business processes and business implementation. Based on multiple cases studies, the authors investigated the differing effects of these three groups of capabilities on the building blocks of the established business model, concluding that they are relevant for business model innovation.

Learning and experimentation capabilities

As mentioned before, the role of learning and experimentation is highlighted in various research frameworks (Achtenhagen et al., 2013; Cavalcante, 2014; Mezger, 2014) and models (Bouwman, Nikou, et al., 2018; Lopez-Nicolas et al., 2020; Torkkeli et al., 2015).

Chesbrough and Rosenbloom (2002) were among the first authors to recognise experimentation as an important capability for business model innovation in established companies, since it helps in overcoming the firm's dominant logic – that is, cognitive barriers and conflicts with existing assets and business models. In this vein, Chesbrough (2010) states that business model innovation "is not a matter of superior foresight ex ante – rather, it requires significant trial-and-error, and quite a bit of adaptation ex post" (p. 356). In recent years, the role of experimentation in business model innovation has been heavily emphasized, usually together with the firm's learning capabilities (Bouwman et al., 2019). As discussed earlier, Achtenhagen et al. (2013) defines experimentation as a critical capability supported by three main activities: gaining information about the environment, encouraging new ideas, and learning from mistakes. Torkkeli, Salojärvi, Sainio, et al. (2015) builds on the lean start-up approach (Eric Ries, 2011), suggesting that experimentation is an iterative learning process enabling SMEs to shorten product development cycles while rapidly testing the market and validating or rejecting business opportunities. Similarly, other authors refer to business model experimentation as the examination of alternative business models or configurations of the business model components through virtual or real-life experiments (Baden-Fuller y Morgan, 2010; Bouwman et al., 2019). In this respect, Bouwman et al. (2019) conceptualise experimentation practices as internal activities related to exploring how to change the company's business logic, the order in which changes in components are made and thought (virtual) versus real experiments.

Among authors often credited with highlighting learning and experimentation are Sosna, Trevinyo-Rodríguez and Velamuri (2010). They study the evolution of a business model during economic recession through the case of NaturHouse, a dietary business in Spain, finding that business model innovation is driven by a trial-and-error learning process. During this process, the authors emphasise experimentation, resilience, learning from failure and applying the gained knowledge as key mechanisms for achieving business model innovation.

Andries et al. (2013) and Andries and Debackere (2013) demonstrate through a simulation that experience, learning and experimentation stimulate business model innovation. They conclude that companies need to change their learning approach over time to successfully renew their business models. In addition, Andries and Debackere (2013) find that simultaneous experimentation along different paths from the existing business model seems to be more beneficial than developing a business model through a sequence of distant business model searches, which might entail considerable difficulties.

Cavalcante (2014) argues that the two main challenges during business model innovation are learning and experimentation. Learning refers to aspects such as acquiring new knowledge, discussing new ideas on possible commercial opportunities and networking with project partners, whereas experimentation means researching the technical challenges, giving demonstrations, making prototypes and performing new practices (i.e. collaborating on the joint project).

Berends et al. (2016) suggest that business model innovation requires both cognitive searching and experiential learning. Cognitive searching involves two mechanisms: conceptualisation and creation. A conceptualisation mechanism allows the development of new ideas, concepts and analysis related to the business model. Creation transforms ideas into new business models. Experiential learning encompasses another two mechanisms: adaptation and experimentation. Adaptation involves changing the established business model through trial-and-error once it is in operation, while experimentation is defined as actions purposively carried out to learn by planning, designing and executing relatively controlled situations in order to develop new knowledge and validate the model.

Finally, Lopez-Nicolas et al. (2020) recently labelled the process conducted prior to achieving business model innovation as business model experimentation, defining it as the engagement in experimenting with new business models and related innovation activities developed by the firm to reconfigure their existing business models.

All the aforementioned contributions emphasize the relevance of experimentation to business model innovation. However, which activities authors relate to experimentation differs from one study to another. Furthermore, some authors view learning and experimentation as distinct capabilities (Cavalcante, 2014), whereas others refer to experimentation as learning from experience (Achtenhagen et al., 2013; Berends et al., 2016). Nevertheless, little quantitative research has measured the influence of experimentation on business model innovation. Furthermore, it seems that some studies assume that firms engage in experimentation activities sequentially, while for others it is a parallel or iterative process (Bouwman et al., 2019; Lopez-Nicolas et al., 2020).

2.2.3. Organisational factors

Beyond companies' dynamic capabilities for business model innovation, several internal factors concerned with organisational characteristics were identified during the review. These include (1) organisational culture; (2) organisational design; (3) strategic resources, activities and practices; (4) strategic choices and (5) a firm's behaviour and decision-making logics.

First, *organisational culture* has been emphasised as a relevant antecedent of business model innovation. Among the critical capabilities Achtenhagen et al. (2013) identified, they stressed a strong organisational culture as a key feature of one of the capabilities driving business model innovation. Bock et al. (2012) particularly explore the influence of organisational culture and structure on strategic flexibility during business model innovation, confirming the relevance of a creative culture for strategic flexibility. Hock, Clauss and Schulz (2016) investigate how efficiency and novelty-oriented cultural values influence business model innovation capabilities and consequently the propensity for business model innovation; they establish a positive relationship between the factors and business model innovation. Pedersen et al. (2018), in turn, state that business model innovation is more likely to be achieved in SMEs with organisational values of flexibility and discretion.

The *organisational design* approach has been studied less frequently than other organisational factors. Nevertheless, some studies suggest that organisational design interacts with business model innovation (Carayannis et al., 2017) and that flexible organisational structures facilitate business model innovation (Bock et al., 2012). In this respect, management of business model innovation requires reallocating resources, capabilities and control mechanisms. Therefore, business model innovation could affect organisational structure, or the organisational structure could constrain business model innovation.

In terms of *strategic resources, activities and practices*, some authors suggest a firm's innovation activities and resource allocation are antecedents of business model innovation. Giesen et al. (2010) suggest that product or service innovation is an internally driven change that may require a new business model. Minarelli et al. (2015) found that most of the European food industry SMEs they surveyed introduced several innovation types simultaneously. The authors suggest that the introduction of a new product type implies the adoption of new business models, new markets or new processes. Cucculelli and Bettinelli (2015), in turn, state that intangible assets such as expenditure on R&D and advertising positively moderate the relationship between business model innovation and performance. Similarly, Bouwman et al. (2018) found that innovation activities such as new product development, R&D activity and marketing innovation motivated SMEs to allocate resources and team activities for business model experimentation. In a later work, Bouwman et al. (2019) stress the relevance of resources for business model experimentation in SMEs, referring to human capabilities, budgets and time. They demonstrate empirically that the allocation of resources supports business model experimentation practices, which in turn have a positive impact on both an SME's innovativeness and overall firm performance.

As for practices for business model innovation, Rumble and Mangematin (2015) also explore the effect of design and implementation practices on business model innovation outcomes, focusing on certain antecedents such as client involvement, feedback, piloting, external search activities and the use of business model design tools. They conclude that business model innovation is a result of the articulation of antecedents, founders' experiences, industry influences and direct environment relationships. Contrary to their expectations, they found that business model innovation tools, instead of facilitating the design of innovative business models, were absent from their implementation.

Addressing this issue from the point of view of strategic management of business model innovation, Lindgren (2012) found that SMEs tend to innovate their business model through a single strategy and practice, which basically moves from idea to market implementation of the value proposition. Lindgren claims that SMEs focus the business model innovation process on managing product, service and process innovation, and do not use the full potential of business model innovation and related strategies. Furthermore, he suggests that very few SMEs have a formal strategy or structured process to be involved in business model innovation.

A fourth approach concerns a firm's *strategic choices*. The research reviewed in this thesis incorporates multiple perspectives on how the posture a firm adopts and the choices it makes affect business model innovation. For instance, various authors focus on a knowledge strategy such as open innovation. Open innovation is "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and to expand markets for external use of innovation respectively" (Chesbrough and Crowther, 2006, p.1). Various scholars have found that open innovation positively influences business model innovation in SMEs (Huang et al., 2013; Liao et al., 2019; Yun y Jung, 2015). Furthermore, research suggests that SMEs tend to develop inbound open innovation activities – that is, they access resources, knowledge and innovation ideas from the outside to complement their in-house resource base. Inbound activities involve exploratory learning with various external partners related to distinct knowledge sources (Brunswicker y Vanhaverbeke, 2015; Scuotto et al., 2017). Collaboration with universities or research institutes for research and development (Yun y Jung, 2015) or for acquiring resources from the outside (Liao et al., 2019) is stressed as critical for business model innovation in SMEs.

Focusing on a different strategy – that is, how SMEs embrace Industry 4.0 – Mueller et al. (2018) highlight the relevance of collaboration. The authors find that internally motivated firms proactively develop research projects with universities and supply chain partners, in contrast to SMEs who, pressured by customer requirements, do not get involved in research partnerships.

Following a different approach, Heikkilä et al. (2018) explore how three strategic goals – namely, starting a new business, generating growth and increasing profitability – relate to business model innovation in SMEs. They conclude that even though SMEs may not have an explicitly formulated strategy, their strategic goals determine the type of improvements they make to their business model and the way they start improving their business model components by taking distinct business model innovation paths. Similarly, Cortimiglia et al. (2016) find that when business model innovation is addressed alongside a formal strategy making process, most SMEs, and some larger firms, focus on the value creation dimension during the internal analysis stage and then innovate the other two dimensions (value delivery and value capture). Moreover, the authors conclude that business model innovation occurs mainly at the end of the process, as a means of executing the firm's strategy. Ammar and Chereau (2018) analyse SME's strategic postures based on Miles and Snow's typology of strategic profiles (Miles et al., 1978). They detect that innovation intensity in a business model differs depending on the strategic posture adopted (i.e. "differentiated" defenders, analysers, "market" prospectors and reactors). Their results stress the fact that business model innovation behaviour among strategic postures is path-dependent.

Turning to the fifth and last factor, *firm behaviour and decision-making logics*, some authors build on entrepreneurial literature to explore this factor in companies addressing business model innovation. Some authors suggest that entrepreneurial orientation – that is, proactive, risk-taking, creativity-oriented thinking and behaviour – has a positive influence on business model innovation (Asemokha et al., 2019; Bouncken et al., 2016). Other scholars have built on effectuation theory (Sarasvathy, 2001) to explore how causation and effectuation behaviours influence business model innovation. For example, Torkkeli, Salojärvi, Sainio, et al. (2015) show that SMEs follow both causation (strategic planning and sensing capabilities) and effectuation (experimentation and organisational flexibility) decision-making logics, which are linked to increased levels of business model innovation. Furthermore, they emphasize the need for both strategizing and experimenting during business model development, whereas organisational flexibility seems not to be significant in the context of SMEs. Futterer et al. (2018) developed a similar study focused on corporate ventures. They show that causation behaviours (i.e. establishment of goal and focus on expected returns, conducting market analysis and monitoring external environment) make the future less uncertain and encourage firms to anticipate business model innovation. In turn, effectuation behaviour (i.e. a firm's focus on means, affordable loss, partnership and acknowledging the unexpected) is oriented towards action, envisioning new business opportunities and fostering experimentation within the company. Aligned with the results provided by Torkkeli, Salojärvi, Sainio, et al. (2015), Futterer et al. (2018) also find that both behaviours lead to business model innovation.

2.2.4. Individual/team-level factors

Prior research suggests that business models represent the mental models of manager, encompassing their assumptions and understandings (Doz y Kosonen, 2010; Martins et al., 2015; Teece, 2010). In this sense, each decision-maker develops a somewhat unique view of reality (Martins et al., 2015). In recent years, empirical research has addressed this cognitive perspective on managerial influence on business model innovation.

The role of managers is especially relevant in the context of SMEs, since ownership and management are typically concentrated in the same individual – the one who makes the decisions (Azari et al., 2017; Huang et al., 2013). Therefore, various works focusing on a manager's and team's individual factors and business model innovation can be found addressing a wide range of factors. Approaches include a manager's growth ambitions (Azari et al., 2017); skills and managerial ties (Guo et al., 2013); personality traits (Anwar et al., 2019); opportunity recognition capabilities (Guo et al., 2017) and past experiences, preferences, understandings and logics about value creation (Child et al., 2017). All these factors were found to positively affect business model innovation in the context of SMEs.

However, it has also been argued that a manager's profile may hinder business model innovation. In this respect, Huang et al. (2013) argues that managers' actions are affected by their past strategic choices, most especially when those actions were successful. The higher the inertia to maintain the status quo in the SME, the slower the company is in addressing environmental threats and opportunities. Additionally, the authors find that organisational inertia has a significant negative effect on business model innovation. Arbussa et al. (2017) suggest that SME's CEOs are more likely to exhibit resistance to change, as their fear of loss is greater than their attraction to potential gain, which can hinder business model innovation. This "endowment effect" usually occurs independently of a firm's wealth or income (Gray, 2002). The owner/manager's fear of the unknown, lack of confidence, age or cultural conservatism may lead to reluctance to change. However, Arbussa et al. (2017) did not detect a significant effect of emotional, motivational or learning barriers on change acceptance by the management team. Thus, the authors conclude that the leadership role of the general manager could compensate for these barriers.

Additionally, some authors have explored how a manager's intentions and perceptions of external opportunities and threats affect business model innovation (Marolt et al., 2016; Osiyevskyy J. et al., 2015; Osiyevskyy y Dewald, 2018; Saebi et al., 2017). For instance, Osiyevskyy J. et al. (2015) suggest that opportunity perception, perceived performance-reducing threats, and risk experience drive a manager's intentions to explore adoption of disruptive business models. By contrast, a perceived critical threat and industry tenure constrain a manager's intentions to exploitatively strengthen an existing business model, while risk experience fosters those intentions. In a later work, Osiyevskyy and Dewald (2018) conclude that critical threat perception is moderated by the predictability and time pressure perceived by the manager, with explorative business model change intentions being mitigated by low predictability and high time pressure. Based on four case studies of Slovenian SMEs, Marolt et al. (2016) conclude that the main driver of these SMEs' decisions to innovate their business model was external opportunity (emerging technologies, collaboration opportunity or geographical positioning), but that it was usually combined with at least one internally perceived opportunity (risk-taking behaviours, intention to collaborate, skilled experts or motivation) or threat (time management challenges). Saebi et al. (2017) in turn find that the more severe the external threat perceived by managers, the more likely firms are to engage in business model adaptation, whereas external opportunities were associated with upholding the status quo of the business model. Furthermore, the authors could not find support for the assumption that perceived threats lead to upholding the status quo.

Beyond the focus on an individual manager's factors, some studies examine the top management team level. In this regard, Al Humaidan and Sabatier (2017) suggest that externally oriented teams adopt a more disruptive approach to business model innovation than internally oriented ones. Guo, Pang and Li (2018) focus on top management team functional and tenure diversity, concluding that managerial cognition might play a critical role in determining business model innovation's effect on performance.

2.2.5. Performance implications of business model innovation in SMEs

Several contributions to the literature have emphasized the relevance of business model innovation for firm competitiveness and performance. This subsection reviews empirical research addressing the performance implications of business model innovation, with a particular focus on articles addressing SMEs.

From the studies analysed, two approaches have been identified. The first does not directly assess business model innovation but rather explores the effect of different business model designs on performance. This approach is built on Zott and Amit's (2007, 2008) work, which has inspired further research in the context of SMEs (Brettel et al., 2012; Ma et al., 2018; Pati et al., 2018; Pucci, Nosi, Zanni, et al., 2017).

Amit and Zott (2001) developed the well-known efficiency- and novelty-centred business model design themes, which years later they operationalised to measure the impact of each design theme on firm performance. Efficiency-centred design is related to enhancing transactions by reducing costs and thus providing more value. Novelty-centred design addresses the potential of introducing innovations in the elements of the business model. Based on these design theme, the authors developed various studies exploring the relationship between business model design and firm performance in entrepreneurial firms (Zott y Amit, 2007) and Internet-based firms (Zott y Amit, 2008). In both cases, they found a positive relationship between novelty-centred business model design and firm performance.

Some years later, Brettel et al. (2012) adopted their approach to empirically prove that novelty-centred business model design coupled with marketing efforts was positively and significantly related to firm performance of SMEs in technology-intensive industries. Similarly, Pucci et al. (2017) studied the role of business model design as an intermediary between a firm's capabilities and firm performance in Italian SMEs. They conclude that different business model designs lead to differences in firm performance and that having greater managerial capabilities is key for SME's performance regardless of their business model design. Ma et al. (2018) find that novelty-centred business model design positively moderates the relationship between green product innovation and firm performance in manufacturing SMEs. Finally, Pati et al. (2018) measure the relationship between efficiency- and novelty-centred business design themes and return on assessment of SMEs in emerging economies. They find that a novelty-centred design theme positively influences the performance of SMEs and that it benefits younger SMEs more than mature SMEs. Additionally, they conclude that mature SMEs benefit more than younger SMEs from deploying novelty-centred and efficiency-centred business models simultaneously.

The second approach links business model innovation with performance outcomes. For example, Huang et al. (2013), explore the relationship between organisational inertia, open innovation, business model innovation and firm performance and show that business model innovation has a positive effect on the firm performance of SMEs from Taiwan. Cucculelli and Bettinelli (2015) compare the performance of Italian manufacturing SMEs that did not change their established business models with those that implemented changes over a period of 10 years. They find that the more innovative the business model change was, the greater the positive effect on firm performance. Focusing on the mediating role of business model innovation between opportunity recognition and firm performance in Chinese SMEs, Hai Guo et al. (2017) find that business model innovation positively affects firm performance. Similarly, Asemokha et al. (2019) explore the mediation effect of business model innovation between entrepreneurial orientation and international performance in Finnish SMEs. They demonstrate that the mediation effect is positive and significant, concluding that entrepreneurial orientation and business model innovation drive international performance in SMEs.

In addition, research conducted within the Envision Project (Bouwman et al., 2015) also suggests a positive relationship between business model innovation practices and SME performance. For instance, Bouwman et al. (2019) explore the relationship between business model experimentation, business model practices, innovativeness and firm performance of digitalising SMEs in a sample of 321 European SMEs from 12 countries. They identify a positive and significant relationship between business model experimentation practices and overall firm performance. Gatautis et al. (2019) find that business model innovation outcomes have a positive impact on both performance and innovativeness in 96 Lithuanian SMEs, and a study conducted by Pucihar et al. (2019) in 71 Slovenian SMEs also shows a positive relationship between the level of business model innovation and performance. Recently, Lopez-Nicolas et al. (2020) suggests that business model experimentation positively affects firm performance in 444 European SMEs.

By contrast, Pedersen et al. (2018) report that business model innovation has a positive but non-significant effect on firm performance. They explore the relationship of organisational values, corporate sustainability and business model innovation to firm performance in a sample of Swedish fashion companies, mainly small companies (78%), finding only a positive and significant influence of business model innovation on corporate sustainability.

Finally, based on one of the reviewed research models (Figure 21), Anwar (2018) analyses the relationship between business model innovation and SME performance in the emergent market of Pakistan, examining competitive advantage as a mediator variable. The author finds that business model innovation has a positive and significant impact on both performance and competitive advantage, while competitive advantage partially mediates the relationship between business model innovation and performance.

Bearing all this in mind, it could be assumed that business model innovation has beneficial consequences for SMEs. Although some studies have found the relationship between business model innovation and firm performance to be non-significant (Pedersen et al., 2018), several studies have identified a positive effect of business model design (Ma et al., 2018; Pati et al., 2018; Pucci, Nosi, Zanni, et al., 2017), business model innovation (Asemokha et al., 2019; Gatautis et al., 2019; Guo et al., 2017; Huang et al., 2013) and business model innovation practices (Bouwman et al., 2019; Lopez-Nicolas et al., 2020) on SME performance. Moreover, some authors include a firm's competitive advantage in their approach (Anwar, 2018), suggesting that it may act as a mediator between business model innovation and firm performance in SMEs.

2.2.6. Research purposes, approaches, methods and main findings of business model innovation research in SMEs

To conclude the analysis of empirical studies, this subsection explores the various research purposes addressed in investigating business model innovation in established SMEs, along with the research approaches and methods applied in these investigations (Table 12). This analysis aims to identify the most appropriate methods to address the research questions of this thesis and allow the exploration of business model innovation from a holistic view.

Some scholars aim to gain an in-depth understanding of factors driving business model innovation (Arbussa et al., 2017; Marolt et al., 2016; Roaldsen, 2014) or the paths SMEs follow to reconfigure their existing business models (Heikkilä, Bouwman y Heikkilä, 2018). These researchers tend to follow a qualitative approach, usually based on interviews and case studies (Table 12). This methodology provides meaningful insights about the influence of SMEs' dynamic capabilities and strategic choices in business model innovation (Arbussa et al., 2017; Heikkilä, Bouwman y Heikkilä, 2018; Marolt et al., 2016; Roaldsen, 2014). Qualitative research is quite useful when dealing with complex phenomena and emerging research areas that need to be better understood, such as business model innovation (Andreini y Bettinelli, 2017). Through the development of case studies, researchers can get a closer view of complex dynamics in business model innovation and an in-depth understanding of how certain factors affect business model innovation and its impact on firm results. This approach is suitable to establish the basis for theory development through inductive reasoning (Saunders et al., 2009). However, findings are case specific, and their generalizability is limited.

Table 12 Qualitative research: Purposes, methods and main findings of business model innovation studies in SMEs

Reference	Research purpose	Data collection/ Analysis/Sample	Findings
Roaldsen (2014)	In-depth understanding of BMI drivers	/Longitudinal case study/2 SMEs from the food industry in Norway	SMEs holding specific dynamic capabilities are more likely to succeed in changing their business models for entrepreneurial purposes
Arbussa et al. (2017)	To explore how the dynamic capabilities underlying strategic agility fit the SME context	Interviews/Single longitudinal case study/ One SME from service industry in Spain	Leadership unity and resource fluidity seem to be inherent to SMEs. Strategic sensitivity is critical for an SME. Resourcefulness emerges as key for SMEs to be able to overcome some of the limitations brought about size
Heikkilä et al. (2018)	To analyse how different strategic goals relate to BMI paths	Interviews/Multiple case studies/7 SMEs from different industries in Europe	SMEs' strategic goals lead them to alternative innovation path in terms of BM components affected. All three paths gradually lead to improvement in several BM components
Marolt et al. (2016)	To gain insights into factors that drive BMI	Interviews/Multiple case studies/4 SMEs, family business and women entrepreneurs from Slovenia	Differences between SMEs regarding the drivers behind BMI and changes in usage of the different BMI elements.

Note: BMI: business model innovation

Other authors, however, seek to analyse the relationships between antecedents and outcomes of business model innovation in SMEs. For that purpose, scholars usually adopt a quantitative approach, where data is collected through a survey instrument in the form of a questionnaire (Table 13). The most prominent methods applied for data analysis are the single regression analysis (Asemokha et al., 2019; Child et al., 2017; Guo et al., 2017; Pati et al., 2018; Pucci, Nosi, Zanni, et al., 2017; Torkkeli et al., 2015) and structural equation modelling, which allow the measurement of multiple regressions within a model (Anwar, 2018; Anwar et al., 2019; Bouwman, Nikou, et al., 2018; Gatautis et al., 2019; Huang et al., 2013; Najmaei, 2016; Pedersen et al., 2018; Pucihar et al., 2019). These two regression-based techniques imply symmetric relationships between variables, allowing the exploration of pre-determined lineal relationships between variables, where it is assumed that high values of antecedent variables lead to high values of the dependent variables (Woodside, 2013). Therefore, as outlined in Table 13, these methods are suitable for improving our understanding of what effect individual antecedents such as strategic resources (Huang et al., 2013), decision-making logics (Torkkeli et al., 2015), manager-related factors (Anwar et al., 2019; Asemokha et al., 2019; Guo et al., 2017) or business model innovation practices (Gatautis et al., 2019; Lopez-Nicolas et al., 2020; Pucihar et al., 2019) have on business model innovation. The methods are also helpful in analysing the effect of business model innovation on firm performance (Anwar, 2018; Guo et al., 2017; Huang et al., 2013; Pati et al., 2018). Hence, they allow exploration of the net effects of individual antecedents on an outcome, and to some extent, allow the prediction of linear causality among them (Leischnig et al., 2016).

Table 13 Quantitative research: Purposes, methods and main findings of business model innovation studies in SMEs

Reference	Research purpose	Data collection/ analysis/Sample	Findings
Huang et al. (2013)	To examine how open innovation affects organisational inertia, BMI and firm performance. To explore the mediating effect and influence of open innovation	Questionnaire/SEM/141 manufacturing SMEs from Taiwan	Open innovation has a mediating effect on the relationship between organisational inertia and BMI and the relationship between organisational inertia and firm performance; BMI has a positive influence on firm performance.
Torkkeli et al. (2015)	To examine the effects of decision-making logics on the extent of BMI	Questionnaire/Hierarchical regression analysis/ Sample of 148 Finnish SMEs from different industries	Causation and effectuation decision-making logics have positive effects on BMI.
Najmaei (2016)	To explore product and process modularity influences on BMI management	Questionnaire/PLS-SEM/87 manufacturing SMEs in Australia	BMI is a missing mechanism in the process modularity-performance nexus, not the product modularity. Environmental dynamism negatively moderates this relationship.
Guo et al. (2017)	To explore the mediator effect of BMI enabling the translation of opportunity recognition into higher performance	Questionnaire/Ordinary least squares regression/155 Chinese SMEs	Opportunity recognition positively influences SME performance, and this relationship is mediated by BMI.
Ammar and Chereau (2018)	To explore the differentiated propensities for BMI and the interactions between BM components among strategic postures	Questionnaire/Cluster analysis and ANOVA/169 French SMEs in the manufacturing sector	Miles and Snow's typology-based strategic postures tend to leverage specific BM components to achieve different strategic choices.

Reference	Research purpose	Data collection/ analysis/Sample	Findings
Anwar (2018)	To examine the importance of BMI in performance and the mediating role of competitive advantage	Questionnaire/SEM/303 manufacturing SMEs from Pakistan	BMI has a positive impact on competitive advantage and SME performance. Competitive advantage partially mediates the relationship between BMI and SME performance.
Pati et al. (2018)	To examine the impact on firm performance of simultaneously operating dual BM designs and the contingent effect of firm age on this relationship	Questionnaire/OLS regression analysis/241 Indian SMEs	The relationship between BM novelty and firm performance is positive, whereas BM efficiency is not. The contingent effects of firm age and environmental dynamism and munificence moderate these relationships.
Anwar et al. (2019)	To examine the influence of managers' personality traits on BMI	Questionnaire/SEM/343 industrial SMEs from Pakistan	Manager's personality has a significant positive influence on BMI except for neurotic personality.
Asemokha et al. (2019)	To explore the mediating role of BMI between entrepreneurial orientation and international performance	Questionnaire/OLS multiple regression/95 Finnish SMEs from different industries	BMI positively mediates the relationship between entrepreneurial orientation and international performance. Entrepreneurial orientation has a positive effect on SMEs' BMI.
Chereau and Meschi (2019)	To highlight different strategy–BM alignments and analyse their performance implications	Questionnaire/Cluster analysis, ANOVA, regression models/156 French SMEs in the manufacturing sector	Identification of different sets of BM configurations across strategic profiles. Deviating from ideal strategy–BM alignments negatively affects performance.
Gatautis et al. (2019)	To explore the relationships between BMI drivers, practices and outcomes	Questionnaire/PLS-SEM/73 Lithuanian SMEs	Internal and external drivers have a positive impact on BMI. Implementation of BMI practices leads to strategic and architectural changes in SMEs and has a positive impact on firm performance and innovativeness.
Pucihar et al. (2019)	To explore the relationships between BMI drivers and outcomes	Questionnaire/PLS-SEM/71 Slovenian SMEs	Innovativeness and business environment have a positive impact on the level of BMI, while information technology impact is non-significant. The level of BMI has a positive impact on BMI outcomes and on overall business performance.
Lopez-Nicolas et al. (2020)	To examine BM relationship with BM experimentation capabilities and firm performance from a gender perspective	Questionnaire/Multi-group SEM analysis/444 European SMEs	The positive impact of internal and external drivers on BM experimentation is different for female-owned and non-female-owned businesses.

Note: ANOVA: analysis of variance, SEM: Structural equation modeling, OLS: Ordinary least squares, PLS: partial least squares, fsQCA: fuzzy-sets qualitative comparative analysis, BM: Business model, BMI: business model innovation

Using a configurational approach, some authors have researched business model innovation by analysing factors such as the manager's personality (Ammar y Chereau, 2018), strategic alignment (Chereau y Meschi, 2019) or components reconfigured in the business model (Clauss et al., 2020). This approach is used to create typologies or taxonomies relating SMEs' features to business model innovation (Table 13). This kind of research usually applies a quantitative approach based on questionnaire-based data collection and cluster analysis. Cluster analysis is a useful technique for grouping cases based on their similarities. Nevertheless, it does not allow further exploration of how these configurations of attributes are linked to an outcome of interest (Greckhamer et al., 2018).

Pursuing this last approach, and in response to the shortcomings listed above, some studies (Ricciardi et al., 2016; Rumble y Mangematin, 2015) seeking to identify configurations of antecedents linked to business model innovation (Table 14), perform fuzzy-set qualitative comparative analysis (FsQCA).

Table 14 Mixed-methods research: Purposes, methods and main findings of business model innovation studies in SMEs

Reference	Research purpose	Data collection/ analysis/Sample	Findings
Rumble and Mangematin (2015)	To identify regular patterns of multi-sided business model and explore its antecedents	Interview/fsQCA/75 European SMEs and two large firms from different industries	Recipes for how certain business design and implementation practices are associated with the emergence of certain types of business models. Tools developed to support business design, creativity or visualization are absent from the operationalization of complex, multi-sided business models.
Ricciardi et al. (2016)	To explore which configurations of organisational dynamism dimensions are antecedents of BMI	Questionnaire/fsQCA/35 Italian SMEs from different sectors	Two organisational dynamism paths lead to BMI in SMEs. Only cases with high dynamic capabilities display high levels of BMI. The paradoxical dimensions of organisational dynamism, although logically opposed, strongly intertwine in enabling BMI.
Child et al. (2017)	To explore which BMs prevail during SME internationalisation and whether they are configured into different types. To explore which factors predict the kind of BMs followed by SMEs	Interviews/Latent class analysis/180 SMEs from different sectors and distributed in six economies	SMEs' choice of BM is highly predictable based on the industry, level of home economy development, and international experience of decision-maker.
Bouwman et al. (2018)	To explore how digital technologies have forced SMEs to reconsider and experiment with their BM and how this contributes to their innovativeness and performance	Questionnaire and interviews/PLS-SEM and case studies/338 European SMEs	Innovation activity, strategy and technology turbulence have a positive effect, whereas competitive intensity has no significant effect on BMI. BMI has a positive effect on innovativeness and firm performance. Innovativeness has a positive and significant effect on firm performance. The case studies show that BMI is driven by big data rather than by social media.
Bouwman et al. (2019)	To explore whether SMEs perform better if they allocate more resources for BM experimentation, engage more in strategy implementation during digitalisation and identify different configurations leading to high performance	Questionnaire/PLS-SEM and fsQCA/321 European SMEs	More resource allocation for experimentation and more engagement in strategy implementation practices positively influence SME performance. These effects are mediated by experimentation practices and company innovativeness. SMEs may take different routes to improve their performance when digital transformation is changing their business model.
Clauss et al. (2019)	To disentangle BMI configurations and explore their degree of radicalness and performance implications	Questionnaire/Cluster analysis, ANOVA and interviews/216 German SMEs from technology sector	SMEs achieve superior performance when implementing a radically new configuration of all the dimensions of the BM.
Liao et al. (2019)	To investigate the BMI formation mechanism, exploring the direct and configurational paths from open innovation and organisational agility to BMI	Questionnaire/SEM and fsQCA/245 scientific and technological SMEs from China	Inbound open innovation has a positive effect on operational adjustment agility and BMI. Outbound open innovation effects on market capitalising agility and BMI were insignificant. The two forms of organisational agility positively affect the BMI. Four configurations of open innovations and organisational agilities can sufficiently explain high levels of BMI, and two configurations of these factors lead to low BMI.
Hock-Doepgen et al. (2020)	To examine the impact of knowledge management capabilities on BMI and how these effects are moderated by risk-taking tolerance.	Questionnaire/PLS-SEM and fsQCA/197 SMEs from the technology sector in Germany	External knowledge management capabilities stimulate BMI. This relationship is strengthened for firms with a high risk tolerance. Internal knowledge is only effective for firms with a low risk tolerance. Four paths of knowledge management capabilities leading to high levels of BMI are identified.

Note: Studies applying only fsQCA are classified as "mixed methods" based on the hybrid nature of the method (Cragun et al., 2016; de Block y Vis, 2018; Rihoux y Ragin, 2008)*. ANOVA: analysis of variance; SEM: Structural equation modeling; PLS: partial least squares; fsQCA: fuzzy-sets qualitative comparative analysis; BM: Business model; BMI: business model innovation.*

FsQCA is a configurational comparative method that has gained attention in recent years (Kumbure et al., 2020). Its hybrid nature provides a bridge between qualitative (case-oriented) and quantitative (variable-oriented) research, and it serves as a practical approach for understanding complex, real-world situations (Cragun et al., 2016; de Block y Vis, 2018). It addresses cases as constellations of interconnected elements while highlighting that causality is complex. Thus, it allows the determination of which conditions or configurations of conditions are necessary or sufficient to bring about a given outcome, providing causal *recipes* explaining a phenomenon (Rihoux y Ragin, 2008). This approach is increasingly supported by business model innovation researchers, who suggest that fsQCA can capture the complexity of business model innovation (Kraus et al., 2018; Täuscher, 2018).

Moreover, an interest seems to be emerging in a more holistic view of business model innovation that seeks to explore both its relationship with key drivers and outcomes and the different paths SMEs can follow to address it. This dual objective relies on a mixed-method approach (Table 14) that combines both structural equation modelling (SEM) and fsQCA (Bouwman et al., 2019; Hock-Doepgen et al., 2020; Liao et al., 2019). Some academics refer to this combination of techniques as a two-step mixed-method approach (Ali et al., 2019; Curado et al., 2018; Duarte y Pinho, 2019; Leischnig et al., 2016), since it sequentially applies regression-based methods (quantitative approach) and qualitative comparative analysis (qualitative approach).

Authors following the two-step mixed-method approach (Bouwman et al., 2019; Hock-Doepgen et al., 2020; Liao et al., 2019) apply SEM techniques to explore the linear causality between antecedents and outcomes of business model innovation, analysing the positive or negative effect that each variable within the model may have on another variable. In a subsequent step, they conduct an fsQCA analysis to explore the configurations of conditions that are sufficient to explain high or low levels of business model innovation, thereby suggesting paths SMEs can follow to improve their performance (Bouwman et al., 2019; Hock-Doepgen et al., 2020; Liao et al., 2019). Thus, while SEM is used to understand the net effects of individual antecedents on an outcome, fsQCA suggests which antecedent factors combine into configurations (combinatory effects) to explain the outcome (Leischnig et al., 2016).

This subsection has highlighted the variety of research purposes and approaches to business model innovation phenomena in SMEs. For research that aims to understand the factors affecting how SMEs can innovate their business model, research that prioritises in-depth knowledge about certain cases over generalised results, the most appropriate approach seems to be the qualitative one, based mainly on the case study method. If instead the aim is to develop typologies or taxonomies of companies, strategies or business model innovation types, a quantitative approach based on cluster analysis is more recommended. In addition, to understand the net effects of individual antecedents of business model innovation, as well as the effects of business model innovation itself, on firm performance within the same research model, a quantitative approach applying SEM is suitable. However, when the aim is to explore the combinatory effects of certain antecedents in business model innovation, a configurational approach based on fsQCA is more appropriate. Mixing SEM and fsQCA methods seems to provide a more holistic view of key factors and outcomes of business model innovation and to reveal the main paths SMEs follow towards business model innovation.

2.3. Business model innovation practices and related tools

The previous section has addressed the main antecedents of business model innovation found in the literature. Overall, firm capabilities, resources, practices and behaviours have been identified. This section, in turn, focuses on the tools that support the business model innovation process and that can facilitate the development of such organisational capabilities, practices and behaviours (Albors-Garrigos et al., 2018; Schoemaker et al., 2018; Zabala-Iturriagagoitia, 2014).

A process is defined as a sequence of activities approached to achieve a managerial objective (Shehabuddeen et al., 1999). Although it is well established that innovation is not a linear process but rather iterative and complex (Frankenberger et al., 2013), innovation processes tend to be modelled as a sequence of steps in order to provide a structural guide in practice. The same is observed with the business model innovation process, which authors tend to model with a set of steps and underlying activities (Bucherer et al., 2012). Thus, in this thesis, the business model innovation process is understood as the approach firms use to achieve business model innovation through a series of activities performed as iterative steps (Frankenberger et al., 2013; Wirtz y Daiser, 2018).

Consequently, business model innovation tools are referred to as "the range of tools, techniques, and methodologies" (Hidalgo and Albors, 2008, p. 117) applied to complete the activities of the business model innovation process in a structured way (Albors-Garrigos et al., 2018; Shehabuddeen et al., 1999). This is in line with the definition recently provided by Bouwman et al. (2020), who define business model tooling as "the use of methods, frameworks or templates to facilitate communication and collaboration regarding Business Model analysis, (re-)design, adoption, implementation and exploitation" (p. 1).

The relevance of the business model innovation process and related tools has been highlighted in various frameworks and research models explored in the previous sections (Figure 16, Figure 17 and Figure 20). However, empirical studies that focus on the effect of the use of tools on business model innovation outcomes are scarce (Rumble y Mangematin, 2015).

Therefore, this section aims to review the main contributions found in the literature to identify the main activities and associated tools that can most effectively facilitate the business model innovation process. Business model innovation tools can be classified based on their purpose (i.e. business modelling, market analysis or financial tooling) or based on their position in the sequence of the business model innovation process (Heikkilä, Bouwman, Heikkilä, Haaker, et al., 2016). Following both approaches, this section first explores business model innovation processes found in the literature. Then, tools stemming from different research fields – namely, business model, strategic management and design, entrepreneurial and agile fields – are analysed according to their purpose.

2.3.1. Business model innovation process: steps and activities

In recent years, various process models have been developed to understand the business model innovation process's main steps and related activities (Wirtz y Daiser, 2018). Table 15 presents a selection of business model innovation processes found in the literature.

When comparing the business model innovation processes, it can be observed that recent contributions outline in greater detail the steps of the process than earlier studies did. Some authors focus on the main activities involved in each step of the process (H Chesbrough, 2007; Frankenberger et al., 2013; Geissdoerfer et al., 2017; Teece, 2010; Wirtz y Daiser, 2018), while others define the tools required to support each step (Heikkilä, Bouwman, Heikkilä, Haaker, et al., 2016; Osterwalder y Pigneur, 2010; Wittig et al., 2017). In addition, the activities and approaches suggested widely differ among processes. However, the activities suggested in all of the analysed processes can be synthetized in four main steps: (1) analyse, (2) design, (3) test and (4) implement.

Table 15 Main steps of business model innovation processes and related activities and tools

Reference	Steps/Actvities
Chesbrough (2007)	1. **Analyse current business model** 2. **Experiment with business model** 3. **Choose the best concept** 4. **Implement**
Osterwalder and Pigneur (2010)	1. **Mobilize:** Assemble all elements for new business model design, create awareness, describe the motivation behind the project and establish a common language. Tools: BM Canvas, storytelling 2. **Understand:** Gain relevant knowledge (customers, technology and environment), collect information, interview experts, study potential customers and identify needs and problems. Tools: BM Canvas, BM patterns, customer insights, visual thinking, scenarios, environment map, BM evaluation tools 3. **Design:** Generate business model prototypes that can be explored and tested and select the best option. Tools: BM Canvas, BM patterns, ideation tools, visual thinking, prototyping, scenarios, BM evaluation tools, BM perspective and blue ocean strategy, BM management 4. **Implement:** Implement the business model design. Tools: BM Canvas, visual thinking, storytelling, BM management 5. **Manage:** Set up the management structures to continuously monitor, evaluate and adapt or transform the new business model. Tools: BM Canvas, visual thinking, scenarios, environment map, BM evaluation tools
Teece (2010)	1. **Segment the market** 2. **Create a value proposition for each market** 3. **Design and implement mechanism to capture value from each segment** 4. **Identify and implement isolating mechanism to avoid imitation by competitors and disintermediation by customers and suppliers**

Reference	Steps/Actvities
Frankenberger et al. (2013)	1. **Initiation (analyse business ecosystem):** Understanding players needs and monitoring their moves, identifying relevant drivers and acting upon changes 2. **Ideation (generate new ideas):** Thinking out of the box, thinking in business models, managing idea creation 3. **Integration (build a new business model):** Detailing business model dimensions, managing partners 4. **Implementation:** Overcoming internal resistance; defining first pilot tests, trials or prototypes; ensuring lessons learned are converted into business model adjustments; managing the roll-out step by step
Heikkilä et al. (2016)	1. **Explore:** Strategy-oriented tools such as Porter's 5 forces or environment scanning tools, other company's business model changes as examples of benchmark 2. **Design:** Business model ontology tools (Canvas, VISOR, C-SOFT, BM Cube) 3. **Test:** Stress-testing and the use of success factors 4. **Implement:** Tools for technical implementation, scalability and agility. Tools related to roadmaps and the order in which certain steps must be followed 5. **Grow:** Specific metrics to analyse progress and to adjust the BM if required
Wittig et al. (2017)	1. **Initiation**: Delivering a new value proposition to an existing or new customer, confrontation with a disruptive competitor, commercialization of new technology that challenges the dominant logic of the focal firm, technological shifts, regulatory changes, declining R&D productivity 2. **Ideation**: Pattern adaptation, business model ideation games, brainstorming on the business model innovation canvas, design-thinking techniques, scenario techniques, SWOT analysis, value curve 3. **Evaluation and integration:** Varim framework, nice framework, value loops, scoring system based on a SWOT analysis, real options, storytelling 4. **Experimentation and implementation:** Translate into falsifiable hypothesis, design and prioritize tests, run tests, validate hypothesis, preserve/rethink/perish the model
Geissdoerfer et al. (2017)	1. **Ideation**: Vision/purpose formulation, stakeholder definition, value mapping/ideation, sustainable value analysis, evaluation and selection of ideas 2. **Concept design**: Integration of ideas, discussion of technological and general trends, definition of value delivery, creation and capture system, BM elements, BM dimensions 3. **Virtual prototyping**: Benchmarking with industry and generic BM concepts, prototype building, evaluation and selection 4. **Experimenting**: Identification of key variables, experiment design, running experiments, analysis and lessons learned 5. **Detail design**: Detailed definition of all elements, overview of each element, business transformation tools 6. **Piloting**: Planning implementation, analysis, adjustment, documentation and communication, identification of failure modes 7. **Launch**: Realisation planning, implementation and scale-up 8. **Adjustment and diversification**: Monitoring, reflection, adjustment, scale-up, diversification, iteration of the business model innovation process
Wirtz and Daiser (2018)	1. **Analysis**: Analyse the current business model, product/services, target group/customers and market/competition 2. **Ideation**: Determine the mission, generate customer insights, develop customer scenarios, visual thinking and storytelling 3. **Feasibility**: Make assumptions about the business environment, analyse interdependencies, potential internal or external business model alignment 4. **Prototyping**: Analyse and create different BMI design alternatives, develop several detailed concepts, refine components/partial models 5. **Decision-making**: Evaluate each BMI design alternative, select final BMI design, final harmonization of components, realization and test of the BMI 6. **Implementation:** Develop the implementation plan, communication and team set up, step-by-step realization of the BMI, complete the implementation 7. **Sustainability:** Monitor and control of the BMI, potential adaptation of the BMI, sustained growth through organisation-wide learning, secure long-term competitive advantage, transition of BMI (incumbent business)

Note: BM: Business model; BMI: Business model innovation

The *analysis* step encompasses the main activities suggested in the first (or first two steps) of most of the processes presented in

Table 15. It involves activities related to the discovery of the need for innovation (Frankenberger et al., 2013), which can derive from improvements in the existing business model or from the exploration of new opportunities. The analysis of the current business model is suggested (H Chesbrough, 2007; Wirtz y Daiser, 2018) as a means to understand the strengths, weaknesses, opportunities and threats of the established business model (Wirtz y Daiser, 2018). Examining the company's

ecosystem, such as competitors, suppliers, technological trends, and other business models (Frankenberger et al., 2013; Osterwalder y Pigneur, 2010; Wirtz y Daiser, 2018), as well as identifying new customer segments and needs (Osterwalder y Pigneur, 2010; Teece, 2010; Wittig et al., 2017), are also core activities within the *analysis* step.

The *design* step implies thinking outside of the box and the generation of ideas through the use of creative tools (Frankenberger et al., 2013; Wittig et al., 2017). It also includes defining in detail different aspects, conceptualising the value proposition and business model, integrating all elements for business model design and analysing the feasibility of the proposed design (Geissdoerfer et al., 2017; Osterwalder y Pigneur, 2010; Teece, 2010; Wirtz y Daiser, 2018). The last activity in this step should be focused on choosing the best business model idea (H Chesbrough, 2007; Osterwalder y Pigneur, 2010; Wirtz y Daiser, 2018).

The *test* step comprises activities to put the conceptualised elements into practice. It highlights experimentation, prototyping, testing and validating key assumptions and hypotheses (H Chesbrough, 2007; Geissdoerfer et al., 2017; Osterwalder y Pigneur, 2010; Wirtz y Daiser, 2018; Wittig et al., 2017).

Finally, the *implementation* step involves the launch of the new business model. Related activities include the development of the implementation plan, achieving commitment within the organisation and scaling up the business model (H Chesbrough, 2007; Frankenberger et al., 2013; Geissdoerfer et al., 2017; Osterwalder y Pigneur, 2010; Wirtz y Daiser, 2018; Wittig et al., 2017). In addition, once the new business model is implemented, it must be continuously monitored and controlled, and it must be revised when necessary to maintain its competitive advantage (Geissdoerfer et al., 2017; Osterwalder y Pigneur, 2010; Wirtz y Daiser, 2018).

The main activities related to the business model innovation process have been explored here. The next subsection analyses business model innovation tools. This thesis focuses on the first three steps of the business model innovation process, which encompass the analysis, design and test of the business model before its implementation. Therefore, tools supporting these three steps and facilitating their practical application are addressed.

2.3.2. Business model innovation tools

The literature on business model innovation tools is widely dispersed, but several authors have reviewed and categorized the techniques and tools discussed in that literature (Bouwman et al., 2020; Eurich et al., 2014; Tesch y AS Brillinger, 2017). For instance, Eurich, Weiblen and Breitenmoser (2014) group tools based on the similarity of their underlying approach in supporting the steps of the business model design process. They propose six archetypes: cases and lessons learned, component-based approaches, taxonomies, conceptual models, causal loop diagrams and design patterns. Tesch and Brillinger (2017), in their search for tools and methodologies for digital business model innovation projects, classify a set of tools using two evaluation criteria: (1) quantitative versus qualitative evaluation and (2) effectual versus causal reasoning. In a recent special issue on business model tooling, Bouwman et al. (2020) use an information systems perspective to explore tools that facilitate business modelling, distinguishing between tools specifically developed for business models and tools focused on strategy. Schwarz and Legner (2020), in turn, classify business model tools as conceptual models, methods or information technology support.

Nevertheless, in the business model innovation literature, three sources of tools seem to be highlighted most often: (1) tools from the business model literature; (2) tools from the strategic management field applied to business model innovation; and (3) tools from design, entrepreneurial and agile fields that are suggested to support business model innovation. In the following paragraphs, tools from each of these streams are reviewed.

Tools based on business model literature

Over recent decades several business model representations, frameworks and ontologies have been developed that provide a nexus between theory and practice (Gassmann et al., 2016). According to Massa and Tucci (2013), these tools to support business model innovation can be structured at different levels of depth and complexity depending on the desired degree of abstraction from the reality they are trying to describe (Figure 23).

At the base of the pyramidal representation of business model approaches (Figure 23) is the activity system perspective (Afuah y Tucci, 2001; Amit y Zott, 2001), which could be considered the closest approach to a real view of business models. As mentioned in subsection 2.1.1, when analysing business model definitions, Zott and Amit (2010) define business models as a system of interdependent activities that includes partners, vendors or customers outside of the firm boundaries. To support business model design, these same authors define three elements (i.e. content, structure and governance) and four design themes (efficiency, novelty, complementarities and lock-in). This approach provides guidance to managers when configuring the firm's architecture and the logic of its network of exchange partners (Gassmann et al., 2016). Consequently, it could be useful in ideating and designing a new business model, whereas, to the best of the author's knowledge, no tools have been developed to help practitioners apply this approach during business model innovation.

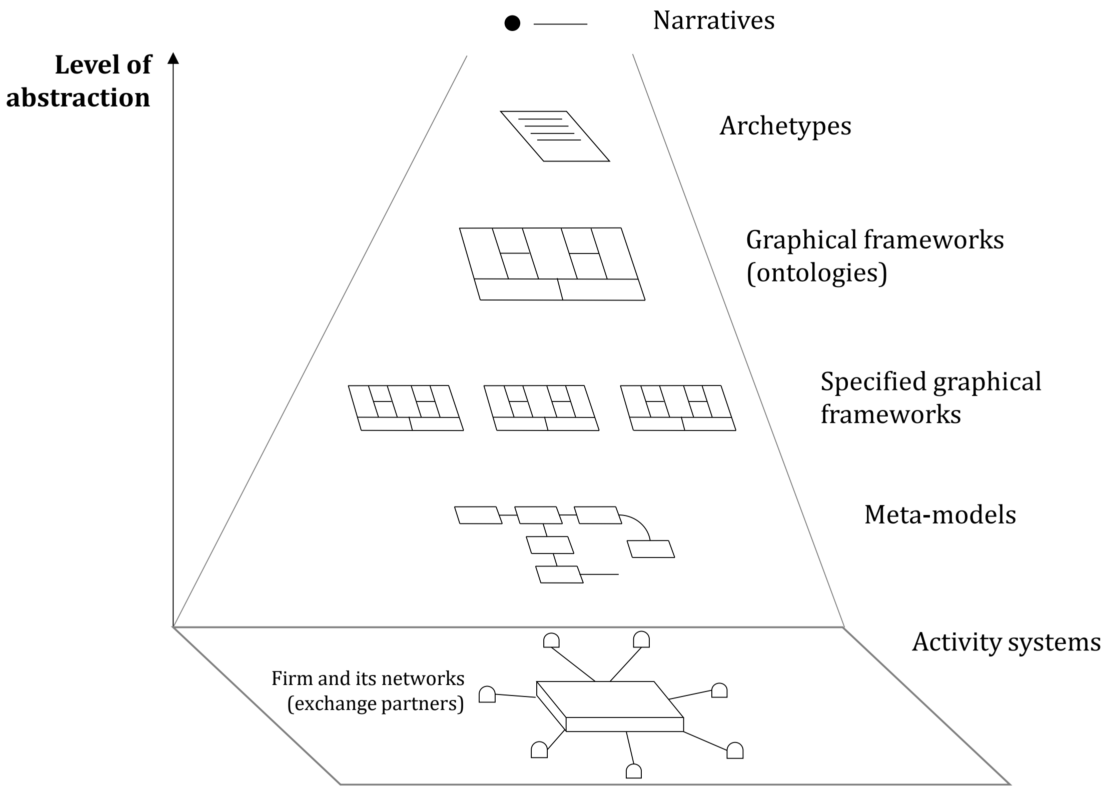

Figure 23 Business models at different levels of abstraction from the "reality". Adapted from Massa and Tucci (2013)

At higher levels of business models abstractions, various tools can be found which support different steps of the business model innovation process (Table 16). Following the business model representation scheme in Figure 23, tools found in the literature are analysed below.

Table 16 Tools from the business models literature for business model innovation

Approach	Tools	Reference	BMI process step
Business model as a representation	Narratives and verbal descriptions	Magretta (2002), Baden-Fuller and Morgan (2010), Perkmann and Spicer (2010)	Analysis
	Archetypes, business model patterns	Lindgardt et al. (2009), Osterwalder and Pigneur (2010), Abdelkafi et al. (2013), Gassmann et al. (2014), Amshoff et al. (2015), Bosbach et al. (2017), Remane et al. (2017), Weking et al. (2018)	Analysis, Design
Business model as component-based configurations	Graphical frameworks and ontologies: Business Model Canvas, VISOR, STOF…	Bouwman H.; Haaker, T. (2008), Osterwalder and Pigneur (2010), Solaimani H. (2012), El Sawy and Pereira (2013), Lindgren and Rasmussen (2013), Gassmann et al. (2014)	Analysis, Design, Test
Business model as a system	Meta-models	Gordijn and Akkermans (2001), Casadesus-Masanell and Ricart (2010), Abdelkafi K. (2016), Cosenz and Noto (2018)	Design, Test

Moving from the activity system perspective to a broader abstraction of the business model we find the meta-models (Figure 23). Strongly influenced by the fields of strategy and system dynamics, some authors understand the business model as a system of interdependent strategic choices and likely consequences. In this sense, Gordijn and Akkermans (2001) propose a modelling tool to define how economic value is created and exchanged within a network of actors. Casadesus-Masanell and Ricart (2010) suggest applying system dynamics modelling (Sterman, 2001) to explore how the architecture of choices drives the overall business model. Building on this approach, later studies (Abdelkafi y Täuscher, 2016; Cosenz y Bivona, 2020; Cosenz y Noto, 2018) demonstrate the suitability of system dynamics for business modelling as a tool to design and experiment with new business models (Table 16).

At a higher level of abstraction, practice-oriented business model ontologies and frameworks are found (Table 16). Unlike meta-models, they focus primarily on representing business model components without delving into the dynamics between components (Figure 23). Tools of this kind are based on graphical frameworks and visual schemes that operationalise in detail the different business model components and therefore are suitable for business model design and reconfiguration (Osterwalder y Pigneur, 2013). According to Massa and Tucci (2013), this kind of graphic frame offers greater descriptive accuracy and a rigorous approach to planning and structuring business model innovation.

Examples of frameworks and ontology-based tools include the business model ontology proposed by Osterwalder (2004), later translated into the *Business Model Canvas* (Osterwalder y Pigneur, 2010), which depicts the business model using nine building blocks at the firm level (customer segments, value proposition, customer relationships, channels, revenue streams, key activities, key resources, key partners and cost structure). This is one of the frameworks best-known and most widely used by professionals to date (Belussi et al., 2019; Lima y Baudier, 2017). According to Heikkilä et al., (2018), European SMEs making use of frameworks to describe and analyse their business model, often use this template. Another example is the *business model navigator* framework (Gassmann et al., 2014), which also conceptualises the business model at the firm level based on the target customer, the value proposition, the value chain and the revenue model. Another tool, the *STOF* framework (Bouwman H.; Haaker, T. et al., 2008), addresses service innovation in particular and defines four domains, named the service, technology, organisation and finance domains. The *Business Model Cube* framework (Lindgren y Rasmussen, 2013) frames the business model based on seven dimensions (value proposition, customer, value chain, competencies, network, relationships and value formula) and their relationships from a business ecosystem perspective. Also adopting a network perspective, the *VISOR* framework (El Sawy y Pereira, 2013) focuses on the modelling of digital business models, suggesting five dimensions (value proposition, interface, service platforms, organizing model and revenue/cost sharing). The framework thus integrates previous dimensions while including user experience and interface factors. Finally, the *VIP* framework (Solaimani H. et al., 2012) focuses on operational processes, decomposing complex interactions between actors in three generic domains related to value, information and processes. Frameworks and ontologies are considered tools that can serve as living documents in constant evolution, being useful in all the steps of the business model innovation process (Table 16). They encourage learning, discussion and continuous improvement of business models, reducing risks and the probability of failure (Osterwalder y Pigneur, 2010; Tesch y AS Brillinger, 2017). Nevertheless, they do not allow for a complete explanation of the dynamic aspects associated with a given business model in the way meta-models do (Belussi et al., 2019; Massa y Tucci, 2014).

Approaching business models as a representation (Table 16), several authors have suggested the use of tools based on patterns or archetypes as analogies for creative imitation, which has already been considered a source of innovation in the traditional innovation management literature (Hargadon, 2002). These tools are meant to serve as ideal examples of business model types (i.e. archetypes and typologies) based on the recognition of patterns in the structure of business models (Belussi et al., 2019). Business model archetypes or patterns embed empirical findings from real cases and are usually described with a meaningful title, a short description and an overview of the business model components that play a key role in the pattern (Gassmann et al., 2016; Massa y Tucci, 2014). They serve as confrontation techniques to challenge the dominant logic of a company when innovating the business model (Gassmann et al., 2014; Osterwalder y Pigneur, 2010). Thus, several contributions can be found in the literature that propose the use of business model patterns as tools to understand and learn from existing solutions and to brainstorm new opportunities (Abdelkafi et al., 2013; Amshoff et al., 2015; Bosbach et al., 2017; Gassmann et al., 2014; Lindgardt et al., 2009; Osterwalder y Pigneur, 2010; Remane et al., 2017; Weking et al., 2018), as the tools are useful for both the analysis and design steps.

Finally, at the top of the pyramid (Figure 23), business model *narratives* (Perkmann et al., 2010) allow us to represent how a company works (Table 16). These tools, also referred to as stories or verbal descriptions (Magretta, 2002), facilitate the adoption of a common language, the sharing of ideas and collective sense-making, and they help create legitimacy for the business model within the firm and with stakeholders (Belussi et al., 2019). Therefore, these tools can improve the analysis of the current business model and facilitate the shared exploration of new opportunities between different actors.

The strength of narratives and business model pattern-based tools lies in their simplicity. However, they tend to be difficult to manipulate during the design, experimentation and evaluation phases of a business model innovation process and do not provide structural guidance for business model innovation (Belussi et al., 2019; Eurich et al., 2014; Massa y Tucci, 2014).

Tools from the strategic management field

Tools from business model literature have been reviewed; this subsection now reviews tools from the strategic management field applied in the business model innovation literature. As depicted in Table 17, a number of authors support the usefulness of strategic tools to analyse, design and test new or existing business models during the business model innovation process.

Table 17 Strategic management tools for business model innovation

Approach/Area	Tools	Author	Related activities
Strategic decisions	- Porter's five forces	Pateli G. M. (2005), Carney et al. (2006), Osterwalder and Pigneur (2010), Keller et al. (2017)	Analysis, Test
	- PESTLE	Osterwalder and Pigneur (2010), Keller et al. (2017), Haaker et al. (2017)	Analysis, Test
	- SWOT analysis	Osterwalder and Pigneur (2010), Abdelkafi et al. (2013), Martikainen et al. (2014), Keller et al. (2017)	Analysis
	- Trend analysis - Scenario planning - Corporate foresight - Business model stress testing	Pateli G. M. (2005), Bouwman et al. (2008, 2009, 2012, 2018), Breuer (2013), Osterwalder (2010, 2014), Tesch (2016), Haaker et al. (2017)	Analysis, Test
	- Roadmapping	Osterwalder and Pigneur (2010), Bouwman et al. (2012), De Reuver et al. (2013)	Analysis, Design
	- Blue Oceans Strategy Canvas	Osterwalder (2010, 2014), Breuer (2013)	Analysis
Market research	- Customer Segmentation tools - Customer relationship management - Market research tools	Eriksson et al. (2008), Brettel et al. (2012), Wu et al. (2013), Osterwalder (2010, 2014)	Analysis
Value networks	- Value stream map - Quality function deployment - Value mapping tool	Pynnönen et al. (2008), Pynnönen et al. (2012), Geissdoerfer et al. (2016), França et al. (2017)	Analysis
Financial tooling	- Profit sheet - Financial tooling	Gordijn and Akkermans (2001), Bouwman et al. (2012), Breuer (2013)	Test
	- Balanced scorecard	Batocchio et al. (2017)	Test
	- Performance indicators - Spreadsheets	Bouwman et al. (2012), Heikkilä et al. (2016)	Test
	- Innovation readiness metrics	Evans (2013)	Test
Others	- Business plan	Osterwalder and Pigneur (2010)	Analyse, Design, Test

Regarding strategic management tools that provide support for strategic decisions, authors suggest techniques such as the PESTLE analysis (political, economic, social, technological, legal and environmental) to brainstorm trends and uncertainties (Haaker et al., 2017; Keller et al., 2017; Osterwalder y Pigneur, 2010). Porter's five forces framework is presented as a useful tool for analysing a market or market segment before designing the business model (Keller et al., 2017; Osterwalder y Pigneur, 2010), for assessing a business model in a particular sector (Carney et al., 2006) or for evaluating the impact of a proposed business model on the external environment (Pateli G. M., 2005).

The SWOT (strengths, weakness, opportunities and threats) analysis is proposed to evaluate an existing or potential business model (Martikainen et al., 2014;

Osterwalder y Pigneur, 2010). Abdelkafi et al. (2013), for example, suggest its use during the decision-making process to examine the strengths and weaknesses of the designed business model, and to determine potential opportunities and threats that may result from it. Keller et al. (2017) also recommend its use for analysing the microenvironment of the firm.

Other strategic management tools suggested to support the business model innovation process include trend analysis, scenario planning and corporate foresight. In this vein, Pateli G. M. (2005) presents a methodology for identifying a set of alternative scenarios for cooperation among stakeholders and for configuring business models based on these scenarios. Breuer (2013) applies corporate foresight and scenarios to develop insights into how the business and competitive environment may evolve and to sensitize the team to emerging opportunities and threats in the telecommunication industry. Bouwman et al. (2008, 2009, 2012) apply scenario analysis in various works to explore future information and communication technologies, to design strategic options and to assess the viability and feasibility of alternative new business models. Bouwman et al. (2012, 2018) use the name *business model stress testing* to describe the process of validating the strong and weak parts of a business model using scenario analysis. Based on their work, Haaker et al. (2017) also evaluate the feasibility, viability and robustness of new business models, applying the business model stress testing approach to what they term "an agile process of strategy experimentation for business model innovation" (p. 23). Tesch (2016) uses scenario planning as an evaluation methodology for business model innovation in the context of the industrial Internet of things.

The roadmap (Phaal, 2004) is also highlighted as a method for developing a business model, evaluating the viability and feasibility of future business models or defining the steps to business model innovation (De Reuver et al., 2013). Bouwman et al. (2012) propose the roadmap as a way to explore how the current business model should be changed to enable the launch of a desired business model in the future. De Reuver et al. (2013) posit that a roadmap serves as an intermediate step between the strategic level and the operational level and that it is needed to translate the business model concept into a practical plan. Osterwalder and Pigneur (2010), in turn, suggest the use of roadmaps to define a plan to implement a business model after it has been designed.

In his practitioner oriented books, Osterwalder (2010, 2014) combines the potential of Porter's five forces, PESTLE analysis and trend analysis into a map to support managers who are assessing the different directions in which a business model might evolve and to identify business model innovation opportunities or prepare the company for the future. The "environment map" suggested by Osterwalder contains the following elements: market forces, industry forces, key trends and macroeconomic forces. The use of tools such as customer scenarios and future scenarios during business model design is also recommended (Osterwalder y Pigneur, 2010).

Adopting an approach less focused on the analysis of the competitive environment (red oceans) and more focused on the search for new opportunities (blue oceans), some authors suggest conducting a blue ocean analysis (Kim y Mauborgne, 2004). The Blue Ocean Strategy Canvas facilitates identifying new market positioning based on new markets or customer segments and thereby interpreting potential innovation opportunities (Breuer, 2013; Osterwalder, 2014; Osterwalder y Pigneur, 2010).

Another group of tools addressed in business model innovation relate to customer and market research techniques. Business model innovation is about delivering new value propositions to an existing or new customer. Along these lines, traditional marketing approaches and tools such as customer intelligence, customer relationship management and other customer-oriented tools have been suggested in the literature (Brettel et al., 2012; Eriksson et al., 2008; Wu et al., 2013). In recent years, other tools adopted from the anthropology field have gained relevance for use in capturing customer insights, such as observation, customer interviews and co-creation processes (Osterwalder, 2014). These kind of tools are useful to explore new customer and market segments or to deepen the analysis of existing customers.

Moving forward to tools focused on network analysis, value stream mapping (VSM) is gaining attention as a technique that facilitates a multi-stakeholder perspective for exploring value creation from a sustainability perspective (e.g. Bocken S.; Rana, P.; Evans, S., 2013; Geissdoerfer, Bocken and Hultink, 2016; França *et al.*, 2017). According to Geissdoerfer et al. (2016), VSM facilitates the analysis of the current value proposition and new value opportunities, since it helps in identifying value that is being destroyed, wasted or missed. Additionally, as an approach to customer-driven business model innovation, some authors combine VSM with the quality function deployment tool to integrate customers' value preferences in the business model (Pynnönen et al., 2008, 2012). Thus, tools of this kind seem useful in the analysis step.

Other authors propose the use of financial and performance indicator-based tools to support the design and evaluation of the financial components of business models. For example, Evans and Johnson (2013) developed a risk/return framework to evaluate the innovation readiness of business model innovation in its early stages. Bouwman et al. (2012) suggest the use of spreadsheets to evaluate and select the best business model design based on viability indicators. Heikkilä et al. (2016) provide a generic repository of metrics (customer value, technologies, organisation, finance and value exchange, information exchange and process alignment) to evaluate the performance of e-business when designing new business models. Batocchio et al. (2017) propose using the balanced scoreboard (Kaplan y Norton, 1992) combined with the Business Model Canvas (Osterwalder y Pigneur,

2010) to assess a start-up's business model performance. Others suggest the use of profit sheets to evaluate the cost and benefit of business models (Gordijn et al., 2001) or to compare the business model viability of different designs (Bouwman et al., 2012). Hence, these financing tools seem to be suitable for testing and evaluating new business model concepts.

Finally, another group of tools found during the literature review refer to the business plan (Osterwalder y Pigneur, 2010). This tool documents business model design choices and can help companies to communicate the new business model inside and outside the organisation. Thus, it can guide the business model innovation process from analysis to implementation.

Tools from design, entrepreneurship and agile fields

Building on the idea that business model innovation should derive from trial and error, learning and experimenting (Demil y Lecocq, 2010; Frankenberger et al., 2013; McGrath, 2010; Sosna et al., 2010), practices such as design-thinking approaches (Brown, 2008), lean start-up methodologies (Ries, 2011) and agile methods (Bouwman et al., 2012) are gaining attention among academics in the business model innovation field (Tesch y A Brillinger, 2017; Trimi y Berbegal-Mirabent, 2012), as depicted in Table 18.

Table 18 Tools from entrepreneurship, agile and design fields for business model innovation

Approach/Area	Tools	Author	Related activities
Design thinking	- Personas - Empathy maps - Customer journey maps - Stakeholder map - Customer value map - Value proposition maps - Customer interviews - Observation - Co-creation - Prototyping	Osterwalder (2010, 2014), Geissdoerfer, Bocken and Hultink, (2016), Iriarte et al. (2018), Beltagui (2018)	Analysis, Design, Test
	Creativity and problem solving techniques: - brainstorming - storytelling	Breuer (2013), Osterwalder (2010, 2014), França *et al.*, (2017), Täuscher and Abdelkafi (2017)	Design
Lean start-up method	- Progress evaluation metrics - Minimum viable product - Rapid prototyping - Experimentation - Testing - Hypothesis development and validation techniques	Osterwalder (2010, 2014), Blank (2013), Breuer (2013), Bocken et al. (2018), Balocco et al. (2019), Ghezzi and Cavallo (2020)	Analysis, Design, Test
Agile methodologies	- Agile Scrum - Visual prototypes	Bouwman et al. (2012)	Test

Design thinking is a human-centred creative problem solving method based on an iterative process addressing customer insight identification, idea generation, testing and implementation (Kimbell, 2011). The three main principles behind this approach are (1) creativity as a driver for innovation, (2) empathizing with customers and (3) the intensive use of prototypes (Brown, 2008). One of the clearest examples of the suitability of design thinking for business model innovation is the process suggested by Osterwalder and Pigneur (2010) in the *Business Model Generation* handbook, which is based on the design-thinking philosophy.

The main purpose of design thinking in the context of business model innovation is to capture the latent needs and expectations of customers and stakeholders and to create, implement, test and refine ideas as many times as needed until the value proposition and the business model of the company truly fit the customer segment's requirements (Link, 2016). Thus, Osterwalder and Pigneur (2010) provide a set of tools such as empathy maps to gain customer insights or visual prototypes to continuously test and refine new business model ideas during the business model innovation process.

The application of design-thinking-based tools for business model innovation is stressed in various contexts, such as in servitization (Beltagui, 2018; Iriarte et al., 2018) and sustainability (Geissdoerfer et al., 2016). For example, Iriarte et al. (2018) apply tools such as "personas", "empathy maps" and "customer journey maps" in various projects with manufacturing firms, showing their relevance for designing customer-centred value propositions in service-based business model innovations. Additionally, Geissdoerfer, Bocken and Hultink (2016), based on different practical workshops, prove that the use of design-thinking tools (value mapping; idea generation techniques; brainstorming; prototypes and artifacts for presentations, discussion and documentation) enhance business model innovation.

The lean start-up approach (Ries, 2011; Trimi y Berbegal-Mirabent, 2012) involves the continuous evolution of early versions of a product or service. Lean start-up relies on optimized, cheap, small and fast iterations, combined with a continuous feedback loop from potential customers until the best solution for a value proposition or business model has been found (Blank, 2013; Bocken et al., 2018; Ries, 2011; Trimi y Berbegal-Mirabent, 2012). It has a strong emphasis on hypothesis testing and validation through customer interaction, and it involves experimentation through the use of minimum viable products (MVPs), which are early versions of the value proposition with the minimum core features needed to rapidly test customer or market reaction using the smallest possible investment in time and resources (Ries, 2011). Thus, lean start-up principles rely on "experimentation over elaborate planning; customer feedback over intuition; and iterative design over traditional 'big design up front' development" (Balocco et al., 2019, p. 1525).

Various practitioner-oriented books for business model innovation build on the lean start-up approach (Bland y Osterwalder, 2020; Osterwalder, 2014). At the same time, the Business Model Canvas has become part of the portfolio of tools in the lean start-up approach (Felin et al., 2019), since it is an important framework for entrepreneurship and business creation. The Value Proposition Canvas (Osterwalder, 2014) also enables the design of value propositions, aligning them with the customer needs, pains and gains, and testing the value propositions rapidly in the market. Other tools based on creativity techniques, such as brainstorming or storytelling, and tools to address customer insights, such as observation, interviews, co-creation sessions, value proposition maps or rapid prototypes, are part of the set of tools proposed in the lean start-up approach to support business model innovation. Recently, Bland and Osterwalder (2020) provided a set of 44 tools to support experimentation and testing, many of them based on the lean start-up approach.

Moreover, various authors have shown the usefulness of lean start-up-based tools during business model innovation (Balocco et al., 2019; Bocken et al., 2018; Ghezzi y Cavallo, 2020). For instance, Bocken et al. (2018) find that the use of MVPs and field test experiments helps small and large companies to test assumptions regarding the three dimensions of value creation, delivery and capture, highlighting the need for an iterative process. Ghezzi and Cavallo (2020) show that the use of tools such as marketing metrics, MVP, wizard of oz testing or sprints from the scrum framework (Schwaber y Beedle, 2001) facilitate business model experimentation and testing and, thus, business model innovation in the early stages of digital start-ups.

Finally, some authors particularly emphasize the usefulness of agile approaches such as scrum methods (Schwaber y Beedle, 2001) for software development (Bouwman et al., 2012; Mezger, 2014). In this sense, Bouwman et al. (2012) apply the tool Dialogues Scrum to iteratively involve stakeholders and team members to gain rapid feedback on business viability in the software industry.

2.3.3. Summary of the section

In this section business model innovation processes and related tools have been analysed. From the review, the following can be concluded:

- Despite the existence of multiple versions of the business model innovation process (from more general to more detailed), the steps involved can be summarized into four main ones: (1) analysis, (2) design, (3) test and (4) implementation. This thesis focuses on the first three steps.
- Several tools that facilitate business model innovation process have been presented and analysed. These tools can simultaneously support multiple activities within the business model innovation process. Indeed, some tools such as the Business Model Canvas seem suitable for most of the steps (i.e. analysis, design and test).
- Despite the large number of studies exploring the business model innovation process or the usefulness of certain tools to support its practical implementation, few studies offer an integrated vision of the tools required to innovate the business model (Heikkilä, Bouwman, Heikkilä, Haaker, et al., 2016; Osterwalder y Pigneur, 2010; Wittig et al., 2017), particularly in the

context of SMEs, studies of which are limited (Heikkilä, Bouwman, Heikkilä, Haaker, et al., 2016; Rumble y Mangematin, 2015).

- Finally, most researchers underline the usefulness and impact of tools based on qualitative approaches (Balocco et al., 2019; Bocken et al., 2018; Ghezzi y Cavallo, 2020; Heikkilä, Bouwman, Heikkilä, Haaker, et al., 2016; Iriarte et al., 2018; Keller et al., 2017), but few of them explore the causal effects of tools on business model innovation. To the best of the author's knowledge, the closest approach is the configurational analysis provided by Rumble and Mangematin (2015), who explore the association between innovation based on multi-sided business models and the use of design, creativity or visualisation tools.

2.4. Critical review of the state of the art

Once the current state of the art in business model innovation in SMEs has been reviewed, various research challenges and opportunities can be identified. This section summarizes the main findings and outlines the critical gaps identified in the literature while emphasising the suitability and relevance of the present thesis.

SMEs are viewed as a source of economic development, wealth creation and employment generation in both the regional economy and the European economy (Pucihar et al., 2019; Scuotto et al., 2017). Hence, new ways to sustain and reinforce their competitiveness in today's uncertain environment have become key for their survival and also for the development of the region (Schoemaker et al., 2018; Voelpel et al., 2004).

In this context, business model innovation is emerging as a new source of competitive advantage that can complement or even substitute for traditional forms of product, process, marketing and organisational innovation (Amit y Zott, 2012; Bucherer et al., 2012; Foss y Saebi, 2018; Massa y Tucci, 2014; Schneider y Spieth, 2013; Teece, 2010).

Several studies support a positive relationship between business model innovation and SME performance (Asemokha et al., 2019; Bouwman et al., 2019; Gatautis et al., 2019; Guo et al., 2017; Huang et al., 2013; Lopez-Nicolas et al., 2020; Ma et al., 2018; Pati et al., 2018; Pucci, Nosi, Zanni, et al., 2017). Nevertheless, various authors suggest that more research is needed to expand our understanding of the performance implications of business model innovation (Anwar, 2018; Foss y Saebi, 2018; Lopez-Nicolas et al., 2020). Moreover, the relationship between business model innovation, competitive advantage and firm performance is still poorly understood (Anwar, 2018). Therefore, further research is required to shed light on the relationship between business model innovation and SME competitiveness.

Given business model innovation novelty as a research stream, there is still a lack of consensus on its definition, along with a lack of solid theoretical foundations and clearly defined constructs (Foss y Saebi, 2018; Ghezzi y Cavallo, 2020; Pansuwong, 2020; B Wirtz et al., 2016). As a result, the relationship between business model innovation and other forms of innovation (product, process, marketing and organisational innovation) remains unclear (Geissdoerfer, Vladimirova, Fossen, et al., 2018; Snihur y Wiklund, 2019). Thus, in addition to better understanding the potential benefits of business model innovation, it is necessary to explore whether business model innovation is valuable for SMEs compared to other types of innovation that may be more familiar to them.

Nonetheless, SMEs face unique challenges when implementing business model innovation due to their limited resources (Berends et al., 2014; Leithold et al., 2016), manager's influence (Arbussa et al., 2017; Pierre y Fernandez, 2018) and environmental contingencies (Orkestra, 2019; Saebi, 2014). In addition, organisational inertia and path dependencies can constrain the organisational restructuring and managerial decisions that business model innovation implies al., 2014). Nevertheless, the literature suggests that certain drivers related to a firm's behaviour (Asemokha et al., 2019; Bock et al., 2012; Hock et al., 2016), dynamic capabilities (Clauss et al., 2020; Hock-Doepgen et al., 2020; Ricciardi et al., 2016) and practices and tools (Bouwman et al., 2019; Lopez-Nicolas et al., 2020; Rumble y Mangematin, 2015) could help SMEs overcome those challenges. It is therefore essential to understand what factors could enable SMEs to proactively address business model innovation and the impact business model innovation could have on SMEs' competitiveness.

From an academic view, several frameworks, research models and empirical studies linking various antecedents and outcomes to business model innovation have been found. However, the literature is widely dispersed, and few studies provide a comprehensive view of the subject, with the identified studies being conceptual (Bashir y Verma, 2019; Foss y Saebi, 2017; Wirtz y Daiser, 2017) or part of a single project (Bouwman et al., 2015; Bouwman, Nikou, et al., 2018; Gatautis et al., 2019; Lopez-Nicolas et al., 2020; Pucihar et al., 2019). In this sense authors are calling for more empirical research, larger samples and replicability of studies (Clauss, 2017; Spieth et al., 2014; Zott et al., 2011). Moreover, recent studies argue that the relationship between drivers, business model innovation and its performance is not linear but rather a complex phenomenon that depends on contingency factors (Foss y Saebi, 2017; Kraus et al., 2018; Täuscher, 2018). From this view, a configurational approach seems to provide a more holistic perspective on how different antecedent conditions combine to drive business model innovation (Bouwman et al., 2019; Hock-Doepgen et al., 2020; Liao et al., 2019; Ricciardi et al., 2016; Rumble y Mangematin, 2015; To et al., 2019). Nevertheless, the application of mixed-method approaches to explore both linear and complex causality of attributes related to business model innovation are just emerging (Bouwman et al., 2019; Hock-Doepgen et al., 2020; Liao et al., 2019). Thus, more studies embracing such a holistic view of business model innovation in SMEs are needed.

Bearing all this in mind, this study aims to address the challenges mentioned above, exploring business model innovation in established SMEs from a holistic view. It particularly focuses on the internal antecedents that may lead SMEs to proactively address business model innovation, the effect business model innovation may have on an SME's competitiveness and its relationship with other forms of innovation. For that purpose, an integrative framework is developed, which is sustained from various theoretical perspectives and approached using a mix of methodological choices, allowing the exploration of business model innovation from different angles.

The present investigation is considered suitable and relevant for several reasons. First, it focuses on the business model innovation phenomenon in the context of SMEs, studying an emerging subject of great relevance that is little understood. Second, business model innovation represents a new source of sustainable competitive advantage in an increasingly uncertain and changing environment, and therefore, comprehension of it is relevant for academics, practitioners and regional policy makers. Finally, this work responds to a research gap in the academic literature, where several authors emphasize the lack of integrative frameworks and the need for further empirical research.

Chapter 3

Theoretical approach, research framework and objectives

3. Theoretical approach, research framework and objectives

The literature has been reviewed, and the theoretical foundations, research framework and research objectives are elaborated in this chapter. First, theoretical foundations that afford consistency to the research framework are addressed. Then, the research framework is developed, providing the basis for the present research. The chapter ends with the definition of specific objectives that guide the empirical exploration of the elements within the research framework.

3.1. Theoretical underpinnings

Several scholars suggest that business model innovation literature has grown paying little attention to the question of theory, with the concept still theoretically underdeveloped and sometimes even overloaded (Foss y Saebi, 2018; Massa et al., 2017; Ritter y Lettl, 2018; Schneider y Spieth, 2013; Zott et al., 2010). Some authors further state that the theoretical reinforcing of the business model and business model innovation has often been done in a rather opportunistic way, with fundamental issues underestimated, making it difficult to conceptualise them using rigorous theory (Foss y Saebi, 2018).

Nevertheless, in recent decades, business model innovation has been explored through several theoretical lenses (Foss y Saebi, 2018; Ritter y Lettl, 2018; Schneider y Spieth, 2013). Indeed, Gassmann et al. (2016) identified up to 20 management theories that contribute to business model innovation and 30 additional theories with potential for future research.

Based on the literature review presented in Chapter 2, the difficulty of associating a single theory with business model innovation has been recognised. Depending on the research purpose, authors have applied different theoretical currents to understand the business model innovation phenomenon. For instance, as has been discussed in depth, several authors have based their approaches in the dynamic capabilities view, using it to analyse the influence of different firm abilities or routines in business model innovation (Achtenhagen et al., 2013; Arbussa et al., 2017; Bashir y Verma, 2019; Bock et al., 2010; Cavalcante, 2014; Čirjevskis, 2019; Clauss et al., 2019; Hock-Doepgen et al., 2020; Hock et al., 2016; Inigo et al., 2017; Liao et al., 2019; Pucci, Nosi, Zanni, et al., 2017; Roaldsen, 2014; Vicente et al., 2018; Voelpel et al., 2004).

In addition, authors concerned with the effect of learning and experimentation on business model innovation approach the subject from organisational learning theory (Andries et al., 2013; Sosna et al., 2010).

Among authors exploring organisational factors, various theoretical underpinnings have been built on, such as organisational ecology theory (Huang et al., 2013) and contingency theory (Chereau y Meschi, 2019; Guo et al., 2013; Kranich A. et al., 2017). Other authors highlighting firms' decision-making logics during business model innovation build on effectuation theory (Futterer et al., 2018; Torkkeli et al., 2015).

Research on individual factor levels tends to explain the role of managers in business model innovation based on different theories, such as upper echelons theory (Anwar et al., 2019; Guo et al., 2013), prospect theory (Najmaei, 2016; Saebi et al., 2017), threat-rigidity theory (Osiyevskyy J. et al., 2015; Osiyevskyy y Dewald, 2018; Saebi et al., 2017) or institutional and cognitive perspectives (Child et al., 2017).

Those authors studying business model innovation as a source of competitive advantage usually build on the resource-based view (Anwar, 2018; Cavalcante, 2014; Child et al., 2017; Liao et al., 2019; Mahadevan, 2004; Schneider y Spieth, 2013). To a lesser extent, Porter's competitive forces (Anwar, 2018) and the Schumpeterian innovation-based competition approach (Anwar, 2018; Mahadevan, 2004) are also referenced.

Other scholars follow a configurational approach (Ammar y Chereau, 2018; Bouwman et al., 2019; Rumble y Mangematin, 2015; To et al., 2019) aiming to create typologies or identify configurational paths to business model innovation, sometimes combining this approach with other theories such as the dynamic capabilities view, ambidexterity theory and organisational learning (Ricciardi et al., 2016), or innovation theory (To et al., 2019).

Finally, integrative research frameworks and models tend to be based on several theoretical approaches. For instance, Foss and Saebi (2017) cite complexity theory, complementarity theory, innovation theory, dynamic capabilities and open innovation theory (Figure 18). Bashir and Verma (2018), in turn, refer to various theoretical notions rooted in evolutionary theory, dynamic capabilities and the resource-based view (Figure 19).

Thus, it can be concluded that addressing business model innovation from a holistic perspective requires the integration of different theoretical foundations. This is in line with the thoughts of Ritter and Lettl (2018), who view the business model as a nexus between theories, contributing to the interconnection among ideas from various theories rather than competing with those ideas. To adopt the metaphor suggested by these authors, business model innovation can operate as a "semipermeable membrane" (Ritter and Lettl, 2018, p. 7) allowing the passage of certain ideas rooted in one theory to another theory through a logical connection between concepts while acting as a barrier to other theories.

In this context, Figure 24 presents the main approaches that provide the theoretical foundations in this thesis, which are linked somehow with each other, creating a theoretical membrane for business model innovation in established SMEs. As can be observed, five theoretical streams are adopted in the context of this research (innovation theories, the dynamic capabilities view, the resource-based view, configurational theory and effectuation theory). Additionally, four theories are presented as peripherals (evolutionary economics, behavioural theory, organisational learning theory and contingency theory), since their ideas influenced the development of the principal theories of the membrane (Figure 24).

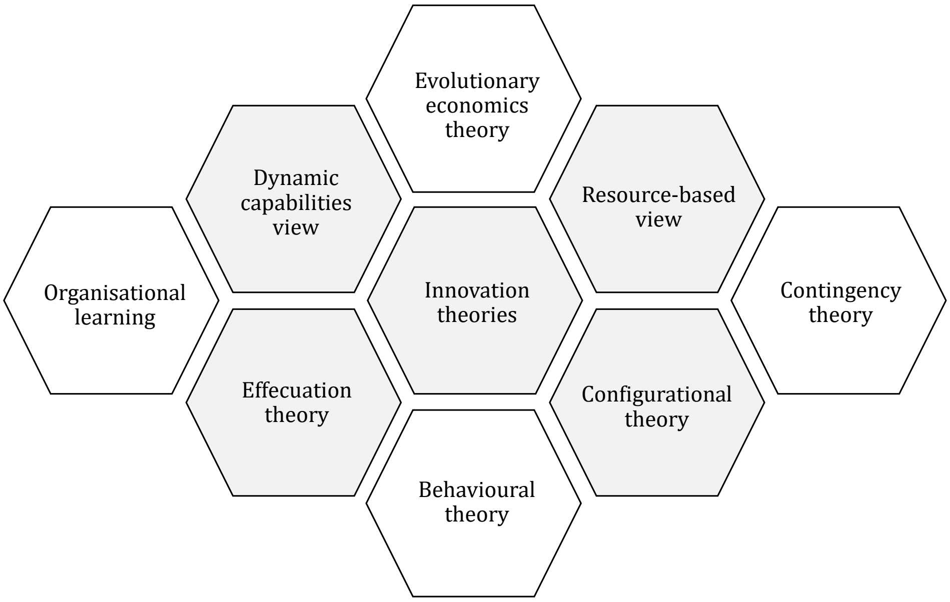

Figure 24 Business model innovation theoretical membrane

Innovation theories are placed in the centre because they have formed the basis for defining business model innovation (subsection 2.1.2). Various theories have been addressed, such as the seminal work of Schumpeter (1934), which considers innovation as a disruptive process and introduced the first conceptions of innovation types and innovation radicalness. In addition, Henderson and Clark's (1990) approach to architectural innovation as a complementary view on radical/incremental innovation has also been explained. Finally, the diffusion of innovation theory developed by Rogers (1983) has been referred to help us understand the degree of novelty with which an innovation can be measured. While these theories help us to comprehend how organisations compete through innovation (Schumpeter, 1934) or how innovation spreads and is adopted (Rogers, 1983), the membrane includes other theories that attempt to explain the way in which organisations innovate and improve their competitiveness.

Thus, the dynamic capabilities view is included as another principal theory in the membrane, since it allows an explanation of how a firm can achieve innovative forms of competitive advantage based on the development of certain abilities (Teece et al., 1997). Similarly, evolutionary economics theory (Nelson et al., 1982) highlights the role of organisational routines in overcoming path dependencies and exploring innovation opportunities (Maijanen et al., 2020). This theory is included together with behavioural theory of the firm and organisational learning theory as peripheral perspectives in the membrane, since their main ideas are integrated in the dynamic capabilities view (Schilke et al., 2018; Teece et al., 1997).

The resource-based view (Barney, 1991) is established as another principal theory within the membrane, as it has become one of the most popular theories for understanding sources of competitive advantage, and therefore it is suitable for exploring business model innovation and its effects on SMEs' competitiveness (Foss y Saebi, 2018; Gassmann et al., 2016; Schneider y Spieth, 2013).

Finally, to gain a more holistic view of the business model innovation phenomenon, configurational theory and effectuation theory are included, which complement the resource-based view and dynamic capabilities view. Thus, configurational theory, which is an extension of contingency theory (a peripheral theory in the membrane), views organisations as constellations of elements and states that the whole is best understood from a systemic perspective (Fiss et al., 2013). Effectuation theory, in turn, suggests that firms can take different routes to identify and exploit opportunities based on their behaviour (causal or effectual). These two theories therefore pave the way for a holistic approach.

Based on the fact that in this thesis business model innovation is understand as a new form of innovation, innovation theories have been useful to define and dimensionalise the construct (subsection 2.1.2). Below, the resource-based view, the dynamic capabilities view, configurational theory and effectuation theory are further developed, to provide, together with innovation theories, a more holistic approach to the business model innovation phenomenon and to establish the basis of the research framework of this thesis.

Resource-based view

The resource-based view (Barney, 1991) adopts an *inside-out* perspective, suggesting that a firm's idiosyncratic resources influence its competitive position (Penrose, 1959; Wernerfelt, 1984). Strategic emphasis is placed on the analysis of the company's internal resources and capabilities to improve production, acquire equipment or train people. A resource is a production asset the company owns, controls or has semi-permanent access to (Helfat M. A., 2003). Resources can be tangible (distribution systems, economies of scale, factories, land, raw materials, equipment, debt or ability to manage internal funds), intangible (patents, technological know-how, technical know-how, reputation or brand image) or people – that is, know-how, motivation or commitment (Barney, 1991; Barney y Hesterly, 2012). Organisational capabilities are those abilities of the firm to perform a coordinated set of tasks, using organisational resources, to achieve a specific end result (Helfat M. A., 2003). Resources and capabilities provide a unique character to a firm that is difficult to imitate and can, therefore, be a source of sustainable competitive advantage (Barney, 1991; Barney y Hesterly, 2012).

The resource-based view is founded on two assumptions. First, firms within an industry are heterogeneous – that is, all firms have different sets of resources– and due to this heterogeneity, some firms are able to outperform others (Barney y Arikan, 2001; Wernerfelt, 1984). Second, resources may not be perfectly mobile between firms, thus resource heterogeneity may be long lasting, enabling some firms to gain sustained competitive advantage (Barney, 1995). To analyse resources and capabilities and their potential to generate competitive advantage, Barney (1995) developed the *VRIO* framework, which determines whether a resource or capability has the potential to create and maintain competitive advantage in terms of *Value, Rareness, Inimitability and Organisation.*

Resources are *Valuable* for the firm when they allow the company to exploit opportunities or neutralize threats. They are *Rare* when a company's current and potential competitors find it difficult to possess them, otherwise they would not provide competitive advantage, since all companies would have the same capabilities. Firms that are able to possess valuable and rare resources (and capabilities) can introduce value creation strategies that others cannot and, consequently, can benefit from the advantages of being pioneer in the market.

Resources are *Imperfectly imitable* when the competition cannot duplicate them. If valuable and rare resources can be easily imitated, competitors will quickly copy them, removing their potential value for competitive advantage. Resources can be difficult to imitate for various reasons: (1) the historical background or path dependencies of the organisation, (2) the ambiguous causalities between the resources and the competitive advantage (the competition cannot understand and therefore does not know how to duplicate them), (3) the complex social processes of the organisation such as the interpersonal relations between managers or the organisational culture (Barney, 1986), (4) patents and legal property rights, (5) the imitation process is lengthy.

Finally, the firm must be *Organised* to properly exploit the maximum potential of its resources and capabilities, otherwise the three first attributes may not result in a sustained competitive advantage (Barney, 1995).

The resource-based view provides an appropriate theoretical foundation to explain how business model innovation may be a potential source of competitive advantage and, consequently, superior performance in SMEs (Foss y Saebi, 2018; Gassmann et al., 2016; Schneider y Spieth, 2013). It emphasizes the relevance of both the effective exploitation of resources and capabilities combinations and the managerial actions that allocate resources effectively, which have been stressed as important aspects of business model innovation in established companies (Cavalcante et al., 2011; Clauss et al., 2020; Cortimiglia et al., 2016; Hock et al., 2016; Massa y Tucci, 2014; Schneider y Spieth, 2013). In addition, it states that a company's competitive advantage is created and sustained in the firm's resources and capabilities, which form the base of their value creation and capture mechanism, and therefore, their business model (Teece, 2007, 2010). In line with this, it can be assumed that when a business model is valuable, rare, difficult to imitate and managed in the best way to be exploited, it is likely to provide sustainable competitive advantage. Based on this, it can be presumed that SMEs may be able to compete through their business model, gaining advantage from the business model itself and, consequently, achieving superior performance (Roaldsen, 2014).

Dynamic capabilities view

The dynamic capabilities theory was first introduced by Teece, Pisano and Shuen (1997) to overcome the relatively static nature of the resource-based view. As explained in Chapter 2, Teece, Pisano and Shuen (1997) defined the dynamic capabilities as "the firm's ability to integrate, build and reconfigure internal and external competences to address rapidly changing environments" (p. 516). Thus, whereas the resource-based view focuses on the company's existing resource and capabilities base, the dynamic capabilities view addresses the purposeful modifications of this resource and capabilities base, to address changing environments and preserve competitive advantage (Schilke et al., 2018). In this sense, the dynamic capabilities view distinguishes between two types of organisational capabilities.

The first type, ordinary or operational capabilities, are the resources, skills, routines, experience, knowledge and characteristics of the firm that focus on the daily activities the company carries out to maintain good performance (Hoopes y Madsen, 2008). Examples of operational capabilities are efficient manufacturing, marketing or operational leadership capabilities which support the production and sales of the firm's products and services (Schoemaker et al., 2018).

The second type, the dynamic capabilities, are considered superior capabilities, or change capabilities, that alter the tangible resources, intangible resources and operational capabilities of the firm (Helfat et al., 2007; Winter, 2000, 2003). Dynamic capabilities can even drive change in the organisational structure, the external environment and the strategy of the firm (Schilke et al., 2018). Therefore, while operational capabilities respond to "how we earn a living now" (Winter, 2003, p. 992), the dynamic capabilities are the ones that enable a firm "to alter how it currently makes its living" (Helfat and Winter, 2011, p. 1244).

The dynamic capabilities view has become one of the most applied theories in management research (Schilke et al., 2018). In the last two decades different approaches to the definition, conceptualisation and dimensionalisation of these capabilities have been developed (Barreto, 2010; Schilke et al., 2018; Zahra et al., 2006). Despite their relevance, the dynamic capabilities concept is still considered abstract by some authors, who state that it is not clear what dynamic capabilities really are and how they can be conceptualised and measured (Achtenhagen et al., 2013; Danneels, 2008; Roaldsen, 2014; Schilke et al., 2018). As observed during the review of the state of the art (Chapter 2), this issue is also reflected in the business model innovation literature, where the conceptualisation and underlying dimensions of dynamic capabilities differ widely from one study to another (Table 19).

In this sense, some authors dimensionalise dynamic capabilities following the procedural distinction of Teece's (2007) sensing, seizing and reconfiguring capabilities (Čirjevskis, 2019; Inigo et al., 2017; Mezger, 2014; Teece, 2017; Vicente et al., 2018). Other scholars conceptualise the capabilities based on the specific type of dynamic capability they are addressing. For instance, various authors focus on the innovation capabilities of the firm, labelling these capabilities as service innovation capabilities (Janssen y den Hertog, 2016; Kiani et al., 2019) or business model innovation capabilities (Hock et al., 2016). Others address a particular set of capabilities such as knowledge management capabilities (Hock-Doepgen et al., 2020), strategic agility (Battistella et al., 2017; Clauss et al., 2019) or organisational agility (Liao et al., 2019). Finally, dynamic capabilities have also been conceptualised as critical capabilities (Achtenhagen et al., 2013), firm capabilities (Pucci et al., 2017) and resilient dynamic capabilities (Ricciardi et al., 2016). When dimensionalising these dynamic capabilities it can be observed that almost all the studies identified (Table 19) differ in terms of how they operationalise the dynamic capabilities. However, although different approaches exist, all of them indicate that the dynamic capabilities view seems to be suitable to understand how firms adapt the existing business model to environmental changes and lead to competitive advantage (Hock et al., 2016).

Delving into its theoretical roots reveals that the dynamic capabilities view has drawn from various theoretical perspectives, such as the behavioural theory of the firm, evolutionary economics theory and organisational learning theory (Teece et al., 1997).

Drawing on the behavioural theory of the firm, the dynamic capabilities view highlights the presumption of bounded rationality, which suggests that individuals' decisions are limited by the traceability of the decision problem, the cognitive limitations of their minds, and the time available to make the decision. This suggests that the role of managerial decisions and their quality are heterogeneous and vary across individuals and firms (Schilke et al., 2018). In this sense, Zahra et al. (2006) define dynamic capabilities as “the abilities to reconfigure a firm’s resources and routines in the manner envisioned and deemed appropriate by its principal decision-maker(s)” (p. 918). Thus, dynamic capabilities of a firm are assumed to be closely linked to its manager’s cognition and mental models (Helfat y Martin, 2015).

Furthermore, this approach seems relevant in the context of SMEs, where managers may have great influence on decisions about the development of capabilities for business model innovation (Arbussa et al., 2017; Pierre y Fernandez, 2018).

Table 19 Conceptualisation and dimensions of dynamic capabilities in business model innovation literature

Conceptualisation	Dimensions	Reference
Dynamic capabilities	- Sensing capabilities - Seizing capabilities - Reconfiguring capabilities	Mezger (2014), Inigo et al. (2017), Teece (2017), Vicente et al. (2018), Čirjevskis (2019)
Critical capabilities	- Recognizing business opportunities - Experimenting with new ideas/business opportunities - Acquisition and allocation of different types of resources (human, financial, intangible etc.) - Leadership style - Characteristics of corporate culture - Interaction of owners/managers/employees	Achtenhagen et al. (2013)
Dynamic capabilities	- Intra-management cooperation routines - Collective learning - Advantage-seeking capability - Trust-advancing capability - Operational process updating	Roaldsen (2014)
Resilient dynamic capabilities	- Sensing and alertness - Rapid activation, deactivation, recombination and collaboration of resources and capabilities - Durable bearing of the possible costs and risks of organisational learning and change	Ricciardi et al. (2016)
Firm capabilities	- Absorptive capability - Marketing capability - Managerial capability - Relational capability	Pucci, Nosi and Zanni (2017)
Organisational agility	- Market capitalising agility - Operational adjustment agility	S. Liao et al. (2019)
Service innovation capabilities	- Sensing customer needs - Sensing technological options - Conceptualising - Co-producing and orchestrating - Scaling and stretching	Janssen and den Hertog, (2016), Kiani et al. (2019)
Business model innovation capabilities/Strategic agility	- Strategic sensitivity - Collective commitment - Resource fluidity	Hock et al. (2016)/ Clauss et al. (2019)
Capabilities for strategic agility	- Strategy innovation capabilities (realise) - Strategy innovation capabilities (anticipate and look for) - Resource capitalisation capabilities - Networking capabilities	Battistella et al. (2017)
Knowledge management (KM) capabilities	- Internal KM: KM culture, KM structure, KM technology - External: KM acquisition process, KM conversion process, KM application process	Hock-Doepgen et al. (2020)

Evolutionary economics theory has contributed an orientation toward innovation to the dynamic capabilities view (Schilke et al., 2018), emphasising the notion of routines (Nelson et al., 1982) and stressing the firm's path dependencies, which suggests that a firm's past investment decisions and repertoire of routines constrain its future behaviour (Teece et al., 1997). According to Nelson and Winter (1982), decision-making processes that lead to innovation are considered organisational routines, which, if successful, can lead to repetition. This routinisation can have an impact on the innovative behaviour and performance of companies in the long term (Zabala-Iturriagagoitia, 2014). In addition, some authors suggest that the dynamic capabilities are developed through learning that can be obtained deliberately, through learning-by-doing, or both (Zollo y Winter, 2002). From this view, it can be assumed that the use of tools can help companies establish routines that allow them to address the business model innovation process in a systematic way. In addition, the use of tools could also support learning-by-doing, fostering organisational learning capabilities within the firm.

Configurational theory

Configurational theory builds on earlier notions of contingency theory (Misangyi et al., 2016), and therefore, its underlying assumption is that organisational effectiveness can be attributed "to the internal consistency, or fit, among the patterns of relevant contextual, structural and strategic factors" (Doty et al., 1993, p. 1196). Configurational theory states that the whole is best understood from a systemic perspective (Fiss et al., 2013) and therefore views organisations as a "multidimensional constellation of conceptually distinct characteristics that commonly occur together" (Meyer et al., 1993, p. 1175). Viewing each case (i.e. company) as a constellation of interconnected elements, configurational theory aims to capture those "patterns" among environmental, strategic and organisational attributes that can lead to organisational effectiveness, while stressing that causality is complex (Misangyi et al., 2016).

Causal complexity involves three main characteristics: conjunction, equifinality and asymmetry (Meyer et al., 1993). Conjunction recognises that an outcome rarely has a single cause but results from the interdependence of multiple conditions. Equifinality means that more than one path may exist that leads to a given outcome. Finally, asymmetry implies that what is "found to be causally related in one configuration may be unrelated or even inversely related in another" (Meyer et al., 1993, p. 1178).

As stated in the literature review, business model innovation is viewed as a complex innovation that requires a systemic reconfiguration of a firm's existing key human, physical and capital resources and capabilities (Cavalcante et al., 2011; Clauss et al., 2020; Cortimiglia et al., 2016; Hock et al., 2016; Massa y Tucci, 2014; Schneider y Spieth, 2013). Addressing business model innovation from a configurational approach, means that not all SMEs will reconfigure their business model identically, and thus, multiple paths towards business model innovation may exist that can be equally effective. This approach can, therefore, provide a more holistic view of the *recipes* for how business model innovation is achieved in the context of SMEs (Rihoux y Ragin, 2008; Rumble y Mangematin, 2015).

Effectuation theory

Effectuation theory (Sarasvathy, 2001) is mainly rooted in entrepreneurship literature, but it has been widely adopted in the strategic management field to explore organisational behaviours (Berends et al., 2014). This theory suggests two contrasting decision-making logics under uncertainty: causation and effectuation.

According to Sarasvathy (2001, p. 245), “causation processes take a particular effect as given and focus on selecting between means to create that effect”, whereas effectuation processes “take a set of means as given and focus on selecting between possible effects that can be created with that set of means”.

According to Chandler et al. (2011), the theoretical foundations for the causation process derive from the rational decision-making perspectives of neoclassical microeconomics (Stigler, 1954), which reflects the classical goal-driven management process commonly associated with the literature on strategic management (Berends et al., 2014). Managers following a causation logic have predefined objectives and a strategy planned, and they select the resources to achieve those objectives.

By contrast, the theoretical underpinnings of the effectuation approach rely on cognitive science, focusing on how entrepreneurs view inputs, make inferences, perceive alternatives, and attend to constraints (Chandler et al., 2011). The effectuation logic, usually related to entrepreneurial behaviour, is described as a means-driven process (Berends et al., 2014; Schumpeter, 1934). Managers following an effectuation process start with the available resources and then create their objective (Galkina y Chetty, 2015). Thus, they make decisions, observe the results and then apply what they have learned, which may change the course of their presumed objectives.

Effectuation and causation processes can therefore be distinguished based on four principles (Berends et al., 2014; Chandler et al., 2011; Sarasvathy, 2001). First, effectuation seeks to identify opportunities in an uncertain environment based on short-term experiments, while causation aims to predict the future by defining the final objective in advance. Second, effectuation focuses on projects based on an affordable loss criterion, whereas causation searches for maximization of expected returns. Third, the effectuation process prioritises the establishment of alliances to control an unpredictable future by securing an accessible resource base. The causation process, in turn, builds on business planning and competitive analyses to predict an uncertain future. Finally, effectuation implies a firm’s learning as it goes and exploiting environmental contingencies by remaining flexible, while causation involves the exploitation of pre-existing knowledge.

Although causation and effectuation are considered two different behaviours, they often complement each other within the same organisation (Berends et al., 2014; Futterer et al., 2018; Sarasvathy, 2001; Torkkeli et al., 2015), providing suitable theoretical foundations to explain business model innovation processes in SMEs.

3.2. Research framework

To proceed with the purpose of the study, the conceptual framework of the research is established in this section (Figure 25). Based on the theoretical membrane previously presented (Figure 24), the research framework tackles the research questions established in Chapter 1, and the need for an holistic view on business model innovation identified in the critical review of Chapter 2. The framework involves four main dimensions:

- Business model innovation antecedents
- Business model innovation
- Business innovation
- Business model innovation outcomes

The framework depicts business model innovation in a sequence that relates it with the set of antecedents and outcomes, as suggested in various research frameworks and models found in the literature (Bashir y Verma, 2019; Bouwman et al., 2015; Foss y Saebi, 2017; Wirtz y Daiser, 2017).

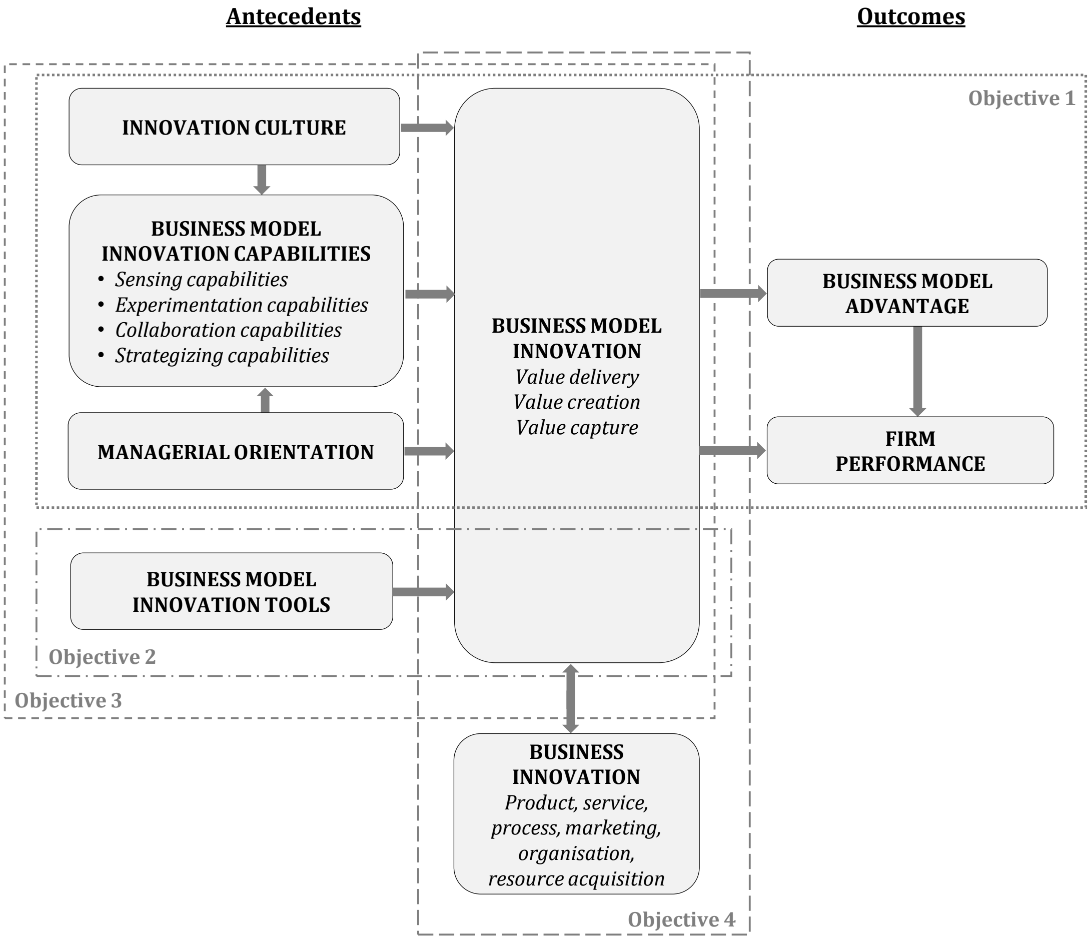

Figure 25 Business model innovation holistic research framework

Going from left to right, the first dimension, *business model innovation antecedents,* involves innovation culture, business model innovation capabilities, managerial orientation and business model innovation tools as main drivers of business model innovation. Located in the centre, *business model innovation*, connects with the other three dimensions, since understanding it is the main reason for this research. At the same level, *business innovation* is included, which encompasses product, service, process, marketing and organisational innovation together with resource acquisition as forms of innovation complementary to business model innovation. The last dimension, *business model innovation outcomes*, implies business model advantage and firm performance, representing the main implications of business model innovation for SME competitiveness. The variables in each dimension are discussed below.

Business model innovation antecedents

The ability to adapt to today's challenging environment is essential for the competitiveness and survival of SMEs, and business model innovation, as a new form of innovation, seems to be the means to this (Amit y Zott, 2012; Bashir y Verma, 2017; Foss y Saebi, 2018; Futterer et al., 2018). However, reconfiguring an existing business model involves certain difficulties, such as identifying the need for change, overcoming organisational inertia, choosing the right innovation approach and accepting the new business model (Battistella et al., 2017; Chesbrough, 2010; Cortimiglia et al., 2016). In line with the dynamic capabilities view, possessing certain distinctive capabilities can allow companies to overcome these obstacles and respond to environmental changes through business model innovation (Hock et al., 2016; Teece, 2017). This, in turn, can lead SMEs to sustain or even improve their competitive advantage and firm performance.

The relevance of dynamic capabilities has been widely emphasised in the frameworks, models and empirical studies reviewed in this thesis (Achtenhagen et al., 2013; Cavalcante, 2014; Čirjevskis, 2019; Foss y Saebi, 2017; Halecker et al., 2014; Hock-Doepgen et al., 2020; Hock et al., 2016; Inigo et al., 2017; Kiani et al., 2019; Mezger, 2014; Ricciardi et al., 2016; Teece, 2017; Vicente et al., 2018; Voelpel et al., 2004). Nonetheless, approaches to conceptualise dynamic capabilities for business model innovation are varied (Table 19). As several authors do in the absence of a unified vision (Achtenhagen et al., 2013; Battistella et al., 2017; Hock et al., 2016; Janssen y den Hertog, 2016; Pucci, Nosi, Zanni, et al., 2017; Ricciardi et al., 2016), this thesis selects, from among those reviewed, a set of four critical capabilities which emerge as relevant to business model innovation in SMEs: sensing capabilities, experimentation capabilities, collaboration capabilities and strategizing capabilities (Figure 25).

- *Sensing capabilities* are a firm's abilities to recognise changes and detect opportunities and threats (Teece, 2007, 2017). Market demands, competition and technology are constantly evolving. An SME must quickly become aware of these trends and their links to its business model in order to adapt to them and stay competitive (Inigo et al., 2017; Ricciardi et al., 2016; Teece, 2010). Sensing capabilities emerge from acquired information (Teece et al., 1997; Vicente et al., 2018). In this sense, companies need to establish routines to continuously monitor the environment and gather information about customers, market, competitors, technological developments and feedback on their product and services (Achtenhagen et al., 2013; Inigo et al., 2017; Vicente et al., 2018). Sensing capabilities, therefore, encompass sensing customer needs and technological options. Sensing customer needs is about understanding customers and detecting their needs and emerging market demands (Čirjevskis, 2019; Janssen y den Hertog, 2016; Kiani et al., 2019). Technology sensing, in turn, implies scanning the environment for promising technological options (Mezger, 2014; Teece, 2017).

- *Experimentation capabilities* allow a firm to explore, ideate, probe and test new or alternative business logics (Achtenhagen et al., 2013; Bouwman et al., 2019; Chesbrough, 2010). In addition to sensing customer needs and technological options, SMEs need to develop and interpret such information to be able to translate identified opportunities into new business ideas (Vicente et al., 2018). Experimentation enables companies to exploit gathered information about the market, technology and competition, while analysing their business models to identify new business model configurations (Achtenhagen et al., 2013; Mezger, 2014). Firms with experimentation capabilities can model unknown assumptions so that they can be tested, leading to the discovery of viable business models or, in case of failure, to learning from mistakes (Chesbrough, 2010; McGrath, 2010; Torkkeli et al., 2015). Exploring alternative business logics is also possible through virtual or real-life experiments such as prototypes and pilot tests (Baden-Fuller y Morgan, 2010; Bouwman et al., 2019; Cavalcante, 2014). Thus, in brief, experimentation capabilities are about exploring new ways of creating and capturing value, exploiting new knowledge while conceptualising it into new business model ideas, and applying experiments such as prototypes or pilot tests for these purposes.
- *Collaboration capabilities* are a firm's abilities to work across firm boundaries to ensure both efficiency and leverage (Battistella et al., 2017; Ulrich y Smallwood, 2004). Since SMEs often suffer from resource scarcity, accessing knowledge, resources and competencies externally is usually critical for them (Huang et al., 2013; Lee, Shin, Park, et al., 2012; Rezazadeh, 2017). In this sense, collaboration capabilities involve establishing routines to co-create with customers and involve external agents as a way to acquire new knowledge, discuss new ideas and take advantage of partners' complementary resources and competences (Achtenhagen et al., 2013;

Cavalcante, 2014; Čirjevskis, 2019; Halecker et al., 2014; Inigo et al., 2017; Mezger, 2014).

- *Strategizing capabilities* describe a firm's abilities to design an innovation strategy and establish a plan to implement it, aligned with the organisational strategy. Consistent with the view developed in subsection 2.1.1, in this thesis the business model is understood as the materialisation of a strategy (Bouwman et al., 2019; Casadesus-Masanell y Joan Enric Ricart, 2010), and therefore, emphasis is placed on the need for certain capabilities to design and plan an innovation strategy that will guide business model innovation. Some authors consider innovation strategy and planning a critical dimension of SMEs' innovation capacity (Pierre y Fernandez, 2018) and a driver of business model innovation (Battistella et al., 2017; Halecker et al., 2014; Lindgren, 2012). Innovation strategy involves having a sense of direction, a framework in which to make decisions about the changes that must be made in the face of the uncertainties and risks inherent in innovation (Tidd y Bessant, 2014). Thus, an innovation strategy makes it easier for companies to decide in a sustainable manner the type of innovation that best suits their corporate goals by guiding decisions on the use of resources to meet innovation objectives (Dodgson et al., 2008; Setyanti, 2016).

In addition to the business model innovation capabilities, the research framework includes *innovation culture* as a second relevant antecedent for business model innovation (Figure 25).

As discussed when exploring business model innovation in the context of established SMEs (subsection 2.1.3), efforts at business model reconfiguration face certain challenges, such as organisational inertia (Huang et al., 2013; Massa y Tucci, 2014), employees' and managers' cognitive resistance to change (Bock et al., 2012; Massa y Tucci, 2014), path dependencies (Bohnsack et al., 2014; Chesbrough y Rosenbloom, 2002) and the firm's dominant logic (Cavalcante et al., 2011; Chesbrough, 2010). These potential barriers largely reside in the underlying assumptions, values, beliefs and norms that guide life in organisations: in other words, the organisational culture (Hult et al., 2004; Schneider et al., 2013). When specific attitudes are accommodated in the organisational culture, the consequences of behaviour are expanded across circumstances, groups, and individuals within the firm (Latifi y Bouwman, 2018). In this sense, culture is a critical determinant of an organisation's informal structure and can provide the firm with the necessary ingredients to overcome above-mentioned barriers and foster business model innovation (Ahmed, 1998; Anderson y Barnard, 1939; Bock et al., 2012).

The literature suggests that an innovation-oriented and creative culture might facilitate business model innovation (Achtenhagen et al., 2013; Bock et al., 2012; Foss y Saebi, 2017; Hock et al., 2016). Hence, this thesis defines *innovation culture* as a firm's expressed norms, shared values and beliefs that support innovativeness, encouragement of employees, open communication and internal cooperation.

Furthermore, as represented in the research framework (Figure 25), innovation culture also links with business model innovation capabilities, since a firm's dynamic capabilities are usually rooted in the organisational culture (Hock et al., 2016; Schoemaker et al., 2018; Teece, 2007; Vicente et al., 2018).

A third business model innovation antecedent included in the research framework is the *managerial orientation* (Figure 25). SMEs' innovation activities are strongly influenced by the managers (Arbussa et al., 2017; Garcia y Calantone, 2002) and are often driven by their vision (O'Regan, Ghobadian y Gallear, 2006; O'Regan, Ghobadian y Sims, 2006), leading to decision-making processes strongly influenced by the manager's personal view of the world, strategic beliefs, assumptions and intentions (Kor y Mesko, 2013; Lampel y Shamsie, 2000). In addition, SME managers are often the first to perceive and interpret changes that may require a business model innovation, and the authority to decide to innovate the business model lies with them (Arbussa et al., 2017; Azari et al., 2017; Cavalcante et al., 2011; Foss y Saebi, 2017; Huang et al., 2013; Pierre y Fernandez, 2018). Thus, the influence of managers is widely acknowledged in both the literature on SMEs' innovation activity (subsection 2.1.3) and that on business model innovation (subsection 2.2.4).

Various authors suggest that managers of SMEs tend to adopt a conservative managerial orientation (Covin y Slevin, 1989), usually related to a risk-averse, reactive behaviour and short-termism (Antlová, 2009; Freel, 2000; Hassink, 1997; Moore y Levermore, 2012). Managers' orientation is closely linked to their past strategic choices, especially successful choices (Ammar y Chereau, 2018; Huang et al., 2013; Osiyevskyy J. et al., 2015). Some authors suggest that SME managers are more likely to exhibit resistance to change due to the "endowment effect" (Gray, 2002), which relates to their fear of the unknown, lack of confidence or cultural conservatism.

Nonetheless, business model reconfiguration involves investments in transforming the organisational structure, allocating resources and achieving organisational commitment (Chesbrough, 2010; Sosna et al., 2010; Velu y Stiles, 2013), the benefits of which are realized in the long run (Foss y Saebi, 2017).

Therefore, managers should develop a long-term orientation (Kindström y Kowalkowski, 2015), together with a risk-taking attitude (Asemokha et al., 2019; Bouncken et al., 2016) and a commitment to investment in innovation (Weimann et al., 2020) to promote business model innovation. Hence, to capture the managerial attitude towards business model innovation, this thesis conceptualises the *managerial orientation* as the investment decisions, time orientation and risk-taking behaviour that characterise the strategic management priorities of SME managers. In addition, as with innovation culture, managerial orientation is linked to business model innovation capabilities, since managerial decisions also affect the deployment of dynamic capabilities within the firm (Helfat y Martin, 2015; Schilke et al., 2018; Teece et al., 1997; Zahra et al., 2006).

To finish with business model innovation antecedents, a *business model innovation tools* variable is defined (Figure 25). The positive influence of using tools during the business model innovation process has been identified as relevant during the review of research frameworks (Halecker et al., 2014; Wirtz y Daiser, 2017), research models (Bouwman et al., 2015) and business model innovation processes (Heikkilä, Bouwman, Heikkilä, Haaker, et al., 2016; Osterwalder y Pigneur, 2010; Wittig et al., 2017), since tools facilitate the exploration and exploitation of opportunities that may lead to business model innovation. The review of the business model innovation process and related tools (subsection 2.3.2) has also shown the relevance of tools in supporting business model innovation. In addition, building on the dynamic capabilities view (section 3.1), it is argued that the use of tools can help SMEs to establish routines that allow them to address the business model innovation process in a systematic way, fostering organisational learning capabilities while reducing cognitive barriers between organisational members.

From the review, a set of tools suitable for the analysis, design and testing of new or existing business models have been identified. Thus, *business model innovation tools* is defined as the use of tools, techniques and methodologies to analyse, design and test business model opportunities in a systematic way.

Business model innovation

As discussed in subsection 2.1.2, this thesis defines business model innovation as the *purposeful changes to the value delivery, value creation and value capture dimensions of a firm's business model and/or the architecture linking them, which are new to the firm and result in observable changes in its practices towards customers and partners* (cf. p. 29). Thus, as reflected in the research framework (Figure 25), three dimensions are specified to capture business model innovation.

- Innovation of the *value delivery dimension* refers to purposeful changes introduced in terms of new offers, novel value and new customers/market segment.
- Innovation of the *value creation dimension* involves purposeful change introduced in terms of new partnerships, reconfiguration of activities and value chain.
- Innovation of the *value capture dimension* implies purposeful change introduced in terms of of new forms of cost reduction, revenue mechanism and profitability.

Business innovation

Viewing business model innovation as a new form of innovation (subsection 2.1.2), the research framework includes business innovation (Figure 25) to gain a complete picture of the different innovation approaches SMEs develop. The framework encompasses product, service, process, marketing and organisational innovation together with resource acquisition. These variables are based on the definitions in the *Oslo Manual* (OECD/Eurostat, 2005, 2018).

- A *product innovation* is a new or improved good that differs significantly from the firm's previous goods and that has been introduced on the market (OECD/Eurostat, 2018, p. 34).
- A *service innovation* is a new or improved service that differs significantly from the firm's previous services and that has been introduced on the market (OECD/Eurostat, 2018, p. 34).
- A business *process innovation* is a new or improved business process for one or more business functions that differs significantly from the firm's previous business processes and that has been brought into use by the firm (OECD/Eurostat, 2018, p. 34).
- A *marketing innovation* is the implementation of a new marketing method involving significant changes in products or processes (OECD/Eurostat, 2005, p. 49).
- An *organisational innovation* is the implementation of a new organisational method in the firm's business practices, workplace organisation or external relations (OECD/Eurostat, 2005, p. 51).
- *Resource acquisition* reflects the acquisition of advanced machinery, equipment or software that is required to implement product or process innovations (OECD/Eurostat, 2005, p. 98). This variable is included to also consider the resource investment efforts of SMEs in innovation.

Business model innovation outcomes

The role of business model innovation as a potential source of competitive advantage and, consequently, superior performance has been heavily emphasised in the literature (Amit y Zott, 2012; Bucherer et al., 2012; Foss y Saebi, 2018; Massa y Tucci, 2014; Schneider y Spieth, 2013; Teece, 2010). Thus, the last dimension of the research framework (Figure 25) includes two interrelated variables that represent the implications of business model innovation for SME competitiveness: firm performance and business model advantage.

Firm performance is a well-established indicator for evaluating organisational results, which, as shown in subsection 2.2.5, has been applied by several authors to explain business model innovation outcomes (Asemokha et al., 2019; Gatautis et al., 2019; Guo et al., 2017; Huang et al., 2013). Thus, this thesis addresses *firm* *performance* in SMEs, focusing on perceived market performance, growth and profitability (Brettel et al., 2012).

Another relevant element to assess the success of a firm relative to its competitors is the competitiveness of the firm (Boons et al., 2013). In the resource-based view (section 3.1), a business model that is valuable, rare, difficult to imitate and managed in the best way to be exploited can guide SMEs in competition and can itself become a competitive advantage (Chesbrough, 2010; Wirtz y Daiser, 2017). Hence, *business model advantage* is defined as the predominance of a business model to provide customers with benefits that are superior to those provided by competitors in terms of higher value, exclusiveness, access to new markets, and inimitability (Lecocq et al., 2010; Sorescu et al., 2011; Teece, 2010).

The dimensions and variables addressed in the holistic framework have been explained. The following section specifies the objectives established to explore the relationships between these dimensions and variables.

3.3. Research objectives

The main purpose of this thesis is to explore business model innovation in established SMEs from a holistic view. The integrative framework presented in the previous section represents the main dimensions and variables that have been defined to achieve this purpose. In addition, as shown in Figure 25, four specific research objectives have been formulated to address this general purpose and explore the research framework from different angles:

Objective 1: *To explore the causal relationships between innovation culture, business model innovation capabilities, managerial orientation and business model innovation, together with the effects of business model innovation on business model advantage and firm performance in SMEs.*

This first objective seeks to understand what factors influence SMEs to proactively conduct business model innovation. It also aims to shed light on the relevance of business model innovation for SME competitiveness. The thesis achieves this through an analysis of the causality between variables.

Objective 2: *To explore the causal relationships between business model innovation tools and business model innovation in SMEs.*

The second objective seeks to explore whether the use of tools in the business model innovation process can help SMEs to innovate their existing business model. Thus, it aims to identify the causality between the use of tools and business model innovation.

Objective 3: *To explore how business model innovation antecedents are configured to achieve business model innovation in SMEs.*

Building on configurational theory, this investigation assumes that SMEs follow different paths to business model innovation. In addition, based on effectuation theory, it presumes that these paths may depend on the effectual and/or causal behaviour of the SMEs. Thus, the third objective aims to explore how antecedent conditions link to business model innovation, providing a more holistic view that complements objectives 1 and 2. In stressing that causality is complex (Misangyi et al., 2016), objective 3 seeks to explore how innovation culture, managerial orientation and dynamic capabilities combine through different configurations leading to business model innovation. Moreover, it aims to examine how SMEs combine tools during the business model innovation process to change their existing business model.

Objective 4: *To analyse the relationship between business innovation and business model innovation in SMEs.*

The literature review (Chapter 2) identified different approaches to the relationship between business model innovation and business innovation. Some authors suggest that business model innovation can be developed separately from other innovation such as product innovation (Markides, 2006). Other authors suggest that they complement each other (Bohnsack et al., 2014). Furthermore, various scholars suggest that business innovations drive business model innovation (Bouwman et al., 2015; Bouwman, Nikou, et al., 2018), while others argue that business model innovation is usually simultaneously introduced with other kind of innovations (Minarelli et al., 2015). This last objective, therefore, aims to compare business model innovation with other forms of innovation to explore their relationships and shed light both on how SMEs approach innovation and on the relevance of business model innovation for them.

Chapter 4

Research methodology and design

4. Research methodology and design

The research methodology is a way to systematically solve the research problem the investigation is addressing (Kothari, 2004). It encompasses the steps from general assumptions to specific methods of data collection, analysis and interpretation (Saunders et al., 2009). Research methodology can be targeted through three main approaches: quantitative, qualitative or a mixed-method approach. These research approaches involve the intersection of philosophy, research designs, and specific methods (Creswell y Creswell, 2017). Figure 26 shows this intersection (Creswell y Creswell, 2017; Saunders et al., 2009).

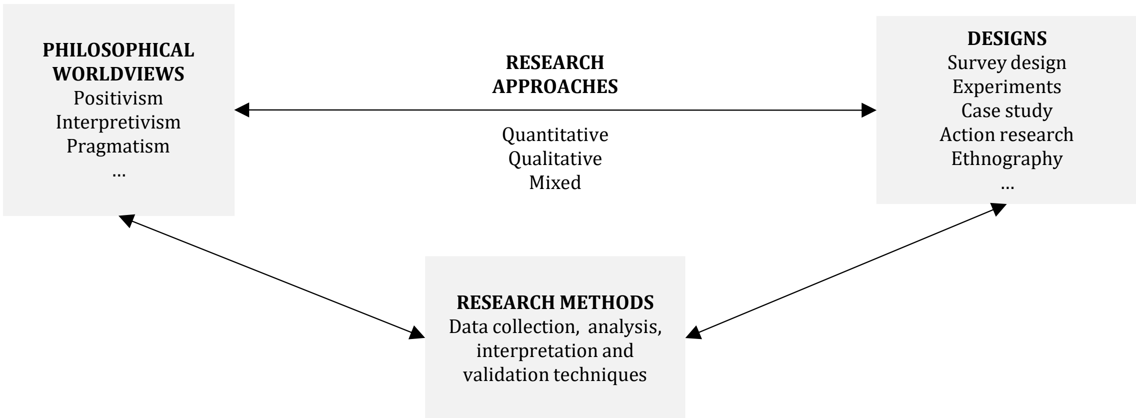

Figure 26 Research methodology.
Adapted from Creswell and Creswell (2017) and Saunders, Lewis and Thornhill (2019)

The research philosophy captures the assumptions the researcher brings to the investigation, determining which methodological approach best suits the study. The research design determines the plans and procedures the researcher follows to conduct the study. Finally, the research methods translate the research approach into practices, meaning the data collection and analysis techniques applied in conducting the study.

4.1. Research philosophy

The research philosophy is the set of beliefs and assumptions that guide the researcher developing knowledge in a particular field (Saunders et al., 2009). The adoption of a philosophy is commonly guided by three types of underlying assumptions: ontological (i.e. how reality is understood), epistemological (i.e. what constitutes acceptable knowledge) and axiological (i.e. the roles, values and ethics that are assumed). These assumptions shape the way the researcher understands the research questions, chooses one method over another, and interprets the findings.

While there is an ongoing discussion about what philosophical paradigms researchers bring to investigations, major paradigms of contemporary research can be placed on a continuum, with positivism at one end and interpretivism at the other end (Saunders et al., 2009).

Positivist researchers adopt a natural scientist stance. The positivist ontology believes that there is a single objective reality regardless of the researcher's interpretations; it therefore states that the world is external (Hudson y Ozanne, 1988). Epistemologically, positivists focus on observing measurable facts, predicting, and providing causal explanations. Positivists are concerned with the rigor and replicability of the research, the reliability of observations, and the generalizability of findings. Thus, the axiological stance the researcher adopts is objective, neutral and independent of what is researched. Positivists tend to follow a deductive approach, starting from theory-based insights and testing them, usually through research methods that involve large samples of quantitative data and statistical hypothesis testing (Saunders et al., 2009).

Interpretivists, in turn, believe that the reality is complex, multiple and relative (Hudson y Ozanne, 1988). Acquired knowledge is socially constructed and interpretivist aim to gather rich insights into subjective meanings than providing law-like generalisations. Social phenomena are studied in their natural environment, with the researcher focusing on people and adopting an empathetic posture to comprehend the world and its meaning from their point of view. The axiological stance is that research is value bound, researchers are part of what is researched and researchers adopt a subjective approach and provide their own interpretations as key contributions. Thus, an inductive approach is adopted to develop new constructs and theories from the insights of the research. Research methods usually involve qualitative data and analysis from in-depth studies with small samples (Saunders et al., 2009).

While some scholars strictly delineate the barriers between these philosophies, other authors advocate a more pluralistic vision, emphasizing that the research philosophy should be based on the approaches required by the research problem itself (Creswell y Creswell, 2017). This is in line with the pragmatist view, which posits that different ways of interpreting the world and developing research exist. This view also claims that since different realities occur, no single point of view can provide a complete picture of a problem. Therefore, instead of focusing on the method, pragmatic researchers highlight the research problem, trying to understand it through all the available approaches (Rossman y Wilson, 1985). Given the above discussion, the current research adopts a pragmatist philosophy for several reasons.

First, this dissertation involves exploratory research mainly aimed at better understanding the business model innovation phenomenon from the perspective of SMEs. Exploratory research is flexible and adaptable to change as it investigates a problem or phenomenon, which sometimes causes deviations from the initial direction of the research based on new insights or data. Pragmatism allows this flexibility in the research process (Saunders et al., 2009).

Second, for a pragmatist, the main determinant of the research design and strategy is the research problem at hand. For pragmatists, the nature of the research question, the research context and the likely research consequences are driving forces determining the most appropriate methodological choice (Nastasi et al., 2010). Pragmatics feel free to choose the research methods, techniques and procedures that best suit their needs and purposes. Consequently, they usually mix approaches (i.e. quantitative and qualitative) and data collection or analysis techniques. In this vein, Saunders, Lewis and Thornhill (2019) posit that if the research problem does not unequivocally suggest the kind of approach and method that should be adopted, the pragmatic approach is only reaffirmed as the most appropriate.

As stated when developing the theoretical foundations, the research framework and the research objectives (Chapter 3), this thesis adopts a holistic view of business model innovation. Thus, it builds on multiple theoretical approaches and aims to explore (1) the independent effects of certain antecedents on business model innovation and business model innovation's performance implications and (2) how different configurations of those antecedents combine to lead to business model innovation. In this sense, two approaches to explanation (i.e. *what* factors drive business model innovation and *how* are these factors linked to business model innovation) are adopted, and therefore, both linear and complex causality are to be addressed. These complementary views on business model innovation differ ontologically and epistemologically in their approaches (Mahoney, 2010; Rihoux y Ragin, 2008; Vis, 2012). Consequently, they require a mix of techniques that allow exploration of the net effects of individual antecedents of an outcome together with analysis of the combinatory effects of factors in multiple configurations (Leischnig et al., 2016). Because this mixed approximation demands techniques that differ in their approaches to explanation (what versus how) and in how they address the notion of causality (linear versus complex), a methodological purist might argue, according to Vis (2012), that the required analysis methods are not applicable in the same study. However, a more pragmatic researcher might see these differences as a strength rather than a weakness (Vis, 2012). The latter stance is adopted in the current research.

Finally, pragmatism posits that concepts are only relevant when they support action (Kelemen y Rumens, 2011), and thus, pragmatists are interested in practical outcomes rather than abstract distinctions. The aim of this research is to gain knowledge about business model innovation but also, in line with the mission of Mondragon Unibertsitatea, to disseminate the research contributions and implications to local SMEs, policy makers, innovation intermediaries and other stakeholders.

4.2. Research approach

In line with the research interests and the pragmatic worldview adopted, the present study uses a research approach characterised by its exploratory nature, following a mixed-methods and deductive approach.

Exploratory research focuses on the early stages of investigation into a phenomenon, which aim to obtain a preliminary view of a subject and provide the basis for the development of more in-depth studies (Forza, 2002). As concluded in the literature review (subsection 2.3.3), business model innovation is an emerging phenomenon, characterised by the lack of a solid theoretical basis, few empirical models, little quantitative research and, consequently, little knowledge about its antecedents and outcomes, particularly in the context of SMEs. For these reasons, this thesis adopts an exploratory approach to business model innovation, which aims to study the relationship of various factors, provide answers to various research questions and generate a better understanding of the causal relationship among the key concepts of interest identified in the literature.

The *mixed-method* choice derives from the aim of exploring the business model phenomenon from a holistic view. According to the research objectives and in line with the pragmatic view, the two-step mixed-method approach identified during the review (subsection 2.2.6) is adopted as the most appropriate approach to fulfil the first three objectives of the investigation. Following this method, data is collected through a single source of quantitative data, and research objectives are addressed in two steps. First, hypotheses about the relationships between variables within a research model are defined and tested quantitatively through a regression-based technique (Leischnig et al., 2016). Second, a set of propositions about possible configurations between variables leading to an outcome is defined and tested through qualitative comparative analysis (Duarte y Pinho, 2019; Rihoux, 2016). On the other hand, statistical tests are used to address the fourth objective, aiming to compare the relationship between variables under study.

The *deductive approach* starts the research from theory-based insights and designs the research to test these insights (Saunders et al., 2009), seeking to test theory rather than building theory (i.e. inductive approach). This approach is commonly associated with quantitative research and is suitable for the two-step mixed-method approach, since it focuses on measuring a set of variables and applying various techniques to them to test causal effects derived from theory (Curado et al., 2018; Leischnig et al., 2016).

4.3. Research plan

With the philosophical worldview and methodological approach described, this section presents the research plan developed for this investigation. The research plan describes how the research questions are to be answered (Saunders et al., 2009). It depicts the research objectives, derived from the research questions and the insights from the literature review, and specifies how to address them. Thus, it also guides the collection and analysis of data to meet the research objectives, specifying the procedures and methods required for that purpose. Aligned with the pragmatic philosophy and based on the exploratory, deductive and mixed-method approach adopted, the present investigation was conducted through a sequential process following the steps outlined in Figure 27. Note that each box includes the number of the chapter (or section) in this document in which each step is presented.

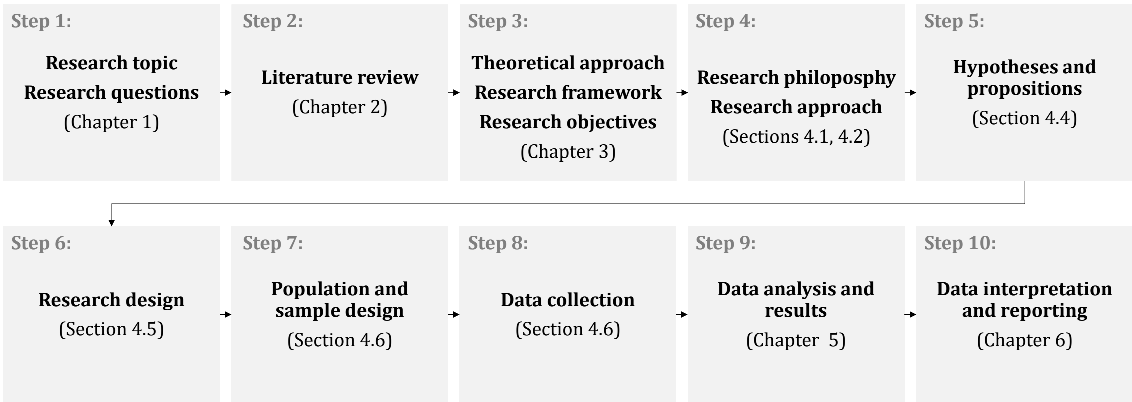

Figure 27 Research design, main steps and thesis chapters and sections

As can be seen in Figure 27, the present investigation started from an idea that was realised by clarifying the research topic and defining four research questions to guide its examination (step 1). Based on the research questions posed, an extensive review of the literature was conducted to identify the most relevant definitions, theories, concepts and prior research findings on business model innovation in established SMEs (step 2). This step ended with a critical review of the state of the art, which allowed the development of the theoretical underpinnings and research framework of the thesis. The objectives to be addressed in the research were outlined in greater detail (step 3). In a subsequent step, the most appropriate philosophy and methodological approach for conducting the research were selected (step 4). Once the research approach was chosen, in accordance with the theoretical and conceptual framework and each of the specific objectives established, the hypotheses and research propositions were developed (step 5). Based on the mixed-method approach, the research design was specified (step 6). Then, the sample design (step 7) and data collection (step 8) procedures were addressed. Once the data were collected, the research proceeded with the analyses of the hypotheses and propositions developed to achieve the research objectives (step 9). Finally, the results of the different analyses were interpreted and reported in the present document (step 10). Thus, as illustrated in Figure 27, the following section introduces the research hypotheses and propositions developed to address the research objectives defined in section 3.3.

4.4. Research hypotheses and propositions

Based on the theoretical foundations, research framework and specific objectives established in Chapter 3, and in line with the methodological choices made, this section presents the research models, hypotheses and propositions developed to address the first three research objectives. Each of the objectives is addressed separately in its own subsection.

4.4.1. Unveiling the drivers and outcomes of business model innovation in SMEs: A resources and capabilities approach

To address the first research objective the research model shown in Figure 28 was developed. This research model is based on the research framework presented in Figure 25 and aims to explore the causal relationships between innovation culture, business model innovation capabilities, managerial orientation and business model innovation, together with the effect of business model innovation on business model advantage and firm performance.

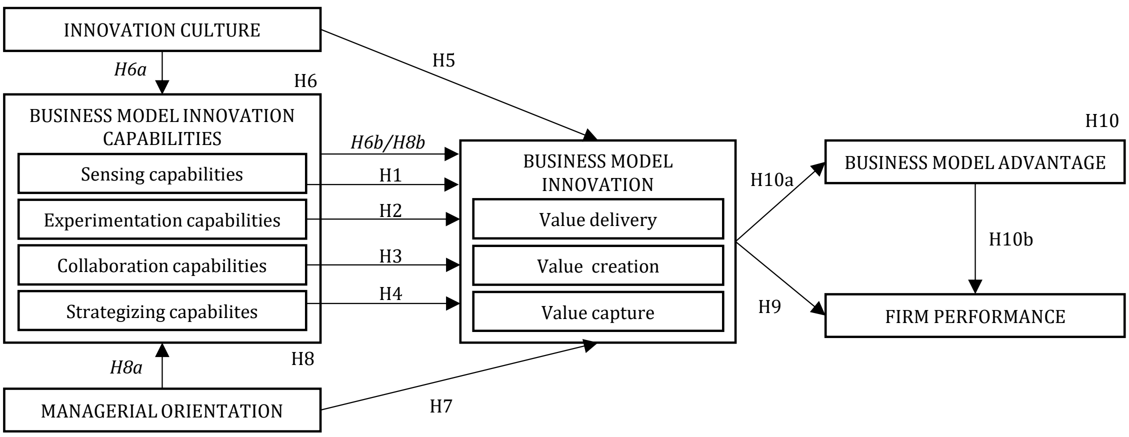

Figure 28 Research model of drivers and outcomes of business model innovation in SMEs

In what follows, the hypotheses developed to analyse the research model are specified. First, the relationship between business model innovation capabilities and business model innovation is addressed (H1, H2, H3 and H4). Next, the relationship between innovation culture and business model innovation (H5) is established, as is the mediating role of business model innovation capabilities on this relationship (H6). Then, the hypotheses suggesting that business model innovation is predicted by the managerial orientation (H7) and that business model innovation capabilities mediate this relationship (H8) are developed. Finally, the effects of business model innovation on firm performance (H9) are hypothesised, as are the mediation effect of business model advantage on the relationship between business model innovation and firm performance (H10).

Hypotheses associated with the influence of business model innovation capabilities on business model innovation

As described when defining sensing capabilities (section 2.3), an initial step towards business model innovation is the understanding and monitoring of the ecosystem surrounding the firm to identify the need for change (Achtenhagen et al., 2013; Frankenberger et al., 2013; Inigo et al., 2017; Vicente et al., 2018).The literature suggests that established firms that continuously sense their environment and opportunity gaps are more likely to reconfigure their business model (Voelpel et al., 2004; Wirtz y Daiser, 2017). It is well established in the literature that business model innovation requires a deep understanding of the customer's needs, technological developments and alternative business models at competitors or across industries (Mezger, 2014; Teece, 2017). Moreover, some authors suggest that the survival and success of SMEs depend on their ability to proactively seek out and identify opportunities (Guo et al., 2017; Ireland et al., 2003; Sambasivan et al., 2009).

In larger companies, responsibility for monitoring market changes usually resides with the marketing, new business or innovation management department (den Hertog et al., 2010). However, SMEs usually do not have such structures but tend to develop closer relationships with customers (Laforet, 2011). In line with this, prior studies point to the market as a driving force for innovation within SMEs, as the need for new technological developments has often been driven by the demands of customers themselves (Doloreux, 2003; Gebauer et al., 2005; Grotz y Braun, 1997; Hassink, 1997; Kaufmann y Tödtling, 2002). Hence, the closeness of SMEs to their customers may facilitate sensing their needs.

In addition, technological developments periodically enable the advent of new business models (Teece, 2017). Thus, firms that are able to gain knowledge of new and emerging technologies and relate it to business model components are likely to identify new business model opportunities (Mezger, 2014; Rachinger et al., 2019). The ability to sense technological options may become a critical capability in the current context, when digital transformation is influencing the way businesses compete and customers consume (Bouwman et al., 2019; Hock-Doepgen et al., 2020; Ibarra et al., 2018). Although large companies have focused extensively on Industry 4.0 and the industrial Internet of things (Kiel et al., 2016), these companies usually act as suppliers of SMEs or have SMEs as suppliers, and therefore their technological developments may bring opportunities to SMEs or may threaten the business model of established SMEs (Mueller et al., 2018). Therefore, to stay competitive, SMEs should be up to date with new technological developments and technologically leading competitors.

Various empirical studies support the above statements, showing how monitoring changes and proactively identifying customer needs and technological developments facilitate business model innovation (Achtenhagen et al., 2013; Čirjevskis, 2019; Inigo et al., 2017; Mezger, 2014; Ricciardi et al., 2016; Vicente et al., 2018). Additionally, various authors empirically demonstrate that sensing shifts in environmental trends positively influences business model innovation (Clauss et al., 2019; Hock et al., 2016). Moreover, some scholars find that SMEs' efforts to proactively search out and detect opportunities have a significant and positive effect on business model innovation (Guo et al., 2017). Recently, Kiani et al. (2019) demonstrated how dynamic capabilities, including both sensing customer needs and sensing technological options, had a positive impact on business model innovation.

Thus, the results of previous studies seem to indicate that sensing capabilities could have a positive effect on business model innovation in SMEs. However, Arbussa et al. (2017) found that SMEs' ability to anticipate the future needs of customers and users of their product or service is less natural and consequently more critical for business model innovation in this kind of firm. In addition, catching up on technological possibilities for business model innovation takes time, since business models are more context-dependent than technology (Teece, 2017). Hence, some authors remark that the lack of financial resources, time, technological knowledge or the capability to search and select relevant information from outside are common limitations in SMEs (Olazaran et al., 2012; Pierre y Fernandez, 2018). Sensing capabilities require moving away from daily tasks and investing time in detection, and therefore, SMEs may have difficulties finding time to monitor their environment. The lack of specialized personnel for strategic planning and technological forecasting may pose yet another difficulty for the deployment of sensing capabilities (Arbussa et al., 2017).

Bearing all this in mind, and to better understand the influence of SMEs' capabilities to sense customer needs and technological options in business model innovation, the following hypothesis is defined:

H1: Sensing capabilities positively influence business model innovation in SMEs.

Moving to the second capability of the research model (Figure 28), as discussed when describing experimentation capabilities (section 3.2), SMEs need to interpret and develop sensed opportunities to be able to translate them into new business ideas (Mezger, 2014; Vicente et al., 2018). Anticipating a business model is a complex task, and according to some authors, such a task should be addressed by learning over time through experimentation and trial and error (Achtenhagen et al., 2013; Chesbrough, 2010; McGrath, 2010; Sosna et al., 2010). In this sense several authors highlight the need for experimentation capabilities to foster business model innovation (Achtenhagen et al., 2013; Andries y Debackere, 2013; Berends et al., 2016; Bouwman et al., 2019; Cavalcante, 2014; Sosna et al., 2010; Torkkeli et al., 2015).

Experimentation capabilities allow SMEs to explore new business opportunities and test them in the market rapidly, without making major investments, which could facilitate business model innovation (Torkkeli et al., 2015). In established companies, experimentation capabilities may help companies determine the best configuration for their business model based on their structure and their plans for the future, facilitating the exploration of risk and reward to decide which investments should be made (Day y Schoemaker, 2016; Teece, 2017; Warner y Wäger, 2019).

Moreover, experimentation capabilities can help firms overcome cognitive barriers and conflicts with existing assets and business models, reducing their reluctance to change the established business model and strengthening their commitment to business model innovation (Chesbrough, 2010; Chesbrough y Rosenbloom, 2002; Warner y Wäger, 2019).

However, conceptualising new business models can be a difficult task due to the intangible nature of the business model and a product culture deeply rooted in SMEs (Frankenberger et al., 2013). Thus, experiments might facilitate both transforming rough ideas into viable business model opportunities and moving from product/service thinking to business model thinking, which in turn, may facilitate business model innovation (Janssen et al., 2016; Mezger, 2014).

Yet, as with sensing capabilities, experimenting capabilities imply investing time and resources (Achtenhagen et al., 2013). Furthermore, SMEs may not have the required skills to experiment with business model concepts as the business model is still a poorly understood concept when compared with other well-known innovations such as product or process innovation (Pucihar et al., 2019).

Even with these limitations, prior studies suggest that experimentation has a positive effect on business model innovation in established SMEs. For instance, Chang et al. (2012) explore organisational capabilities required for radical innovation in established firms and report that experimentation capability has a significant positive relationship with radical innovation performance, suggesting that firms that develop abilities “to probe, experiment with, test, and commercialize radical ideas and concepts” (p. 445) are more likely to successfully develop radical innovation such as business model innovation. Exploring the effect of effectuation processes during business model innovation, Torkkeli et al. (2015) demonstrate that experimentation is linked to higher levels of business model change in the context of Finnish SMEs. Recently, various researchers found that European SMEs which allocated more resources (i.e. budgets, human capabilities and time) for experimentation and which experiment with different business models achieve better performance when innovating their business models (Bouwman et al., 2019; Lopez-Nicolas et al., 2020).

Thus, in this thesis, it is presumed that SMEs with the ability to explore new business logics, exploit new knowledge about their environment, conceptualise new business model ideas and actively experiment with prototypes or pilot tests will find it easier to innovate their business model. Therefore, the following is hypothesized:

H2: Experimenting capabilities positively influence business model innovation in SMEs.

Referring to the third capability for business model innovation in SMEs (Figure 28), collaboration capabilities have also been considered relevant, since they can compensate for SMEs' limited economic and technical resources (Huang et al., 2013). Collaboration allows SMEs to benefit from external sources of knowledge and external resources and has been emphasized as a key determinant of innovation performance and the survival of SMEs (Lee, Shin, Park, et al., 2012; Rezazadeh, 2017). Collaboration capabilities can help SMEs to face external threats, attain legitimacy, share risk and reach individual goals that are unreachable without the help of partners (Radziwon et al., 2017).

Authors exploring the influence of dynamic capabilities on business model innovation often stress the relevance of integrating partners with complementary competences and resources (Achtenhagen et al., 2013; Mezger, 2014) and of co-creating with customers (Inigo et al., 2017), since they facilitate business model reconfiguration. Involving external agents in the business model innovation process and investing in information sharing with them is also suggested to foster business model innovation (Vicente et al., 2018). Collaboration enables the discussion of new ideas and the sharing of talent across firm boundaries, which may lead to new business model opportunities not identified before within the company (Cavalcante, 2014). Furthermore, since business model innovation is about evolving new ways to collaborate with partners to create new value for customers and stakeholders (Amit y Zott, 2012; Bouwman, Nikou, et al., 2018), the company's ability to collaborate seems to be a clear requirement (Battistella et al., 2017). The literature also suggests that business model innovation requires new collaborative approaches to co-design and co-produce new value propositions or new governance capabilities (Teece, 2017; Warner y Wäger, 2019).

In line with this, Ricciardi et al. (2016) found that in the 35 Italian SMEs they studied, all business model innovation initiatives were based on collaborative business networking. Hock-Doepgen et al. (2020) reported that acquisition and application of external knowledge from business partners was a core capability leading to high successful business model innovation in SMEs.

Authors focused on open innovation also highlight the positive effect of inbound open innovation activities on business model innovation (Huang et al., 2013; Liao et al., 2019; Yun y Jung, 2015). Inbound open innovation can be considered to be close to collaboration capabilities, since it focuses on activities such as accessing resources, knowledge and innovation ideas from the outside to complement the firm's in-house resource base (Chesbrough y Crowther, 2006). In this sense, Yun et al. (2015) emphasise collaboration with universities and research institutes on research and development as critical for business model innovation. Liao et al. (2019) demonstrate that resource acquisition from outside the firm is critical to business model innovation in SMEs. They find that inbound practices are positively and significantly related to business model innovation, whereas the effect of outbound open innovation on business model innovation is non-significant. These results are in line with those form a study by van de Vrande et al. (2009), who report that SMEs are very likely to involve customers, draw on network partners and gain external knowledge to support their innovation process. Moreover, some authors suggest that SMEs prefer networking and informal knowledge sourcing, since these are free resources (Hossain, 2015).

Bearing all this in mind, it is assumed that SMEs with the ability to exchange knowledge with external partners and involve customers and partnerships during innovation processes will be more likely to achieve business model innovation. To empirically explore this assumption, the following is hypothesized:

H3: Collaboration capabilities positively influence business model innovation in SMEs.

The last business model innovation capability of the research model (Figure 28), strategizing capabilities, has been identified as an SME's ability to design and implement an innovation strategy that can facilitate business model innovation. The literature on business model innovation emphasises the need for strategizing capabilities to foster business model innovation (Battistella et al., 2017; Halecker et al., 2014; Lindgren, 2012). Additionally, these capabilities are believed to be a critical dimension of SMEs' innovation capacity (Pierre y Fernandez, 2018). However, SMEs tend to lack an explicitly formulated strategy on innovation and therefore on business model innovation (Heikkilä, Bouwman y Heikkilä, 2018; Lindgren, 2012). Furthermore, SMEs' critical decisional processes such as the prioritisation of innovation projects become less rational than those decisions made in larger firms, and largely depend on a manager's intuition (Osiyevskyy J. et al., 2015).

This means that SMEs often miss out on business model innovation opportunities, as they are unable to see their potential and lack strategic capabilities for business model innovation (Lindgren, 2012). Some authors also suggest that SMEs tend to innovate in a reactive manner and do not usually strategically plan their innovation activities (Torkkeli et al., 2015)(Torkkeli et al., 2015)(Torkkeli et al., 2015)(Torkkeli et al., 2015)(Torkkeli et al., 2015)(Torkkeli et al., 2015)(Torkkeli et al., 2015)(Torkkeli et al., 2015)(Olazaran et al., 2009). Given SMEs' inability to shape and influence the external environment, innovation occurs in the short term as a response to environmental challenges rather than as part of a long-term strategy (Freel, 2000; Hassink, 1997; Olazaran et al., 2009).

Nonetheless, faced with limitations in resources and competencies, SMEs should design a deliberate innovation strategy to optimize their resources and capability base and to identify and integrate external resources (Pérez-De-Lema et al., 2019; Pierre y Fernandez, 2018).

The literature generally agrees that companies with formal strategies perform better than those without strategies (O'Regan, Ghobadian y Sims, 2006; Terziovski, 2010). The establishment of goals and milestones and the definition of a well-documented innovation plan leads to the improvement of innovation activities (De Jong y Vermeulen, 2006). Additionally, it is suggested that the formulation of innovation strategies joined with appropriate innovation management can improve the competitiveness of SMEs (Singh et al., 2008).

Prior research suggests that SMEs' strategic goals influence business model innovation, leading SMEs along different paths (Heikkilä, Bouwman y Heikkilä, 2018). Various authors have found that business model innovation is driven by a causation process (Sarasvathy, 2001), which suggests that designing and planning business strategies foster business model innovation (Futterer et al., 2018; Torkkeli et al., 2015). Additionally, Cortimiglia et al. (2016) finds that business model innovation tends to occur as a means of executing firm strategy at the end of a formal strategy development process. These studies suggest that SMEs with a designed and planned innovation strategy are more likely to innovate their business model.

Literature on SME innovation performance also highlights the positive effect of a formalised strategy on other kind of innovations, such as product innovation and process innovation (O'Regan, Ghobadian y Sims, 2006; Pérez-De-Lema et al., 2019; Salavou et al., 2004). A study by Terziovski (2010) identifies innovation strategy results as the key drivers of innovation leading to high SME performance. Similarly, Poorkavoos et al. (2016) recognise that innovation strategy is the most important condition for a high level of radical and incremental innovation performance in SMEs. Recently, Pérez-De-Lema et al. (2019) found that a formalized and structured strategy of innovation had positive effects on product and process innovations and consequently on firm performance in high-technology services SMEs in Spain.

Based on the above, it is conjectured that SMEs with the ability to design and implement an innovation strategy are more likely to innovate their business model. This leads to the next hypothesis:

H4: Strategizing capabilities positively influence business model innovation in SMEs.

Hypotheses associated with the influence of innovation culture on business model innovation and the mediating role of business model innovation capabilities

Having defined hypotheses linking business model innovation capabilities with business model innovation, the relationship of innovation culture to business model innovation is now hypothesised (Figure 28). The mediating role of business model innovation capabilities in this relationship is also explored.

As stated in the explanation of the research framework (section 3.2), an innovation culture helps firms overcome cognitive barriers related to business model innovation (Bock et al., 2012; Bohnsack et al., 2014; Cavalcante et al., 2011; Chesbrough, 2010; Chesbrough y Rosenbloom, 2002; Huang et al., 2013; Massa y Tucci, 2014).

Business model innovation requires a systemic reconfiguration of the firm (Clauss et al., 2020; Cortimiglia et al., 2016; Hock et al., 2016), which can be difficult in organisations that prioritise formal rules and procedures over creativity and out-of-the-box thinking (Pedersen et al., 2018; Prajogo y McDermott, 2011). Moreover, it is well established in the literature that business model innovation often involves breaking with the dominant mindset and business models (Chesbrough, 2010; Frankenberger et al., 2013; Pedersen et al., 2018; Prajogo y McDermott, 2011), therefore a culture that allows company members to question existing norms and routines seems to be a prerequisite for business model innovation. Several authors have highlighted the role of organisational culture as a driver of business model innovation (Achtenhagen et al., 2013; Bashir y Verma, 2019; Bock et al., 2012; Foss y Saebi, 2017; Halecker et al., 2014; Hock et al., 2016; Pedersen et al., 2018; Vicente et al., 2018).

It is believed that a culture that promotes innovation and creativity facilitates the development of innovative projects, business improvements and new business models (Amabile y Khaire, 2008; Bock et al., 2012; GOODSTEIN et al., 1996), since it stimulates and conducts the energy and creative behaviour of employees (Seshadri y Tripathy, 2006). Such a culture can encourage SMEs staff to take risks, develop new ideas and sense new opportunities (Aksoy, 2017), while it also helps to reduce employees' resistance to change that may arise in response to business model innovation (Bock et al., 2012; Dutton et al., 1994).

Typically, SMEs have more flexible and flatter structures that facilitate intra-firm communication and cooperation, the sharing of mental models, the detection of mistakes and the ability to learn from those mistakes (García-Morales et al., 2007). These, in turn, lead to a culture that is typically characterised by relatively low resistance to change, low risk aversion, and tolerance of ambiguity, all of which may facilitate the embracing of business model innovation (Damanpour, 2010; Terziovski, 2010).

In line with this, Achtenhagen et al. (2013) show that a culture that encourages open communication, fosters employee engagement and encourages employees to question the current ways of doing things and experiment with new business model ideas is key to business model innovation in SMEs. Pedersen et al. (2018) also demonstrate that organisational values of flexibility and discretion positively affect business model innovation in SMEs.

Based on the above ideas, it is assumed that an organisational culture that supports innovativeness, open communication and internal cooperation may positively influence business model innovation. Therefore, the following hypothesis is stated:

H5: Innovation culture positively influences business model innovation in SMEs.

Despite the relevance of an innovation culture in supporting business model innovation, organisational behaviour may not be enough to address business model innovation without the required business model innovation capabilities. Early studies suggest that dynamic capabilities are intermediaries between novelty-oriented cultural values and business model innovation (Hock et al., 2016). On this basis, this thesis suggests that business model innovation capabilities intermediate the relationships between innovation culture and business model innovation; thus, business model innovation capabilities act as a mediator.

Mediation occurs when a third variable intervenes between two other variables that are related in a causal sequence (Hair et al., 2016). Mediation leads to an indirect effect that may partially or fully explain the direct effect between the variables under study (Cheong y MacKinnon, 2012). Mediation means that a change in the independent variable (innovation culture) causes a change in the mediator variable (business model innovation capabilities) that in turn results in a change in the dependent variable (business model innovation) (Nitzl et al., 2016). Thus, the mediator governs the nature of the underlying relationship between the independent and the dependent variables (Yáñez-Araque et al., 2017).

To demonstrate mediation, strong relationships must be established between the independent and the mediating variable and between the mediating variable and the dependent variable (Baron y Kenny, 1986; Yáñez-Araque et al., 2017). Therefore, as presented in the research model (Figure 28), to theoretically support a mediating effect of business model innovation capabilities (H6), a relationship between innovation culture and business model innovation capabilities (H6a) and a relationship between business model innovation capabilities and business model innovation (H6b) must be demonstrated.

Schoemaker et al. (2018) argue that, to be efficient, the dynamic capabilities of a firm must be rooted in an organisational culture in which shared values guide risk-taking, experimentation, learning, and failure tolerance. Prior research has demonstrated that innovation-oriented culture positively affects strategic flexibility, which is a form of dynamic capability, during business model innovation (Bock et al., 2012). Organisational culture can increase a company's ability to detect and exploit market opportunities (Bashir y Verma, 2019; Doz y Kosonen, 2010). In line with this, Anand et al. (2009) show that a constant-change culture influences the development of dynamic capabilities for proactive scanning of opportunities and threats. Matzler et al. (2013) report that adhocracy culture, which fosters a dynamic and entrepreneurial workplace committed to innovation and development, positively affects both exploration and exploitation capabilities. Fainshmidt and Frazier (2017) illustrate that an organisational climate for trust is positively related to sensing, seizing and reconfiguration capabilities. Finally, as mentioned above, Hock et al. (2016) proves that novelty-oriented cultural values positively influence business model innovation capabilities, which in turn increase the propensity for business model innovation. Based on this, the following hypothesis is proposed:

H6a: Innovation culture positively influences business model innovation capabilities in SMEs.

In addition, based on the arguments used to establish the four earlier hypotheses (H1, H2, H3 and H4) which relate business model innovation capabilities to business model innovation, the following hypothesis can be proposed:

H6b: Business model innovation capabilities positively influence business model innovation in SMEs.

Having established the relationships between innovation culture and business model innovation capabilities (H6a) and between business model innovation capabilities and business model innovation in SMEs (H6b), the following is hypothesised:

H6: Business model innovation capabilities mediate the relationship between innovation culture and business model innovation in SMEs.

Hypotheses associated with the influence of managerial orientation on business model innovation and the mediating role of business model innovation capabilities

The last antecedent variable defined in the research model (Figure 28) is the managerial orientation. When the research framework was defined (section 3.2), managerial orientation was established as a relevant factor influencing business model innovation in SMEs.

In SMEs, the manager usually is the one to identify a need to change the business model and the one to make the decision to do so (Arbussa et al., 2017; Azari et al., 2017; Cavalcante et al., 2011; Foss y Saebi, 2017; Huang et al., 2013; Pierre y Fernandez, 2018). Thus, the manager’s interpretation of what needs to be done in the face of external changes is critical, affecting the firm strategy, the business model innovation capabilities to be deployed, and the prioritisation of innovation projects, such as business model innovation (Foss y Saebi, 2017; Gherardini et al., 2017; Osiyevskyy J. et al., 2015; Saebi et al., 2017).

In addition, since in SMEs, ownership and management are often concentrated in the same individual, the manager's strategic decisions on reconfiguring the existing business model do not face bureaucratic barriers, making it more likely business model innovation will be carried out (Weimann et al., 2020). Prior research has shown the influence that managerial behaviour, traits or intentions have on business model innovation in SMEs (Anwar et al., 2019; Azari et al., 2017; Child et al., 2017; Guo et al., 2013, 2017). However, the literature suggests that SME managers tend to lack awareness of what business model innovation means and how they can develop it (Heikkilä, Bouwman, Pucihar, et al., 2018; Pucihar et al., 2019).

Furthermore, managers are likely to consider changing the business model to be a risky undertaking, as the results are uncertain compared to the status quo (Osiyevskyy y Dewald, 2018; Saebi et al., 2017). Moreover, risk aversion appears to be stronger and more common in SMEs than risk acceptance, a trend that seems to hold regardless of wealth and income (Arbussa et al., 2017; Gray, 2002). Nonetheless, some authors have found that a manager's willingness to be proactive with external opportunities, to be innovative and to make risky business decisions have a positive effect on business model innovation in SMEs (Asemokha et al., 2019).

SME strategic decisions such as investing in innovation activities (i.e. R&D activity) or allocating resources (i.e. time and budget) are likely to facilitate business model innovation (Bouwman et al., 2019; Cucculelli y Bettinelli, 2015). However, according to Brenk et al. (2019), established firms prioritise the protection of the existing business model's dominant logic, focusing on increasing efficiency and maintaining financial stability. These contributions suggest a possible managerial orientation towards cost reduction in established SMEs, to the detriment of investment.

However, it must be remembered that business model innovation is not a one-time project (Bucherer et al., 2012). The time elapsed from when a company starts to explore how to reconfigure its business model until it achieves business model innovation can be years, requiring constant and long-term organisational commitment (Baines et al., 2020). Furthermore, a business model can take several years to produce tangible returns (Bucherer et al., 2012; Foss y Saebi, 2017). Thus, managerial orientation towards the long term seems to be essential (Weimann et al., 2020).

Nonetheless, according to a survey conducted by McKinsey, in recent years companies have installed themselves in a short-term performance logic, due to economic uncertainty after the global economic crisis (Bailey et al., 2014). The results of this survey indicate that economic pressure has led more than one-half of business leaders to review their strategy within a timeframe of no more than 2 years, although the majority of respondents believe that a longer-term approach would increase innovation and financial benefits. In line with this, Lazonick (2014) argues that companies' decisions about resource allocation have slipped from a model of value creation to one based on value extraction, which results in the destruction of long-term value and affects the competitiveness and survival of firms.

Basque companies reflect a similar situation (Orkestra, 2019), focusing on financial restructuring, reducing debt and strengthening equity capital. Additionally, external challenges are accentuating the environmental uncertainties for Basque SMEs, and an aversion to risk can be observed, with companies adopting a conservative orientation in their financial strategy and approach innovation (Orkestra, 2019).

In summary, its seems that a managerial orientation towards the long term, taking risks and investing in innovation activity (Asemokha et al., 2019; Bouncken et al., 2016; Bouwman et al., 2019; Cucculelli y Bettinelli, 2015; Kindström y Kowalkowski, 2015; Weimann et al., 2020) is likely to promote business model innovation in SMEs. Thus, the following hypothesis is suggested:

H7: Managerial orientation positively influences business model innovation in SMEs.

As happens with innovation culture, in addition to a strong managerial orientation towards business model innovation, the deployment of business model innovation capabilities seems to be an intermediary step, and it is suggested that business model innovation capabilities may mediate the relationship between managerial orientation and business model innovation.

According to the dynamic capabilities view, management leadership, decisions and abilities can either hinder or foster dynamic capabilities within a firm (Helfat y Martin, 2015; Schilke et al., 2018; Teece et al., 1997; Zahra et al., 2006). The literature suggests that a manager's decisions about resource allocation and deployment drive exploitation of business opportunities, while risk-taking and innovation-oriented attitudes may promote the sensing and seizing of business model opportunities (Guo et al., 2013). In line with this, Hock-Doepgen et al. (2020), find that the relationship between knowledge management capabilities and business model innovation is stronger in SMEs with a high risk-taking tolerance. Moreover, an orientation to the long term allows managers to deploy the required capabilities within the firm to develop a sophisticated search for business model innovation (Weimann et al., 2020). Prior research found a positive relationship between managerial orientation and dynamic capabilities (Jiang y Mavondo, 2009), and various studies of dynamic capabilities highlight the leadership of the top management team and the CEO (Day y Schoemaker, 2016; Kor y Mesko, 2013; Rindova y Kotha, 2001) and the mental models of managers (Dunning y Lundan, 2010; Leiblein, 2011; Schilke et al., 2018) as antecedents of dynamic capabilities of the firm. Thus, the following is suggested:

H8a: Managerial orientation positively influences business model innovation capabilities in SMEs.

The relationship between business model innovation capabilities and business model innovation has already been hypothesised when exploring the mediation effect of innovation culture (H6b), and therefore it is equally applied in the context of managerial orientation. The following hypotheses is proposed:

H8b: Business model innovation capabilities positively influence business model innovation in SMEs.

Thus, having established the relationships between managerial orientation and business model innovation capabilities (H8a) and between business model innovation capabilities and business model innovation in SMEs (H8b), the following is assumed:

H8: Business model innovation capabilities mediate the relationship between managerial orientation and business model innovation in SMEs.

Hypotheses associated with the influence of business model innovation on firm performance and business model advantage

As established in the research model (Figure 28), business model innovation's effect on business model advantage and firm performance is hypothesised together with the mediating effect of business model advantage between business model innovation and firm performance.

It is generally accepted that business model innovation allows both exploiting business opportunities and improving existing business model profitability (Anwar, 2018; Cavalcante et al., 2011). Furthermore, various studies have determined that business model innovation may offer established SMEs profitable growth (Lopez-Nicolas et al., 2020; Trapp et al., 2018).

As discussed in the subsection 2.2.6, although some authors find the relationship between business model innovation and firm performance non-significant (Pedersen et al., 2018), several studies indicate a positive effect of business model design (Ma et al., 2018; Pati et al., 2018; Pucci, Nosi, Zanni, et al., 2017), business model innovation (Asemokha et al., 2019; Gatautis et al., 2019; Guo et al., 2017; Huang et al., 2013) and business model innovation practices (Bouwman et al., 2019; Lopez-Nicolas et al., 2020) on SME performance.

Cucculelli and Bettinelli (2015) conclude that SMEs that introduce more innovative changes in their business models achieve better results than SMEs that do not. From this contribution, it is expected that the greater the business model innovation, the better the firm performance of the SME. Therefore, the following hypothesis is presented:

H9: Business model innovation positively influences firm performance in SMEs.

Successful innovation occurs when there is a gap between market demand and existing offers, and the company has the necessary resources to fill this gap (Slater y Narver, 1995). The same applies to business model innovation (Pölzl, 2016). Changing the existing business model is not a winning strategy in itself unless it leads SMEs to differentiate themselves in the market (Cucculelli y Bettinelli, 2015; Taran, Boer, et al., 2015).

As discussed when defining the research framework (Figure 25) and in line with the resource-based view, when valuable, rare, difficult to imitate and managed in the best way to be exploited, a business model may itself become a competitive advantage (Casadesus-Masanell y Joan E Ricart, 2010; Chesbrough, 2010; Teece, 2010), a phenomenon this thesis refers to as business model advantage. This is in line with prior research which suggests that competitive advantage rises when the business model (1) offers high value that is perceived as such by customers, (2) is exclusive or provides greater advantages than the competition, (3) allows access to new markets and/or (4) is difficult to imitate (Lecocq et al., 2010; Sorescu et al., 2011; Teece, 2010).

As a result, it can be assumed that successful business model innovation can lead to business model advantage (Boons et al., 2013; Chesbrough, 2010; Wirtz y Daiser, 2017). Business model innovation allows firms to proactively adapt the business model to the changing competitive environment, which increases the business model advantage (Mahadevan, 2004; Mishra, 2017; Voelpel et al., 2004).

When the above is considered, business model advantage emerges as an interesting outcome to assess business model innovation success in SMEs. It is assumed that if SMEs can change their business model in favour of novel value that is perceived by customers as superior to value offered by competitors, this will lead to business model advantage. To add empirical evidence, the following is hypothesized:

H10a: Business model innovation positively influences business model advantage in SMEs.

In regard to competitive advantage and firm performance in the context of business model innovation, various authors suggest that companies need to establish a distinctive competitive advantage before they can appropriate value from business model innovation (Mahadevan, 2004; McGrath et al., 1996; Wirtz y Daiser, 2017). By creating a business model advantage, SMEs may create superior value for customers, which may result in improved firm performance (Roaldsen, 2014; Teece, 2010). In line with this, prior research suggests that competitive advantage positively affects financial performance (López-Gamero et al., 2009). Furthermore, various studies empirically support a positive relationship between competitive advantage and firm performance in SMEs (Anwar, 2018; Anwar et al., 2018; Ibrahim y Mahmood, 2016; Saeidi et al., 2015). In particular, Anwar (2018) demonstrates that an SME's competitive advantage positively influences its performance after business model innovation. Based on this, it is assumed that SMEs that achieve a business model advantage will obtain superior firm performance, thus the following is proposed:

H10b: Business model advantage positively influences firm performance in SMEs.

Previous hypotheses established a relationship between business model innovation and firm performance (H9), another relationship between business model innovation and business model advantage (H10a), and a final relationship between business model advantage and firm performance (H10b). Applying the same logic followed in hypothesising a mediating effect for business model innovation capabilities, it is proposed that business model advantage may mediate the relationship between business model innovation and firm performance. This is in line with the study by Anwar (2018) finding that competitive advantage mediates the relationship between business model innovation and firm performance in SMEs. In addition, various studies support the role of competitive advantage as a mediator between firm performance and other antecedent variables, such as corporate social responsibility (Saeidi et al., 2015), entrepreneurial orientation in SMEs (Ibrahim y Mahmood, 2016) or big data capabilities in SMEs (Anwar et al., 2018). Thus, it is considered that business model innovation leads to superior business model advantage, which in turn, improves firm performance. Based on this, the following hypothesis is defined:

H10: Business model advantage mediates the relationship between business model innovation and firm performance in SMEs.

4.4.2. Structuring the process of business model innovation: Key practices and related tools

This subsection addresses the second research objective. The research model developed to respond to this objective is presented in Figure 29. This research model is based on the research framework shown in Figure 25 and focuses on the causal relationships between business model innovation tools and business model innovation in SMEs.

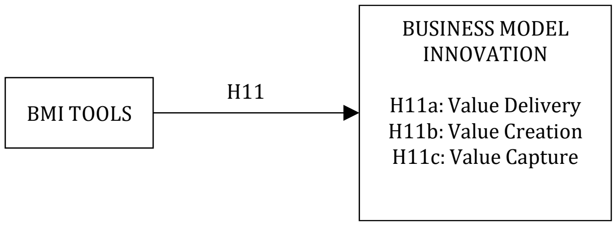

Figure 29 Research model of tools and business model innovation in SMEs

As discussed when explaining the research framework (section 2.3), several authors suggest that the use of business model innovation tools facilitates the exploration and exploitation of opportunities that may lead to business model innovation.

SMEs have poorly structured approaches to innovation, and the lack of processes or methods can hinder innovation management, making innovation activities less efficient (Pierre y Fernandez, 2018). This can be aggravated in the case of business model innovation, since the business model concept is not widely known by SMEs (Heikkilä, Bouwman, Pucihar, et al., 2018; Pucihar et al., 2019). Further studies suggest that established SMEs are not aware of the tools that can help them to foster business model innovation, or if they know them, they find them too complicated and academic (Heikkilä, Bouwman, Heikkilä, Haaker, et al., 2016; Trapp et al., 2018).

Nonetheless, business model innovation tools allow the adoption of a common language, the sharing of ideas and collective sense-making, which may help SMEs better understand their business model and how to innovate it (Belussi et al., 2019). These tools also enable firms to outline the components of the business model to be addressed, designed or discussed, while also facilitating communication and knowledge-sharing between stakeholders involved in the business model innovation process, such as SME managers, employees or external agents (Schwarz y Legner, 2020).

Business model innovation tools allow SMEs to be inspired by other business model patterns, which may help them to challenge the current dominant logic and help them to understand and learn from existing solutions and brainstorm new opportunities (Gassmann et al., 2014; Remane et al., 2017; Weking et al., 2018). A better comprehension of other business logics may help them change their business logic. The use of business model innovation tools can also aid SMEs' exploration of the strengths and weaknesses of their business model and help them identify and interpret potential opportunities for business model innovation (Breuer, 2013; Keller et al., 2017). Finally, these tools allow SMEs to deepen their knowledge of current or potential customer needs, which may facilitate value delivery innovation (Iriarte et al., 2018).

The use of frameworks, ontologies and meta-models encourages learning, discussion and continuous improvement of business models, reducing risks and failure probabilities (Osterwalder y Pigneur, 2010; Tesch y AS Brillinger, 2017), although Rumble and Mangematin (2015) conclude that the implementation of complex business models is more related to imitation and heuristic reasoning than to the use of design tools.

In addition, the use of tools can promote experimentation with new business model ideas, allowing firms to evaluate their viability and feasibility while defining steps towards business model innovation (Bouwman et al., 2012; De Reuver et al., 2013; Gordijn et al., 2001). Experimenting allows SMEs to learn cheaply and to quickly reinvest the acquired knowledge, opening a path to business model innovation (De Reuver et al., 2013; Tesch y A Brillinger, 2017). In this sense, the usefulness of lean start-up-based tools during business model innovation is highlighted by various authors (Balocco et al., 2019; Bocken et al., 2018; Ghezzi y Cavallo, 2020).

Prior research has shown that innovation management techniques positively influence radical innovation in Spanish companies (Igartua et al., 2014). Other authors have demonstrated the positive influence of innovation management techniques and tools on innovation results, finding them to be more critical for incremental innovation than for radical innovation (Albors-Garrigos et al., 2018).

Given this, it is hypothesised that using business model innovation tools positively affects business model innovation in its three dimensions. Therefore, the following is proposed:

H11: Business model innovation tools positively influence business model innovation in SMEs.

Since tools are employed for different purposes and may therefore influence value delivery, value creation and value capture in different ways, this hypothesis is further disaggregated for the three dimensions compounding business model innovation:

H11a: Business model innovation tools positively influence the value delivery dimension of business model innovation in SMEs.

H11b: Business model innovation tools positively influence the value creation dimension of business model innovation in SMEs.

H11c: Business model innovation tools positively influence the value capture dimension of business model innovation in SMEs.

4.4.3. Paths to business model innovation in SMEs: A configurational approach

The previous subsections have developed a set of hypotheses to analyse the causal relationships between business model innovation and its antecedents and outcomes (subsection 4.4.1), and between the use of tools and business model innovation (subsection 4.4.2). This subsection addresses the third research objective, adopting a configurational approach to the antecedents leading to business model innovation. Thus, managerial orientation, innovation culture and business model innovation capabilities are addressed, as well as business model innovation tools leading to business model innovation.

Three main assumptions support the explanation of complex phenomena such as business model innovation from a configurational view (section 3.1). First, configurational theory assumes that more than one path exists to the same outcome (equifinality), an outcome rarely has only a single cause and can result from the combination of different conditions (conjunction), and causally related conditions in one configuration may not be related in another (asymmetry) (Fainshmidt et al., 2020; Meyer et al., 1993). Based on this, it is assumed that SMEs can follow many paths to business model innovation that can be equally effective (Bouwman et al., 2019).

Following this approach, prior research has found that SMEs follow different paths combining knowledge management capabilities that link to business model innovation in SMEs (Hock-Doepgen et al., 2020). Other authors have found that SMEs' overall business performance is explained by four different recipes combining resources for business model experimentation, business model strategy implementation practices, innovativeness, and business model experimentation practices (Bouwman et al., 2019). In addition, logically opposed dimensions of organisational dynamism, such as exploration-exploitation, cooperation-competition or conformity-agency, are suggested to be strongly interlinked in two different paths leading to business model innovation (Ricciardi et al., 2016). The latter further suggests that only cases with high dynamic capabilities display high levels of business model innovation. This is in line with Teece's (2018) thoughts. He points out that companies do not necessarily have to be strong in all types of dynamic capabilities, as these are multi-faceted. Nevertheless, he stresses that the stronger the set of dynamic capabilities, the better a firm's ability to innovate and respond to external changes.

Various authors offer a complementary view on this issue building on effectuation theory, suggesting that causation and effectuation processes lead to the deployment of different dynamic capabilities favouring business model innovation (Futterer et al., 2018; Torkkeli et al., 2015).

Since business model innovation is new to established SMEs, they can adopt a causal logic that responds to the common stage-based process for new product development (Brenk et al., 2019). Causation logic views the future as predictable and controllable, and is usually supported by strategic planning and competitive analysis to address uncertainty (Sarasvathy, 2001; Tesch y A Brillinger, 2017). It is oriented to increase the awareness of the status quo and predict prospective developments (Futterer et al., 2018). Thus, the causation process relies mainly on strategic planning and sensing capabilities (Berends et al., 2014; Futterer et al., 2018; Torkkeli et al., 2015).

However, since SMEs often lack a structured approach to innovation and financial and technical resources, they can adopt an effectual logic that responds to entrepreneurial behaviour (Berends et al., 2014). Effectuation seeks to take advantage of uncertainty and contingencies, which implies a firm learns as it goes and searches for alliances to secure a resource base (Futterer et al., 2018; Sarasvathy, 2001). Effectuation in the context of business model innovation translates into a trial and error (Sosna et al., 2010) and discovery-driven approach (McGrath, 2010). Thus, experimenting, prototyping and testing become key practices (Futterer et al., 2018; Tesch y A Brillinger, 2017), while collaboration capabilities allow access to heterogeneous resources and knowledge from alliances (Berends et al., 2014; Futterer et al., 2018; Torkkeli et al., 2015).

From a management approach, a long-term managerial orientation may favour causation logics, whereas short-term orientations may lead to effectual logics (Futterer et al., 2018). Furthermore, an innovation culture is likely to support effectual behaviour in SMEs (Chesbrough, 2010).

With regard to the use of tools leading to business model innovation, the effectual or causal processes may lead to different approaches to the business model innovation process (Tesch y A Brillinger, 2017). Therefore, strategic tools with prospective exploration purposes found in the literature, such as scenario planning or roadmapping and strategic analytical techniques such as PESTLE or SWOT, together with tools such as business model frameworks could gain relevance in the configurations of tools for business model innovation following a causation process. By contrast, tools supporting experimentation, such as prototypes and minimum viable product, and methods promoting learning and experimentation, such as design thinking, lean start-up or agile approaches, would be important in configurations of tools for business model innovation following an effectuation process.

Finally, the literature suggests that both causation and effectuation processes link together to provide high levels of business model innovation in SMEs (Broekhuizen et al., 2018; Futterer et al., 2018; Torkkeli et al., 2015). Based on this, the following propositions are suggested:

Proposition 1: No single configuration of managerial orientation, innovation culture and business model innovation capabilities leads to business model innovation; rather, there exist multiple, equally effective configurations of causal conditions that will respond to a causation process, an effectuation process or both.

Proposition 2: No single configuration of business model innovation tools leads to business model innovation; rather, there exist multiple, equally effective *configurations of causal conditions that will respond to a causation process, an effectuation process or both.*

4.5. Research design

With the research objectives and related research models, hypotheses and propositions defined, this section describes the design of the research, specifying the procedures and methods applied to collect and analyse data. This thesis adopts a pragmatic perspective and aims to meet the research objectives following a deductive and mixed-method approach based on the research plan presented in Figure 27.

To collect data, a survey strategy in the form of an online questionnaire was developed. This strategy is common to the two-step mixed-method approach (Bouwman et al., 2019; Hock-Doepgen et al., 2020; Liao et al., 2019) and to quantitative studies exploring the antecedents and outcomes of business model innovation (Anwar et al., 2019; Gatautis et al., 2019; Guo et al., 2017; Huang et al., 2013; Lopez-Nicolas et al., 2020; Pucihar et al., 2019; Torkkeli et al., 2015).

A survey strategy is used to describe trends, behaviours or opinions of a population and to test relationships between variables in a sample of a population. It is widely recognised as appropriate for business and management studies, exploratory research and deductive approaches for theory development (Saunders et al., 2009). Thus, it can be considered suitable in the context of this investigation.

Questionnaires are generally designed to collect a large amount of quantitative data, and they are less expensive and time consuming than other survey methods for collecting data, such as interviews (Sekaran y Bougie, 2016). Online questionnaires can be designed to be attractive and easy to use, while facilitate data processing and further statistical analysis (Wright, 2005). Nevertheless, the use of questionnaires present some risks, as respondents may not follow the questionnaire instructions and some questions may remain unanswered. This leads to method and response bias, which need to be carefully examined before the data can be exploited for research purposes (Jakobsen y Jensen, 2015).

Bearing all this in mind, an instrument in the form of a self-administered online questionnaire was developed for the present research. Data was collected at one point in time, constituting a cross-sectional study (Connelly, 2016).

Following the sequence of steps established for the two-step mixed-method approach, once data was collected, it was first analysed using structural equation modelling (SEM) to address the hypotheses related to the first and second objectives (subsections 4.4.1 and 4.4.2). Thereafter, qualitative comparative analysis (QCA) was performed to address the research propositions developed to meet the third objective (subsection 4.4.3). To achieve the fourth objective, the analysis phase was concluded with a broad exploration, using various statistical tests, of the relationship between business model innovation and other forms of business innovation (section 3.3).

The data analysis methods applied in this research are described below. The variables under study are then defined and operationalised.

4.5.1. Data analysis methods and techniques

As explained above, this thesis combines three main analysis approaches. This subsection describes the analysis methods applied as part of the two-step mixed approach: SEM and QCA. The selection of the methods to be used and the advantages of combining them are then explained. Finally, the t-test and chi-square test statistical methods used to address the fourth objective, which explores the relationships between business model innovation and business innovation, are described.

Structural equation modelling (SEM)

SEM allows multiple regression analysis of complex interrelationships between observed and latent variables and accounts for various forms of measurement error, giving a high level of confidence in the results, and a high level of statistical efficiency thanks to robust and powerful software (Martínez Ávila y Fierro Moreno, 2018).

Two SEM approaches to parameter estimation can be distinguished: covariance-based structural equation modelling (CB-SEM) and variance-based structural equation modelling (PLS-SEM). The former uses the covariance matrix of the data and estimates the model parameters by considering only common variance. The latter estimates partial model structures by combining principal components analysis with ordinary least squares (OLS) regressions, accounting for the total variance and using that total variance to estimate parameters (Hair et al., 2019) .

While CB-SEM has been the preferred method for researchers, in recent years PLS-SEM has also been widely applied in many social science disciplines, including strategic management (Hair et al., 2012; Henseler et al., 2016). The choice of CB-SEM or PLS-SEM should be made based on the research objective. Table 20 sets out the criteria, based on the recommendations of various authors, for choosing between the two methods (Hair et al., 2011; Jimenez, 2017).

Table 20 Rules of thumb for choosing between PLS-SEM and CB-SEM (Hair et al., 2011; Jimenez, 2017)

Criteria	CB-SEM	PLS-SEM
Research objectives	- Theory testing, theory confirmation or comparison of alternative theories	- Predicting key target constructs or identifying key "driver" constructs - Conducting exploratory research - Extending an existing structural theory - Taking preliminary measurement instruments
Measurement model specification	- Overall, reflective constructs - Error terms require additional specification, such as covariation	- Both formative and reflective constructs are part of the structural model - Number of items measuring a construct is low (1 or 2)
Structural model	- Non-recursive - Circular relationships	- Complex models with many constructs and indicators - Higher-order constructs
Data characteristics	- Meets minimum sample size requirements - Meets data distribution assumptions	- Relatively small sample sizes - Non-parametric data - CB-SEM requirements cannot be met
Model evaluation	- Research requires a global goodness-of-fit criterion - Measurement model invariance must be tested	- Latent variable scores must be used in subsequent analyses

Based on the rules of thumb presented in Table 20, PLS-SEM better suits the current research, for the following reasons.

- The current research is exploratory research into business model innovation, which is an emergent phenomenon, to identify key antecedent drivers and their effect on certain outcomes. PLS-SEM is recommended for exploratory research where theory is scarce; therefore, it is more appropriate than CB-SEM for the study.
- Although the measurement instrument used in this thesis was mostly developed based on previously validated scales, some items were modified to fit the context of the study. In addition, given the novelty of the topic, no scales were found for variables such as business model innovation tools, thus items were developed ad hoc. In this sense, the measurement instrument could be considered a preliminary measurement instrument, for which PLS-SEM is more appropriate than CB-SEM.
- The study's final sample comprised 78 observations, considered a small sample size, which better meets the sample size requirements for PLS-SEM than for CB-SEM.
- Normal distribution of the collected data was, to some extent, non-normal. PLS-SEM is a non-parametric statistical method, and thus it is more convenient than CB-SEM for this research.
- Additionally, PLS path models are suitable for analysing high-order constructs combining reflective and formative variables, and they allow for the building of parsimonious models that ensure a moderate statistical power for the sample size under study. Given this, PLS-SEM is the better option to address the research model developed for the first objective (Figure 28), which links business model innovation with a set of antecedents and with its outcomes. The multidimensional nature of the business model

innovation variable, reflected by its three dimensions (value delivery, value creation and value capture), requires the use of high-order constructs. Business model innovation capabilities are also treated as high-order constructs in some models. Moreover, given the small sample size, the use of high-order constructs allows for a reduction in the complexity of the research model, ensuring moderate statistical power.

- Finally, PLS-SEM is commonly applied in the study of business model innovation, and therefore it seems suitable for the present research (Bouwman et al., 2019; Bouwman, Nikou, et al., 2018; Clauss, 2017; Gatautis et al., 2019; Hock-Doepgen et al., 2020; Najmaei, 2016; Pucihar et al., 2019).

Qualitative comparative analysis (QCA)

QCA was introduced as a new research approach for the social sciences in Ragin's *The Comparative Method* (1987), which has become one of the most widely cited methodological books in the social sciences (Marx et al., 2014). It emerged in response to the limitations of examining causal complexity in the context of comparative sociological and political phenomena at a macro level (i.e. governments or countries), since these phenomena involved sample sizes that were too small for regression techniques but too large for cross-cases comparisons (Misangyi et al., 2016). The aim was to “integrate the best features of the case-oriented approach with the best features of the variable-oriented approach” (Ragin, 1987, p. 84) in studies typically employing small and medium-sized datasets.

The method was expanded to other research fields, where its hybrid nature, which bridges the qualitative (case-oriented) versus quantitative (variable-oriented) research gap, served as a practical approach for understanding complex, real-world situations (Cragun et al., 2016; de Block y Vis, 2018; Fainshmidt et al., 2020). Thereby, it soon became widely recognised in strategy and organisation management research, where the idea of complex causality plays a key role (Fiss, 2007, 2011).

QCA is non-probabilistic method that uses Boolean algebra to determine which condition or configurations of conditions are necessary or sufficient for a given outcome to occur (Rihoux y Ragin, 2008). It is built on set-theoretic methods, which operate on the membership scores of the elements in the sets (Ragin, 2008). Therefore, conditions and outcomes encompassed in a case are conceptualised as sets. Thus, the researcher must determine the degree of membership of the cases under study in the sets representing the antecedent conditions and the outcome (Greckhamer et al., 2018). This process is known as calibration and is the first key step of QCA (De Block y Vis, 2017).

The first proposal of QCA built on a crisp set approach (Ragin, 1987), which only distinguishes a case’s full membership or full non-membership in a set. In crisp sets, the raw data is calibrated from fully in (1) and fully out (0). The 1 and the 0 are the so-called qualitative thresholds, and the crossover point is at 0.5 (Ragin, 2000; Schneider y Wagemann, 2012). Ragin (2000) expanded this binary approach into a fuzzy-set approach. A fuzzy set is seen as a “continuous” variable which presents additional gradations of set membership (Ragin, 2008), such as almost fully in (>0.50) or more out than in (<0.50). Thus, fuzzy sets enable the capture of more fine-grained differences in degrees of membership and are preferable to crisp sets when the research allows it (Schneider y Wagemann, 2012). Fuzzy-sets are commonly used to calibrate data collected with Likert scale-based questionnaires, being mostly used in the two-step mixed method approach (Bouwman et al., 2019; Hock-Doepgen et al., 2020; Liao et al., 2019). Thus, this thesis uses fuzzy-set QCA.

The two-step mixed method approach: advantages of combining fuzzy-set qualitative comparative analysis (fsQCA) and PLS-SEM

Various authors have discussed the differences between fsQCA and regression-based techniques, such as PLS-SEM, stressing the advantages of combining the two methods (Leischnig et al., 2016; Vis, 2012; Woodside, 2013).

PLS-SEM follows a quantitative approach to explanation which addresses the effects of causes. It seeks to estimate the net or average effect of one or more independent variables on a set of cases to explain a maximum of variance in the dependent variables. The method’s main objective is to determine the magnitude of the effect of the cause on the outcome.

FsQCA, in turn, adopts a qualitative approach, looking for the causes of effects. It is used to reveal how outcomes come about, and it does this by analysing what conditions or combinations of conditions are necessary, the outcome cannot be produced without the condition; and sufficient, the condition can lead to the outcome by itself without the help of other conditions (Bouwman et al., 2019; Leischnig et al., 2016). Moreover, FsQCA implies equifinality, which means that the same outcome can be produced by multiple scenarios that combine alternative conditions. These solutions reflect different recipes or paths involving combinatorial statements which are logically equivalent and substitutable (Ragin, 2008). It thus allows exploration of the combinatory effects of certain causal conditions, showing the result as multiple configurations of causal conditions leading to an outcome.

Whereas PLS-SEM assumes the homogeneity of populations and samples, fsQCA addresses the limited diversity inherent in causal complexity by examining configurations that do not exist in the empiric data (Ragin, 1987). Exploring unobserved configurations enriches the analysis, providing additional information about the phenomenon under study rather than reducing the diversity of cases to empirically observed patterns, as occurs with PLS-SEM (Misangyi et al., 2016).

Therefore, combining PLS-SEM and fsQCA allows for both the identification of potential drivers and their impact on a dependent variable and the examination of how these drivers are combined in terms of necessary or sufficient configurations leading to the outcome. This means the combination provides finer-grained insights than would result from conducting each analysis in isolation. It allows a more holistic view of a complex phenomenon, allowing the exploration of its antecedent conditions from different approaches. Moreover, mixing PLS-SEM and fsQCA within the same analysis allows each method to complement and even validate the results of the other (Leischnig et al., 2016). Thus, the combination of PLS-SEM and fsQCA seems suitable to address the first three objectives of the research and produce a broader view of the business model innovation phenomenon.

Statistical tests

To address the fourth objective, two statistical tests were applied. The t-test for independent samples was used, which allows comparison of the means of two independent sample groups and reveals whether there is a significant difference in means from one group to another. The Pearson's chi-square test was also used, which serves to test the relationships between categorical or dichotomous variables (Druiven et al., 2019).

4.5.2. Operationalisation of variables

With the analysis methods identified, the current section describes the operationalisation of the variables (also referred as constructs or latent variables) to be analysed with these methods. Operationalisation translates the latent variable to be addressed into observable and measurable elements so an index of measurement of it can be developed (Sekaran y Bougie, 2016).

The variables under study were defined in the research framework (section 3.2). This subsection specifies the instrument (set of items or indicators) and the response format defined to assess the constructs.

Table 21 defines each variable and lists its dimensionalisation, its measurement type, the number of items used to measure it, the response format and the references on which the measurement instruments are based.

The variables were operationalised based on the business model innovation theory reviewed and the research models developed in section 4.4., which determine the best way to dimensionalise and measure each construct.

Table 21 Operationalisation of variables

Dimensionalisation	Definition	Nº of items/ Response format	Reference
Business model innovation capabilities/Sensing capabilities	A firm's ability to understand customers and sense their needs and emerging market demands, while scanning its environment for promising technologies	6 items/5-point Likert Scale	Janssen and den Hertog (2016), Janssen, Castaldi and Alexiev (2016), Kiani, Ahmad and Gillani (2019)
Business model innovation capabilities/Experimentation capabilities	A firm's ability to explore new ways to create and capture value, exploit new knowledge, conceptualise new ideas and use prototypes or pilot tests	6 items/5-point Likert Scale	Mezger (2014), Janssen and den Hertog (2016), Janssen, Castaldi and Alexiev (2016), Kiani, Ahmad and Gillani (2019)
Business model innovation capabilities/Collaboration capabilities	A firm's ability to exchange knowledge with external partners and involve customers and partnerships during innovation processes	3 items/5-point Likert Scale	van de Vrande et al., (2009)
Business model innovation capabilities/Strategizing capabilities	A firm's ability to design an innovation strategy and establish a plan to implement it aligned with its organisational strategy	4 items/5-point Likert Scale	Huurinainen (2007)
Innovation Culture	A firm's expressed norms, shared values and beliefs that support innovativeness, encouragement of employees, open communication and internal cooperation	5 items/5-point Likert scale	Homburg and Pflesser (2000), Hock, Clauss and Schulz (2016)
Managerial orientation	The strategic management priorities of SME managers, based on investment decisions, time orientation and risk-taking tendencies	4 items/5-point Likert scale	Covin and Slevin (1989)
Business model innovation tools	The use of tools, techniques and methodologies to analyse, design and test business model opportunities in a systematic way	9 items/5-point Likert scale	Self-developed
Business model innovation/ Value delivery	Purposeful changes to the value delivery dimension in terms of new offers, novel value and new customers or market segments	6 items/5-point Likert scale	Zott and Amit (2007), Schrauder et al. (2018)
Business model innovation/ Value creation	Purposeful changes to the value creation dimension in terms of new partnerships, reconfiguration of activities and value chain	4 items/5-point Likert scale	Zott and Amit (2007), Schrauder et al. (2018)
Business model innovation/ Value capture	Purposeful changes to the value capture dimension in terms of new forms of cost reduction, revenue mechanism and profitability	4 items/5-point Likert scale	Johnson, Mark, Christensen and Kagermann (2008), Lindgardt et al. (2009), Bouwman et al. (2015), Verhagen (2018)
Business model advantage	The ability of a business model to provide customers with benefits superior to those provided by competitors in terms of higher value, exclusiveness, access to new markets, and inimitability	5 items/5-point Likert scale	Cooper et al. (1994), Pölzl (2016)
Firm performance	Overall performance of the firm based on perceived market performance, growth and profitability	8 items/5-point Likert scale	Homburg and Pflesser (2000), Brettel, Strese and Flatten (2012)
Business innovation	New or improved products, services, processes or related activities introduced by the firm that differ significantly from the previous ones	5 items/ Dichotomous scale	CIS Survey (2014)

Regarding the dimensionalisation of variables, when the entire domain of a variable can be represented through a set of items that are directly observable, the variable is defined as a unidimensional construct (Sekaran y Bougie, 2016). By contrast, when a variable, although treated as a single theoretical concept, is represented through different related dimensions, it is defined as a multidimensional construct (Edwards, 2001). In this thesis, business model innovation and business model innovation capabilities were defined as multidimensional constructs (Table 21), since their complex nature has been addressed as such in prior research (Clauss, 2017; Futterer et al., 2018; Kiani et al., 2019; Spieth y Schneider, 2016). The remaining variables were defined as unidimensional constructs.

In developing measurement scales for each variable, previously validated scales were used for item formulation, as they are preferable to ad hoc and modified scales (Furr, 2014). Nevertheless, in some cases existing scales were slightly modified to address the purpose of this study. For instance, scales identified measuring organisational culture and collaboration capabilities were too lengthy and were reduced to a suitable set of items (Furr, 2014). In other cases, no existing measures were found that fully addressed the definition of the variables (e.g. business model innovation tools). In such cases, a scale development process was followed (Furr, 2014). After defining the construct to be measured, a set of items was created based on a rigorous review of the related literature. These items were validated against judgmental criteria (Wieland et al., 2017) by a panel of experts.

All items in the measurement instrument were evaluated in a pilot test with a group of SMEs as part of the pretesting of the questionnaire (subsection 4.6.3). Furthermore, during data analysis (Chapter 5) construct dimensionality (i.e. factor structure), reliability and validity were examined and interpreted using exploratory factor analysis and PLS-SEM (Clauss, 2017). The final measurement instrument was considered appropriate to conduct the analyses for this research.

As for the response format, all the variables were assessed with a Likert 5-point scale (Likert, 1932), anchored by "strongly disagree" and "strongly agree", except for business innovation, which was measured with a dichotomous scale (yes/no). In the following paragraphs, the measurement instruments for all variables are defined.

Sensing capabilities

The sensing capabilities variable measures the degree to which an SME is able to understand customers, sense their needs and sense emerging market demands while it scans its environment for promising technologies. To assess this variable, items were selected from Janssen, Castaldi and Alexiev (2016). These items have been used in prior research on business model innovation (Janssen y den Hertog, 2016; Kiani et al., 2019) and thus are considered appropriate for the current research. As shown in Table 22, three items measuring sensing customer needs

(SCN1, SCN2 and SCN3) and another three measuring sensing technological options (STO1, STO2 and STO3) were defined and assessed on Likert 5-point scales. Each item begins with the phrase "In our company…".

Table 22 Items for measuring sensing capabilities

Code	Items	Reference
SCN1	We systematically observe and evaluate the needs of our customers.	Janssen and den Hertog (2016), Janssen, Castaldi and Alexiev (2016), Kiani, Ahmad and Gillani (2019)
SCN2	We analyse the actual use of our products and services.	
SCN3	Our organisation is strong in distinguishing different groups of users and market segments.	
STO1	We keep up to date with promising new products, services and technologies.	
STO2	We use different sources of information to identify opportunities related to new products/services and technologies.	
STO3	We follow which technologies our competitors use.	

Experimentation capabilities

The experimentation capabilities variable measures the degree to which an SME is able to explore new ways of creating and capturing value, exploit new knowledge about its environment, conceptualise new business model ideas and actively experiment through prototypes or pilot tests. For this purpose three items assessing a firm's ability to conceptualise, design, prototype and test new business model ideas were selected from Janssen, Castaldi and Alexiev (2016). These items have been used in prior research on business model innovation (Janssen y den Hertog, 2016; Kiani et al., 2019) and therefore are considered appropriate for the current research. To better fit the definition of experimentation capabilities adopted in this thesis, these three items were complemented with another three based on Mezger's (2014) approach to business model innovation capabilities, which emphasises the role of experimentation and learning based on a firm's ability to systematically deploy new knowledge into new business model configurations. The six items (Table 23) were defined and assessed on a Likert 5-point scale. Each item begins with the phrase "In our company…".

Table 23 Items measuring experimentation capabilities

Code	Items	Reference
EX1	We frequently come up with new ideas for products, services, value propositions or business models.	Mezger (2014), Janssen and den Hertog (2016), Janssen, Castaldi and Alexiev (2016), Kiani, Ahmad and Gillani (2019)
EX2	We find it easy to convert ideas and concepts into detailed products, services, value propositions or business models.	
EX3	New concepts are tested through prototypes and pilot tests before their final development.	
EX4	We regularly experiment with new ways of both creating value for our customers and capturing value from our innovations.	
EX5	We combine technological, market and business model knowledge in the idea generation and/or experimentation processes.	
EX6	When ideating new concepts, we analyse each of the elements of our business model (value proposition, target customers, relationships and channels, activities and resources, cost and revenue streams and key partnerships).	

Collaboration capabilities

The collaboration capabilities variable measures the degree to which an SME is able to exchange knowledge with external partners and involve customers during innovation processes. Three items were adapted from van de Vrande et al., (2009) and assessed on a Likert 5-point scale (Table 24). Each item begins with the phrase "In our company…".

Table 24 Items measuring collaboration capabilities

Code	Items	Reference
CO1	We involve customers in our innovation processes (e.g. through active market research or developing products or services based on their specifications).	van de Vrande et al., (2009)
CO2	We exchange knowledge with external partners (e.g. suppliers, universities, research centres, clusters, public organisations and other organisations).	
CO3	We collaborate with external agents in the development of innovations.	

Strategizing capabilities

The variable strategizing capabilities measures the degree to which an SME is able to design an innovation strategy and establish a plan to implement it while aligns that plan with the organisational strategy. Four items were adapted from Huurinainen (2007) and assessed on a Likert 5-point scale (Table 25). Each item begins with the phrase "In our company…".

Table 25 Items measuring strategizing capabilities

Code	Items	Reference
STRC1	We have a well-defined innovation strategy.	Huurinainen (2007)
STRC 2	Innovation strategy is aligned with our firm's strategy.	
STRC 3	Innovation strategy is clearly articulated as a means to transform our organisation.	
STRC 4	We have a well-defined action plan to execute and implement our innovation strategy.	

Innovation Culture

The innovation culture variable measures the degree to which an SME's expressed norms, shared values and beliefs support innovativeness, encouragement of employees, open communication and internal cooperation. Items were selected from Homburg and Pflesser (2000) that have been used in prior research on business model innovation (Hock et al., 2016), and therefore are considered suitable in the context of this research. Five items were adapted (Table 26) and assessed on a Likert 5-point scale. Each item begins with the phrase "In our company…".

Table 26 Items measuring innovation culture

Code	Items	Reference
IC1	We promote creativity and innovation.	Homburg and Pflesser (2000), Hock, Clauss and Schulz (2016)
IC2	People are encouraged to experiment with new ways of doing their job.	
IC3	We take advantage of people's knowledge and initiatives (collecting suggestions, encouraging them to propose ideas or creating teams for the development of innovations).	
IC4	We promote open communication and interdepartmental exchange of information.	
IC5	We promote teamwork and interdepartmental cooperation.	

Managerial orientation

The variable managerial orientation measures the degree to which the strategic management priorities of SME managers are focused on cost reduction rather than investment decisions, are oriented to the short term rather than long term and are engaged in low-risk rather than high-risk projects (Table 27). Items were developed from Covin and Slevin (1989). In addition, a last item was included to measure the extent to which managerial decisions were made during a crisis, as a way to measure with a single item an orientation towards cost-reduction, the short term and low-risk projects (Bailey et al., 2014; Lazonick, 2014; Orkestra, 2019). The four items were assessed on a Likert 5-point scale. Each item begins with the phrase “In the last three years, my strategic priorities in management have been…”.

Table 27 Items measuring managerial orientation

Code	Items	Reference
MO1	Influenced by the need to manage the company in a crisis.	Covin and Slevin (1989)
MO2	Focused on cost reduction rather than investment (in R&D, capital etc.).	
MO3	Focused on the short term rather than long term.	
MO4	Focused on low-risk projects rather than projects with greater potential but that entailed higher risks.	

Business model innovation tools

Business model innovation tools aims to measure the degree to which an SME uses tools, techniques, and methodologies for business model innovation.

The literature review of business model innovation tools (section 2.3) revealed that no available study provides a scale for measuring the use of business model innovation tools. Therefore, a new scale was created following the well-known scale development procedure of Churchill (1979), as it ensures a scale with high reliability and validity (Clauss, 2017; Verma y Bashir, 2016).

First, the domain of the construct was specified, defining business model innovation tools as the use of tools, techniques and methodologies to analyse, design and test business model opportunities in a systematic way. Second, a set of key tools for business model innovation in SMEs and their purpose was defined based on the literature review in section 2.3. These items were extensively discussed with other academicians and with SMEs’ top and middle managers during various workshops. From the insights gained, nine items were defined (Table 28).

Each item shows a specific activity related to the business model innovation process along with examples of the tools most commonly used to fulfil it. The examples were included to make it easier for respondents to understand each item. These examples were extracted from the literature and from workshops with SMEs. Some tools were presented as examples in multiple items (i.e. *business model canvas* and *value proposition canvas*), since they are commonly applied for several purposes within the business model innovation process, such as exploration, analysis, ideation, design and evaluation (Osterwalder, 2014; Osterwalder y Pigneur, 2010).

The nine items were assessed on a Likert 5-point scale. Each item begins with the phrase "In projects aimed at the transformation, reactivation and improvement of our business models and value propositions, we regularly use techniques for...".

Table 28 Items measuring business model innovation tools

BMI process	Code	Items	Reference
Analysis	BMIT1	The prospective exploration of opportunities. *For example: technological surveillance, trend watching, scenarios, roadmapping, etc.*	Self-developed
	BMIT2	Identifying improvements and help in making strategic decisions. *For example: SWOT analysis (weaknesses, threats, strengths and opportunities), Porter's five forces model, value chain analysis, stakeholder map, etc.*	
Analysis, Design	BMIT3	The identification, understanding and segmentation of clients and their needs, expectations and problems. *For example: interviews, focus group, empathy map, personas, stakeholder map, etc.*	
	BMIT4	The analysis of the value proposition and its alignment with the needs, expectations and problems of the clients. *For example: canvas of the value proposal, value map, product or service portfolio, etc.*	
	BMIT5	The systemic and integral evaluation of our current value proposition and business model. *For example: canvas of the business model, canvas of the value proposition or other similar models, business plan, simulation-based methodologies, business model patterns, etc.*	
Design	BMIT6	The creative generation of new ideas of products, services, value proposition or business model. *For example: brainstorming, mental maps, lateral thinking, etc.*	
	BMIT7	The design of new value propositions and business models. *For example: canvas of the business model, canvas of the value proposition or other similar models, business plan, simulation-based methodologies, business model patterns, etc.*	
Test	BMIT8	Testing and validating of hypotheses or ideas related to the value proposition or business model. *For example: benchmarking, rapid prototyping, usability tests, experimentation, simulations, minimum viable product, use of indicators, etc.*	
	BMIT9	We apply agile methodologies based on iteration, learning and experimentation for the development and validation of new value propositions and business models. *For example: design thinking, lean start-up, scrum, kanban, agile, etc.*	

Business model innovation

Business model innovation is defined as a multidimensional construct comprising three dimensions: value delivery, value creation and value capture. The construct measures the degree to which an SME has introduced purposeful changes in any of these dimensions.

The literature review for this thesis found only three studies providing multidimensional constructs of business model innovation (Clauss, 2017; Futterer et al., 2018; Spieth y Schneider, 2016).

Spieth and Schneider (2016) defined a formative-reflective higher-order construct containing three dimensions: value architecture innovation, value offering innovation and revenue model innovation. Clauss (2017) also suggested a formative-reflective higher-order construct encompassing three dimensions: value creation innovation, value proposition innovation and value capture innovation. Futterer, Schmidt and Heidenreich (2018) created a reflective-formative higher-order construct involving four dimensions: value offering architecture, internal value creation architecture, external value architecture and financial architecture.

When defining the items for their scale, Spieth and Schneider (2016) proposed a very general scale, simply adding the "have changed" indicator to the variables under study (e.g. target customers have changed). Clauss (2017) focused on a firm's capacity for business model innovation rather than measuring its outcomes. Finally, Futterer, Schmidt and Heidenreich (2018) focused on measuring to what extent new elements were required, established or developed by the implementation of the business model.

Since this thesis focuses on business model innovation outcomes (changes introduced to an existing business model), it was concluded that the measurement approaches detailed above did not fit the thesis approach. There was also a need for a scale that could be easily understood by SMEs. Therefore, it was decided to adapt existing unidimensional scales from the business model innovation literature to create a formative-reflective higher-order construct for business model innovation for this thesis (Table 29).

Table 29 Items measuring business model innovation

High order construct	Code	Items (Lower order construct)	Reference
Value delivery dimension	VDEL1	We have met new customer needs previously unmet by the market.	Zott and Amit (2007), Schrauder et al. (2018)
	VDEL2	We have solved customer problems not solved by our competitors.	
	VDEL3	We have introduced new forms of value for customers.	
	VDEL4	We have introduced new forms of value for other partners (suppliers or distributors).	
	VDEL5	We have diversified into new markets, targeting completely new customer types or new geographical environments.	
	VDEL6	We have expanded our activity to new customer segments.	
Value creation dimension	VCRE1	We have significantly modified the set of key activities of our business through the acquisition or elimination of certain activities or their internal and/or external reorganisation, allowing us to be more efficient and provide better response.	Zott and Amit (2007), Schrauder et al. (2018)
	VCRE2	We have established new collaborations with third parties that have allowed us to optimize and improve our value proposition and/or business model.	
	VCRE3	We have integrated customers, suppliers, distributors and other agents in innovative ways in relation to the delivery of products and services.	
	VCRE4	We have reconfigured our value chain, allowing us to be more efficient and provide better response to all interested parties.	
Value capture dimension	VCAP1	We have introduced new ways to reduce costs.	Johnson, Mark, Christensen and Kagermann (2008), Lindgardt et al. (2009), Bouwman et al. (2015), Verhagen (2018)
	VCAP2	We have introduced new pricing mechanisms.	
	VCAP3	We have introduced new ways to be profitable.	
	VCAP4	We have introduced new revenue streams.	

Value delivery and value creation were based on Zott and Amit (2007) and Schrauder et al. (2018) and were measured with six-item and four-item scales, respectively. Value capture, in turn, was based on the four-item scale adapted from the Envision Project (Bouwman et al., 2015), which was based on prior research (Johnson et al., 2008; Lindgardt et al., 2009) and was empirically validated by Verhagen (2018). All items were assessed on a Likert 5-point scale. Each item begins with the phrase “In the last three years, in our company...”.

Firm performance

Firm performance measures an SME’s perception of its market performance, growth, and profitability.

Perceived performance scales have certain disadvantages, since they are liable to the subjective opinion of the respondents, who in turn, can be conditioned by their tendency to rate the company's objective financial performance using a subjective substitute (Kraus et al., 2012). Nevertheless, these scales also have some advantages. For instance, objective data on the financial performance of SMEs is rarely available, since owners are not legally required to publish this data (Lubatkin et al., 2006). Moreover, it is common for entrepreneurs and managers of small firms to refuse to provide performance information to researchers (Kraus et al., 2012).

In addition, SME managers are generally seen as knowledgeable informants regarding their firm’s performance (Lubatkin et al., 2006). Moreover, several studies have proven the accuracy and reliability of perceived performance measures. For instance, small differences (Geringer y Hebert, 1991; Rauch et al., 2009) and strong associations have been found between subjective and objective performance measures (Dess y Robinson, 1984; Geringer y Hebert, 1991; Govindarajan, 1988; Rauch et al., 2009; Sarkar et al., 2001; Wall et al., 2004). Additionally, some authors suggest that multiple performance measures should be used when there are reasons for questioning the validity of one method or when single-measure objective data is not available (Govindarajan, 1988; Kraus et al., 2012).

Based on the information above, a six-item scale was defined to measure firm performance based on perceived market performance, growth and profitability (Table 30). Items measuring market performance and growth (MP1-MP6) were selected from Brettel et al. (2012), who had adapted the items from Homburg and Pflesser (2000) to measure the performance implications of business model design on SMEs. Since business model innovation is about creating new value for customers and addressing new markets, this scale was considered appropriate to measure business model innovation outcomes from the market view. In addition, two items were included to capture perceived profitability (FP1 and FP2) based on prior research measuring business model innovation performance implications in SMEs (Bouwman et al., 2019; Guo et al., 2017; Lopez-Nicolas et al., 2020; Pucihar et al., 2019). Respondents were asked to self-evaluate their company’s performance relative to that of their competitors (Brettel et al., 2012; Guo et al., 2017; Pedersen et al., 2018) using a 5-point Likert scale.

Table 30 Items measuring firm performance

Code	Items	Reference
FP1	Earnings growth	Brettel, Strese and Flatten (2012), Guo et al. (2017), Bouwman et al. (2019), Pucihar et al. (2019), Lopez-Nicolas et al. (2020), Pedersen et al. (2018)
FP2	Profit growth	
MP1	Sales growth	
MP2	Market share growth	
MP3	Customer satisfaction	
MP4	Customer loyalty	
MP5	Attracting new customers	
MP6	Delivering value to customers	

Business model advantage

The variable business model advantage measures the ability of a business model to provide customers with benefits superior to those provided by competitors in terms of higher value, exclusiveness, access to new markets, and inimitability (Lecocq et al., 2010; Teece, 2010). To construct the scale for business model advantage (Table 31), five items from Cooper et al. (1994) measuring product advantage were adopted. The word "product" was changed to "business model", as has been done in other studies on business model innovation (Pölzl, 2016). A new self-developed item was also added (BMA6) to ensure that the scale was capturing the meaning of the construct. The six items were assessed on a Likert 5-point scale. Each item begins with the phrase "Our business model…".

Table 31 Items measuring business model advantage

Code	Items	Reference
BMA1	Is difficult for the competition to copy.	Cooper et al. (1994), Pölzl (2016)
BMA2	Offers unique benefits for the client that cannot be found elsewhere.	
BMA3	Offers significant advantages compared with the business models of our competitors.	
BMA4	Is perceived by our clients to offer greater value or quality than that of our competitors.	
BMA5	Has a strong and distinctive brand.	
BMA6	Is more competitive now than three years ago.	

Business innovation

The variable business innovation measures the extent to which an SME has introduced new or improved products, services, processes or related activities that differ significantly from the previous ones. Seven items were adopted from the Community Innovation Survey (CIS, 2014). Product, service, process and organisational innovation were measured with one item (Table 32). Marketing-based innovation activities were differentiated into two distinct activities: promotion and communication (INNOMARPC) and sales and distribution (INNOMARSD). Finally, a last item assessing the acquisition of advanced machinery, equipment or software (INNOACQ) was included to address the resource investment efforts of SMEs. All the items were measured based on a dichotomous scale (yes/no), as in the original survey. Each item begins with the phrase "In the last three years…".

Table 32 Items measuring business innovation

Innovation form	Code	Items	Reference
Product innovation	INNOPROD	New or significantly improved products to the market (excluding the simple resale of new goods and changes of a solely aesthetic nature).	CIS Survey (2014)
Service innovation	INNOSERV	New or significantly improved services to the market.	
Process innovation	INNOPROC	New or significantly improved methods of manufacturing or producing goods or services.	
Resource acquisition	INNOACQ	Acquire advanced machinery, equipment or software to produce new or significantly improved products and processes.	
Marketing innovation	INNOMARPC	New or significantly improved communication and promotion channels improved at the marketing level.	
Marketing innovation	INNOMARSD	New or significantly improved sales and distribution channels.	
Organisational innovation	INNORG	New management practices, work organisation methods and decision-making or methods for the organisation of external relations with other companies or institutions.	

4.6. Data collection and preparation

As mentioned in the previous section, data collection was done through a self-administered online questionnaire. The different aspects of data collection are presented below. This section first describes the population under study and the sample design and then addresses the questionnaire design. The section ends with an explanation of the process for validating the questionnaire and collecting data.

4.6.1. Population and sample design

The population is the entire group of people, events, or things the researcher wishes to investigate in responding to a research problem, while sampling is the process of selecting a segment from that population with which to conduct the study (Sekaran y Bougie, 2016).

The two major types of sampling design applicable to Internet surveys are probability and non-probability sampling (Creswell and Creswell, 2017). In probability sampling, the research population is known, the sample is chosen at random, and subjects have an equal probability of being selected. In non-probability sampling, by contrast, data is collected based on subjective judgment, thus the sample is not randomised. In quantitative research, probability sampling is preferred, as it can produce findings that are more widely generalizable. However, when critical factors such as time, resources or other research-related issues take precedence over generalizability, non-probability sampling is generally used.

This research aims to explore the phenomenon of business model innovation in SMEs, and thus the population of interest is SMEs that have engaged in business model innovation. Due to the difficulty of determining the exact number of SMEs engaged in business model innovation, the population frame was unknown. Thus, non-probability sampling, specifically judgment (purposive) sampling, was employed. This sampling strategy allows the selection of study subjects based on a set of predetermined criteria that are relevant to the research (Loon y Chik, 2019). For this thesis, the following criteria were established:

- The size of the SMEs was limited to companies with a staff headcount less than 250 and turnover less than €50 million. This criteria was selected based on the European Commission's definition of SME (EU Commission, 2003).
- The geographical location was delimited to the region of Gipuzkoa, due to researcher's interests and data accessibility.
- It was determined that the analysis would be multi-sectorial to avoid the biases inherent in selecting data for only specific activities (Huselid, 1995; Yáñez-Araque et al., 2017).
- To ensure that SMEs selected were engaged in business model innovation, they were chosen from among SMEs that had participated during the previous three years (2017–2019) in the Regional Government of Gipuzkoa's funding programmes for 1) the improvement of competitiveness and 2) business transformation through differentiation, diversification and the contribution of value to products, services and business models.

Based on these criteria, the sampling frame was obtained in collaboration with the Department of Economic Promotion, Tourism and Rural Environment of the Regional Council of Gipuzkoa. This department provided access to a list of 267 SMEs in Gipuzkoa that within the previous three years had participated in at least one of the listed funding programmes and therefore could have implemented business model innovation.

Sample size requirements

The minimum sample size required for the data analysis was established before selecting the sample, since it has an impact on the data analysis technique selected. As mentioned in subsection 4.5.1, this study adopts multiple methods to investigate the research objectives.

While fsQCA is suitable for both small and large samples (Russo y Confente, 2019), in PLS-SEM the sample size affects the robustness of the model (Hair et al., 2019). Thus, a minimum sample size should be established before the analysis is conducted to ensure that the results will have adequate statistical power.

For minimum sample size estimation in PLS-SEM, Hair *et al.* (2016) suggest two methods: the 10-times rule method and the minimum R-squared method. Both methods were used to determine the minimum sample size required for this thesis.

The 10-times rule method suggests that the sample size should be greater than 10 times the maximum number of predictor variables pointing at latent variables in the inner or the outer model[5] (Goodhue et al., 2012). The research model with the greatest number of predictor variables is the one reflecting the relationships between business model innovation and its antecedents and outcomes (Figure 28), which in the PLS models include four predictors (section 5.3) pointed at one variable. Thus, in line with the 10-times rule method, the minimum sample size for the present research should be 40 observations.

Although the 10-times rule method is the most widely used for size estimation in PLS-SEM (Kock y Hadaya, 2018), Hair *et al.* (2016) recommend further determining the size against the background of the model and data characteristics. For this purpose, they introduce the R-squared method, in which the minimum R-squared[6] in the model is used to determine the minimum sample size required for a model (Kock y Hadaya, 2018).

Since the PLS-SEM is essentially based on OLS regressions, this method builds on the tables developed by Cohen (1992) for statistical power analysis in multiple regression models (Hair et al., 2016). These tables list the minimum sample sizes required depending on the minimum R-squared of the path model and the number of predictors to achieve a statistical power of 0.80 (80%) with a significance level $\alpha = 0.05$ (Cohen, 1992).

Following the guidelines of Kock and Hadaya (2018), the minimum sample size was established based on Table 33. In the present research, the maximum number of arrows pointing at a latent variable is four. Assuming a moderate R-squared value of at least 0.25 (Hair et al., 2016), to achieve a statistical power of 80% with a 5% probability of error, a minimum sample size of 65 is required.

Table 33 Table for the minimum R-squared method.
Adapted from Kock and Hadaya (2018)

N	Minimum R^2 in the model			
	.10	.25	.50	.75
2	110	52	33	26
3	124	59	38	30
4	137	**65**	42	33
5	147	70	45	36
6	157	75	48	39
7	166	80	51	41
8	174	84	54	44
9	181	88	57	46
10	189	91	59	48

Note: N: Maximum number of arrows pointing at a construct

[5] In PLS-SEM a path model illustrating the research hypotheses and the relationships between variables is developed. Path models are defined through two elements: the structural model (commonly known as the inner model in PLS-SEM) and the measurement model (or outer model). The former describes the relationships between the variables, while the latter describes the relationship between the variables and the items used to measure it (Hair et al., 2016).

[6] The R-squared value explains the variance of each endogenous variable and is a measure of the model's explanatory power (Hair et al., 2019).

The final sample size of the present study is 78 observations and thus exceeds the minimum sample size estimated by both methods. The appropriateness of the sample size for a statistical power of 80% was further validated during the PLS-SEM analyses through a post hoc power analysis in G*Power (Faul et al., 2007).

4.6.2. Questionnaire design

The questionnaire was developed in the online platform SurveyMonkey (https://www.surveymonkey.com/). This platform was chosen for several reasons. It meets the design specifications for a "respondent-friendly" questionnaire (Dillman, 2011, 2014), and gives the questionnaire a more attractive look than other platforms tested (e.g. Google Forms). It is a widely used tool and usually recommended by academic experts (Sekaran y Bougie, 2016). Lastly, the SurveyMonkey platform allows the direct export of data to various statistical software packages such as Excel and SPSS that can be used for data analysis.

The questionnaire was developed in Spanish. Thus, items were translated from English to Spanish following the back-translation method to ensure equality of the items (Sekaran and Bougie, 2016; Rangus and Slavec, 2017). The new scales specifically developed for this research in Spanish were translated following the same back-translation process for the English version gathered in this report.

Common method variance (CMV) issues were also addressed in designing the questionnaire, since they can prove problematic with survey-based studies. CMV arises when the variance "is attributable to the measurement method rather than to the constructs the measures represent" (Podsakoff et al., 2003, p. 879). In this research, data was collected on the perceptions of a given respondent, at a given point in time, and by means of one measurement instrument assessing both independent and dependent variables. As recommended by some authors, procedural and statistical remedies were applied to reduce and control CMV that could otherwise affect the validity of the measures (Craighead et al., 2011; MacKenzie y Podsakoff, 2012; Podsakoff et al., 2012). Procedural remedies were applied prior to data collection, during questionnaire design, to minimize possible CMV, while statistical remedies were applied after data collection to determine whether there were biases related to the data collection method (statistical remedies will be presented in subsection 5.1.3). The procedural remedies applied were the following:

- The questionnaire included an introductory section explaining how to complete the questionnaire, highlighting that the purpose was to gain the participant's opinions, and therefore, no good or bad answers existed. The purpose of this wording was to reduce the tendency of participants to respond in a socially desired way (Podsakoff et al., 2012).

- The independent and dependent variables were arranged in separate sections. As far as possible, different scales (categorical, dichotomous and Likert-type) were combined in each section, and some items were reversed (managerial orientation) to reduce the likelihood a participant would respond based on previous answers or by following a given pattern (Podsakoff et al., 2012).
- The final questionnaire was developed based on an iterative review process, pretests and discussion with experts to reduce social and contextual biases.
- The link to the questionnaire was sent in an email signed by the Regional Government of Gipuzkoa to the SMEs' managers inviting them to participate in the research. The email briefly explained the purpose of the study and the relevance the results could have for the respondent's company, and it promised that the findings of the study would be shared with respondents. This strategy was intended to increase the response rate and motivate participants to answer more accurately.
- To ensure response accuracy, the confidentiality and anonymity of both the company and the respondent were guaranteed (Craighead et al., 2011).
- Finally, to ensure that respondents had sufficient knowledge to respond correctly to each measure, the email asked recipients who were not managers to forward the message to their manager.

The final questionnaire was structured as shown in Table 34. Full copies of the original version of the final questionnaire and the presentation email are attached in Appendix B.

Table 34 Structure of the final questionnaire

	Questionnaire section	Items
1	RESPONDENT DATA	Years in the company, level in the organisational structure, training background, previous experience and department or function.
2	COMPANY CHARACTERISTICS	Main activity, legal form, company ownership, age of the company, personnel employed, turnover, number of business units and customer sector.
3	HOW IS THE ORGANISATION?	Managerial orientation, innovation culture and strategizing capabilities.
4	HOW DO YOU REACTIVATE AND TRANSFORM YOUR ORGANISATION?	Sensing customer needs, sensing technological options, experimentation capabilities, collaboration capabilities and business model innovation tools.
5	WHAT HAS BEEN TRANSFORMED IN YOUR ORGANISATION IN THE LAST THREE YEARS?	Value delivery innovation, value creation innovation, value capture innovation and business innovation.
6	WHAT RESULTS HAVE BEEN OBTAINED?	Business model advantage and firm performance.

4.6.4. Data collection procedure

The data collection process started with the validation of the questionnaire. The questionnaire pretest was conducted in two steps. In a first stage, the reliability and validity of all the variables and items were tested by four academicians and research scholars in management and innovation fields. In a second stage, a pilot study emulating the procedure to be used with the final sample was conducted with eight potential respondents who were not included in the final sample. The link to the survey questionnaire was shared with these test respondents. After the responses to the pilot were received, an open-ended personal interview was conducted with each participant regarding the key issues of the study. To check that terminology and survey questions were understandable, the researcher asked respondents to interpret each question and their response to it (Fink, 2017). Special attention was paid to questions referring to "business model" and "business model innovation" concepts. Content validity was established by rewording and simplifying several items based on the feedback received.

The final questionnaire was launched on 7th May, 2019. The process of collecting questionnaires lasted until 12th June. During this period, two reminders were sent, one every two weeks. Of the 267 surveys sent, 89 were returned, which is a response rate of 33.33%, in line with the average response rates for similar studies in the business model innovation field (Cucculelli y Bettinelli, 2015).

Chapter 5

Analysis and results

5. Analysis and results

This chapter describes the analyses performed and the results obtained in evaluating the four research objectives and the related hypotheses and propositions. The chapter is structured as follows:

- The first section describes the data examination and preparation for subsequent analysis.
- The second section provides a descriptive analysis of the sample under study.
- The third section presents the PLS-SEM procedure and the analyses developed to respond to the first and second objectives. This section also validates the eleven hypotheses and interprets the results.
- In the fourth section, the fsQCA procedure is described, and the analyses developed to address the third objective are presented. This section includes the validation of the two defined propositions and the interpretation of the results.
- The final section explains the statistical tests carried out to address the fourth objective. This section includes the exploration of relationships among several variables and the interpretation of the results.

5.1. Data examination

The data collected was downloaded from the SurveyMonkey platform in Excel file format and prepared for processing in SPSS and later in both PLS-SEM and fsQCA. Items were converted to numerical values in cases where answers were shown in text for dichotomous scales (i.e. yes or no) or Likert-based scales (i.e. from "strongly disagree" to "strongly agree"), and items were coded to simplify them and make them more manageable.

Variables negatively worded, such as "managerial orientation", were recoded into a new variable inverting their scores, so that higher scores indicated long-term orientation, high-risk projects and investment activities rather than short-term orientation, low-risk projects and cost reduction.

Once the data sheet was suitable for processing in SPSS, issues related to collecting data using self-reported questionnaires were examined, including issues of missing data, outliers and suspicious response patterns, data distribution and bias (i.e. common method variance and non-response bias). Finally, an exploratory factor analysis was conducted to validate the items and check the dimensionality of the variables under study.

5.1.1. Missing data

Missing data results from a respondent not answering one or more questions, either consciously or unconsciously (Tabachnick y Fidell, 2012). Regardless of the reason for the missing data, once it is missing, its lack becomes part of the dataset and should be managed prior to data analysis. Several methods exist for handling missing data, ranging from eliminating the observations to replacing missing values. The most appropriate method should be chosen based on factors such as the number of missing values, sample size and the pattern of missing data (Cheema, 2014; Tabachnick y Fidell, 2012).

Hair et al. (2016) recommend eliminating observations when the percentage of values missing for an item exceeds 15% and using a replacement method when fewer than 5% of values for an item are missing. Cheema (2014) advocates ensuring that values are missing completely at random (MCAR) and that the missing values do not fall into any predictable pattern affecting any variable under study. When data is MCAR and the sample is large enough to provide adequate power for hypotheses testing even without the missing values, observations with missing values should be removed. On the contrary, when dealing with small samples, as in the case of this research, retaining as many cases as possible is recommended, and the replacement of missing values using imputation methods such as expectation maximization (EM) imputation is suggested (Cheema, 2014; Tabachnick y Fidell, 2012). As outlined in Table 35, 11 of the 89 observations are missing more than 15% of their values, and thus, the observations were removed from the dataset.

Table 35 Missing values per case

Missing data	Number of cases
Unanswered	5
Missing data >15%	6
Missing data < 15%	5
No missing data	73
Total cases	89

The remaining 78 cases were checked to determine whether more than 5% of data values were missing from any item. As indicated in Table 36, the highest percentage found was 3.8%, and thus, the remaining cases were maintained. Next, a missing data analysis was carried out in SPSS to determine whether missing data was MCAR. Little's MCAR test results (below Table 36) showed a p-value of 0.279, exceeding the recommended threshold of 0.05 (Cheema, 2014; Tabachnick y Fidell, 2012). Therefore, it was assumed that data was missing completely randomly, and missing values were replaced using the EM imputation method.

Table 36 Missing values per item

Items	Missing Count	Percent
Strategizing capabilities (STRC3)	1	1.3
Value creation (VCRE2)	1	1.3
Firm performance (FP1)	2	2.6
Firm performance (FP2)	2	2.6
Firm performance (MP2)	2	2.6
Firm performance (MP3)	2	2.6
Firm performance (MP4)	2	2.6
Firm performance (MP5)	3	3.8
Firm performance (MP6)	2	2.6
Business model innovation tools (BMIT1)	1	1.3
Business model innovation tools (BMIT3)	1	1.3

Little's MCAR test: Chi-Square = 317.952, DF = 304, Sig. = .279
The EM algorithm failed to converge in 25 iterations

5.1.2. Outliers and suspicious response patterns

Outliers are those observations with unusually high or low values that clearly differ from the rest of the observations (Hair et al., 2014). Although for variables measured on Likert scales, outliers commonly do not cause problems (Gelei et al., 2015), it is highly recommended to explore them, as they may represent cases that are not members of the population under study. Furthermore, such outliers can distort statistical tests if they happen to be problematic outliers. Visual assessment of univariate outliers was conducted by means of boxplots using SPSS (Hair et al. 2014). The boxplots identified a number of outliers, but none of them were extreme (see Appendix C). Therefore, the 78 observations were maintained.

Suspicious response patterns were also visually assessed to avoid inconsistencies in the data (Hair et al., 2016). Two types of response patterns can be considered suspicious: when a respondent has given inconsistent answers and when a respondent has chosen the same answer for almost all the questions. No anomalies or tendencies of respondents to continuously mark the same values were identified. Consequently, all observations were considered adequate in terms of response patterns.

5.1.3. Statistical remedies to common method variance (CMV)

This subsection explains the statistical remedies applied after data collection to detect CMV. Harman's single-factor test was used, as it is commonly applied to manage CMV in business research (Fuller et al., 2016).

For Harman's single-factor test, all the items measured with Likert scales were loaded into a factor analysis in SPSS. According to Podsakoff et al. (2003), a substantial amount of CMV is present when (a) a single factor emerges from the factor analysis or (b) one general factor accounts for most of the covariance among the measures.

First, the unrotated factor solution was examined using principal component analysis (PCA) and eigenvalues greater than 1.0. No single dominant factor emerged, as the results revealed 17 distinctive factors which accounted for 80.987% of the total variance. A second factor analysis was performed forcing one-factor extraction. The results indicated that one general factor accounted for only 29.094% of total variance, which was less than one-half the total variance percentage.

Although the applied procedural and statistical remedies do not exclude the possibility of CMV, based on the tests described above, it was assumed that CMV was unlikely to lead to misreading the results of this study.

As a follow-up to this, a full collinearity test capturing variance inflation factors (VIFs) was developed, as recommended by Kock (2015) for PLS-SEM based studies. This was checked during the PLS-SEM analysis phase. As can be seen in section 5.3, all the VIF values were below the recommended threshold of 3, indicating that there were no collinearity issues between predictor constructs (J. F. Hair et al., 2019).

5.1.4. Non-response bias

Non-respondents are those who, for some reason, have refused to participate in the research and are therefore considered different from the rest of the sample (Saunders et al., 2009). Non-responses can lead to biases, since responses by these non-respondents could have changed the results of the study. In this study, it was assumed that participants who responded to the questionnaire in the last weeks of the data collection period or after feeling pressured by reminder emails were equivalent to non-respondents (Creswell y Creswell, 2017). Thus, a t-test for independent samples was conducted to compare the means of early and late respondents for the main constructs of the study (Mikalef y Pateli, 2017).

For the t-test, early respondents were considered those who had submitted responses before the first reminder (n = 34), whereas late respondents were those who had responded after the first reminder (n = 44). The differences between the means of early and late respondents calculated with the t-test analysis are presented in Table 37.

Table 37 Variables' mean differences between early and late respondents

Early_late		N	Mean	Std. deviation	Std. error mean
Managerial orientation (MO)	1,00	34	3.5147	.80468	.13800
	,00	44	3.2784	.88465	.13337
Innovation culture (IC)	1,00	34	4.0000	.72864	.12496
	,00	44	3.9182	.78512	.11836
Strategizing capabilities (STRC)	1,00	33	3.4876	.90673	.15550
	,00	44	3.4659	.73054	.11013
Sensing capabilities (SENC)	1,00	34	3.7647	.62444	.10709
	,00	44	3.6591	.51175	.07715
Experimentation capabilities (EC)	1,00	34	3.2255	.68397	.11730
	,00	44	3.2386	.78041	.11765
Collaboration capabilities (CO)	1,00	34	3.5735	.79898	.13702
	,00	44	3.5114	.89889	.13551
Business model innovation tools (BMIT)	1,00	33	2.9618	.80482	.13803
	,00	43	2.8656	.74228	.11190
Value delivery (VDEL)	1,00	34	3.3431	.74529	.12782
	,00	44	3.3902	.78169	.11784
Value creation (VCRE)	1,00	33	3.2266	.92226	.15817
	,00	44	3.1080	.85657	.12913
Value capture (VCAP)	1,00	34	2.9559	.81294	.13942
	,00	44	3.1477	.74185	.11184
Business model advantage (BMA)	1,00	34	3.2647	.61638	.10571
	,00	44	3.1227	.68365	.10306
Firm performance (FP)	1,00	32	3.7506	.33658	.05772
	,00	43	3.5098	.52490	.07913

The differences in means between variables are given in Table 38 with their statistical significance. To examine the results of the t-test, the group of variances calculated through Levene's test must first be observed. If Levene's test presents p-values above 0.05, equal variances are assumed (EVA), and therefore, the significance levels of the mean differences (Sig. [2-tailed]) presented in the upper row (equal variances assumed) must be examined. By contrast, when equal variances are not assumed (EVNA), which means that p-values are below 0.05, the Sig. (2-tailed) values of the lower row need to be considered (Mooi y Sarstedt, 2019). When the Sig. (2-tailed) value is below 0.05, the hypothesis of mean equality is rejected, indicating the value of the dependent variable differs significantly between the two groups.

Assuming equal variance of the constructs (p-values < 0.05 in Levene's test), Table 38 shows that the significance levels (Sig. [2-tailed]) were higher than the minimum cut-off (<0.05), suggesting that dissimilarities between respondents did not affect significantly the answers.

Table 38 t-test for non-response bias

		Levene's test for equality of variances		t-test for equality of means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% Confidence Interval of the Difference	
									Lower	Upper
MO	**EVA**	**.627**	**.431**	**1.216**	**76**	**.228**	**.23630**	**.19428**	**-.15065**	**.62324**
	EVNA			1.231	73.934	.222	.23630	.19191	-.14610	.61870
IC	**EVA**	**.052**	**.821**	**.471**	**76**	**.639**	**.08182**	**.17379**	**-.26432**	**.42795**
	EVNA			.475	73.421	.636	.08182	.17212	-.26118	.42481
STRC	**EVA**	**1.442**	**.234**	**.117**	**76**	**.907**	**.02174**	**.18536**	**-.34743**	**.39091**
	EVNA			.114	62.366	.910	.02174	.19055	-.35913	.40260
SENC	**EVA**	**.585**	**.447**	**.821**	**76**	**.414**	**.10561**	**.12866**	**-.15063**	**.36186**
	EVNA			.800	63.099	.427	.10561	.13199	-.15813	.36936
EC	**EVA**	**.840**	**.362**	**.318**	**76**	**.752**	**.06217**	**.19567**	**-.32755**	**.45188**
	EVNA			.323	74.458	.748	.06217	.19272	-.32179	.44612
CO	**EVA**	**1.505**	**.224**	**.801**	**76**	**.425**	**.14305**	**.17853**	**-.21252**	**.49862**
	EVNA			.823	75.799	.413	.14305	.17380	-.20312	.48922
BMIT	**EVA**	**.636**	**.428**	**.547**	**76**	**.586**	**.09620**	**.17584**	**-.25401**	**.44640**
	EVNA			.541	68.070	.590	.09620	.17769	-.25837	.45076
VDEL	**EVA**	**.443**	**.508**	**.611**	**76**	**.543**	**.10896**	**.17826**	**-.24607**	**.46399**
	EVNA			.612	71.329	.543	.10896	.17811	-.24616	.46408
VCRE	**EVA**	**.054**	**.817**	**.587**	**76**	**.559**	**.11865**	**.20224**	**-.28414**	**.52145**
	EVNA			.581	68.350	.563	.11865	.20419	-.28875	.52606
VCAP	**EVA**	**.133**	**.716**	**-1.086**	**76**	**.281**	**-.19184**	**.17663**	**-.54363**	**.15994**
	EVNA			-1.073	67.640	.287	-.19184	.17873	-.54853	.16484
BMA	**EVA**	**.001**	**.979**	**.949**	**76**	**.346**	**.14198**	**.14963**	**-.15603**	**.43999**
	EVNA			.962	74.142	.339	.14198	.14764	-.15218	.43614
FP	**EVA**	**.253**	**.616**	**1.573**	**73**	**.120**	**.16570**	**.10536**	**-.04428**	**.37567**
	EVNA			1.610	71.596	.112	.16570	.10290	-.03945	.37085

Note: MO: Managerial orientation; IC: Innovation culture; STRC: Strategizing capabilities; SENC: Sensing capabilities; EC: Experimentation capabilities; CO: Collaboration capabilities; BMIT: Business model innovation tools; VDEL: Value delivery; VCRE: Value creation; VCAP: Value capture; BMA: Business model advantage; FP: Firm performance; EVA: Equal variances assumed; EVNA: Equal variances not assumed

5.1.5. Normal distribution

Both PLS-SEM and fsQCA are non-parametric methods, so they do not require data to be normally distributed. However, Hair et al. (2016) recommend that before running a PLS-SEM analysis, the researcher should check that the data is not too far from normality, as extremely non-normal data is problematic in the assessment of the parameters' significances. Skewness and kurtosis distribution measures are commonly used to verify normality of the data in PLS studies.

Skewness assesses the extent to which a variable's distribution is symmetrical, while kurtosis measures the height of the distribution (Hair et al., 2014). The distribution of responses is considered skewed when a variable stretches too much to the right or left tail of the distribution, whereas a distribution that is too peaked indicates that most of the responses are near the centre.

Skewness and kurtosis values of the indicators were analysed (Table 39). Non-normality of data was not an issue, since most of the items ranged between -1 and 1 (Hair et al., 2016), and those that strayed from these values did not exceed the range of ±2 (Garson, 2012; Zainol et al., 2014).

Table 39 Descriptive statistics and normal distribution of items

Items	Mean	Std. dev.	Skewness	Skewness std. error	Kurtosis	Kurtosis std. error
MO1	3.22	1.112	-.040	.272	-1.001	.538
MO2	3.45	1.077	-.216	.272	-1.050	.538
MO3	3.45	1.089	-.361	.272	-.641	.538
MO4	3.41	1.050	-.344	.272	-.497	.538
IC1	3.76	.871	-.832	.272	.734	.538
IC2	3.85	.854	-.338	.272	-.474	.538
IC3	3.87	.888	-.428	.272	-.491	.538
IC4	4.12	.837	-.904	.272	.568	.538
IC5	4.18	.818	-1.077	.272	1.140	.538
STRC1	3.45	.863	-.647	.272	.444	.538
STRC2	3.63	.854	-.476	.272	.297	.538
STRC3	3.48	.930	-.306	.272	-.419	.538
STRC4	3.35	.865	-.249	.272	-.286	.538
SENC1	3.79	.745	-1.001	.272	2.244	.538
SENC2	3.63	.775	-.958	.272	1.222	.538
SENC3	3.46	.833	-.221	.272	-.552	.538
STO1	3.74	.692	-.576	.272	.579	.538
STO2	3.65	.787	-.610	.272	.060	.538
STO3	3.44	.783	-.616	.272	.321	.538
EX1	3.28	.952	-.136	.272	-.794	.538
EX2	3.23	.911	-.162	.272	-1.245	.538
EX3	3.31	1.061	-.248	.272	-.730	.538
EX4	3.31	.887	-.081	.272	-.899	.538
EX5	3.17	.828	-.323	.272	-.755	.538
EX6	3.10	.847	-.199	.272	-.271	.538
CO1	3.27	.976	-.140	.272	-.936	.538
CO2	3.46	.893	-.275	.272	-.755	.538
CO3	3.62	.943	-.486	.272	-.235	.538
BMIT1	2.93	1.008	-.023	.272	-.787	.538
BMIT2	3.67	.832	-.827	.272	.794	.538
BMIT3	2.86	1.099	-.019	.272	-.823	.538
BMIT4	2.85	1.129	-.133	.272	-1.002	.538
BMIT5	2.73	1.065	-.099	.272	-1.059	.538
BMIT6	2.97	.980	-.118	.272	-.916	.538
BMIT7	2.71	1.094	-.177	.272	-1.302	.538
BMIT8	2.76	.983	-.078	.272	-.790	.538
BMIT9	2.69	.997	.175	.272	-.628	.538
VDEL1	3.49	.908	-.281	.272	-.270	.538
VDEL2	3.47	.893	-.538	.272	.289	.538
VDEL3	3.51	.950	-.551	.272	-.024	.538
VDEL4	2.94	1.049	.131	.272	-.453	.538
VDEL5	3.41	1.156	-.501	.272	-.689	.538
VDEL6	3.40	1.049	-.380	.272	-.531	.538
VCRE1	3.27	1.040	-.424	.272	-.593	.538
VCRE2	3.20	1.086	-.228	.272	-.888	.538
VCRE3	3.03	1.057	.287	.272	-.697	.538
VCRE4	3.14	.977	-.119	.272	-.546	.538
VCAP1	3.04	.946	.016	.272	-.871	.538
VCAP2	2.96	1.012	-.153	.272	-.653	.538
VCAP3	3.31	.971	-.485	.272	-.357	.538
VCAP4	2.95	.979	-.151	.272	-.757	.538
BMA1	2.90	.988	-.121	.272	-.710	.538
BMA2	2.94	.944	.035	.272	-.864	.538
BMA3	3.21	.843	-.408	.272	-.143	.538
BMA4	3.50	.698	-1.059	.272	1.252	.538
BMA5	3.26	.959	-.541	.272	-.528	.538
BMA6	3.63	.854	-.476	.272	.297	.538
FP1	3.43	.815	.309	.272	-.068	.538
FP2	3.33	.829	.218	.272	-.387	.538
MP1	3.45	.680	-.316	.272	1.277	.538
MP2	3.39	.733	-.501	.272	.560	.538
MP3	3.72	.582	.069	.272	-.447	.538
MP4	3.77	.613	-.520	.272	.767	.538
MP5	3.48	.638	-.535	.272	-.235	.538
MP6	3.71	.662	-.140	.272	.031	.538

A single item (SCN1) exceeded this threshold, with a kurtosis of +2.24. Because this value was not far from the threshold, it was decided to keep the item (Hair et al., 2016).

5.1.6. Exploratory factor analysis (EFA)

Exploratory factor analysis (EFA) is used to analyse the interdependencies among items and related theoretical constructs, commonly named factors, to discover the underlying structure of the items (Jimenez, 2017). EFA involves reducing data until those factors emerge that by definition are highly interrelated and are supposed to represent the dimensions within the data (Hair et al., 2014; Jung y Lee, 2011). Thus, EFA is useful for removing overloaded items from self-developed or modified measurement scales, and for checking the dimensionality theoretically attributed to a construct before investigating item reliability and validity in further confirmatory analysis (Clauss, 2017).

This thesis conducted EFA to evaluate the scales of those measurement instruments that had been markedly modified or were self-developed. Since the present study contains 78 observations, and the total number of items to be explored was 51, it was decided to conduct three different EFAs to ensure that the number of observations per item was large enough to provide a reliable estimation of the correlation coefficients (Tabachnick y Fidell, 2012). Thus, the variables whose factor structure was being analysed were grouped based on their relationship in the research models and configurational propositions, resulting in three groups that contained the following:

- The antecedents variables affecting the research model (Figure 28) and proposition 1 (subsection 4.4.3): managerial orientation, innovation culture, sensing capabilities, experimentation capabilities, collaboration capabilities and innovation strategy.
- The three dimensions comprising business model innovation: value delivery, value creation and value capture.
- The self-developed scale for business model innovation tools used in the research model (Figure 29) and proposition 2.

In addition, when carrying out an EFA, statistical and methodological decisions must be made regarding data appropriateness, the factor analytic method, the factor retention method, the factor rotation method, and the factor loading cut-off (Howard, 2016).

Prior to each EFA, the Kaiser-Meyer-Olkin (KMO) index and the Bartlett's test statistic were calculated to ensure data appropriateness (Huang, 2016). The KMO index is calculated using the sum of partial correlations in relation to the sum of correlations; it measures sampling adequacy. When Bartlett's test is significant, it indicates that the observed inter-item correlation matrix diverges significantly from an identity matrix, which implies that the inter-item correlation matrix is suitable for factor analysis (Sun et al., 2019). According to Kaiser and Rice (1974), who introduced the calculation, when KMO is at least 0.6 and the p-value of Bartlett's sphericity test is close to 0.000, factorial analysis can be conducted (Huang, 2016).

The next step was to analyse whether the communalities of the items (i.e. the proportion of the variance in each item that is explained by the factors) were above 0.4. Communalities below this threshold are considered low communalities, which means that the item shares little variability with the other items on the scale, and it should be considered for elimination after an examination of the pattern matrix (MacCallum et al., 1999; Sun et al., 2019). Communalities between 0.60 and 0.80 are considered high, suggesting that items are well represented by the extracted factors (Goretzko et al., 2019).

The three EFAs were carried out following the same process. The most commonly recommended analytic methods for EFA are maximum likelihood (ML) and principal axis factoring (PAF) (Howard, 2016). The ML method is suggested when the data is normal and a clear factorial structure is met. When these conditions are not met, PAF is the most appropriate option (Jimenez, 2017). Based on this, PAF was considered the best choice for the current study.

Two rotation methods can be performed: orthogonal and oblique. The former preserves the non-correlation between factors, while the latter allows the factors to be correlated (Tabachnick y Fidell, 2012). The oblique rotation method *promax* was applied, as correlation between factors was assumed and was subsequently checked when conducting the EFA.

The factors' retention was determined based on the Kaiser criterion (1960), which suggests that all factors with eigenvalues above 1 should be retained (Howard, 2016). The Kaiser criterion is usually displayed in a scree plot in which the eigenvalues are plotted in descending order against the number of factors, which are represented in increasing order. The number of factors is chosen based on the point at which the curve forms an elbow towards a less steep decline (Cleff, 2019).

Finally, the factor loading cut-off was established at 0.4; all items with a factor loading below this threshold were eliminated (Hair et al., 2014; Nunnally, 1978). The results of the three EFAs are detailed below.

EFA of business model innovation antecedents

In the first EFA, the constructs for managerial orientation (MO), innovation culture (IC), strategizing capabilities (STRC), sensing capabilities (SENC), experimentation capabilities (EX) and collaboration capabilities (CO) were measured together.

Table 40 presents the KMO and Bartlett's test results. The KMO value was 0.807, exceeding the threshold of 0.4. Moreover, according to the labelled threshold values provided by Kaiser and Rice (1974), adequacy of the correlations can be considered "meritorious". Bartlett's test of sphericity was highly significant (p-value of 0), confirming the appropriateness of the data for factor analysis.

Table 40 KMO and Bartlett's tests for the antecedents constructs

KMO and Bartlett's tests		
Kaiser-Meyer-Olkin (kmo) Measure of Sampling Adequacy.		0.807
Bartlett's test of sphericity	Approx. Chi-Square	1585.187
	df	378
	Sig.	0.000

Table 41 presents the communalities of the items before and after principal factor analysis extraction. Results indicated that five items (MO1, SCN3, STO1, STO3 and EX3) should be considered for elimination after analysis of the pattern matrix. The remaining items present high communalities, and thus are considered to be well represented (Sun et al., 2019).

Table 41 Communalities for the antecedents constructs

Variables	Items	Initial	Extraction
Managerial orientation (MO)	MO1	0.520	**0.350**
	MO2	0.613	0.530
	MO3	0.819	0.906
	MO4	0.822	0.635
Innovative culture (IC)	IC1	0.819	0.740
	IC2	0.844	0.786
	IC3	0.765	0.660
	IC4	0.858	0.814
	IC5	0.841	0.772
Strategizing capabilities (STRC)	STRC1	0.842	0.851
	STRC2	0.835	0.860
	STRC3	0.886	0.830
	STRC4	0.771	0.676
Sensing capabilities (SENC)	SCN1	0.676	0.507
	SCN2	0.632	0.589
	SCN3	0.553	**0.347**
	STO1	0.658	**0.359**
	STO2	0.699	0.521
	STO3	0.497	**0.317**
Experimentation capabilities (EX)	EX1	0.762	0.621
	EX2	0.744	0.617
	EX3	0.642	**0.447**
	EX4	0.759	0.744
	EX5	0.798	0.769
	EX6	0.687	0.666
Collaboration (CO)	CO1	0.673	0.512
	CO2	0.722	0.775
	CO3	0.660	0.665

Note: Extraction method: principal axis factoring.

In addition, factor correlation matrix presented in Table 42 indicated that variables correlate with each other, suggesting that oblique rotation is appropriated (Tabachnick y Fidell, 2012).

Table 42 Correlation matrix for the antecedents constructs

Factor correlation matrix						
Factor	**1**	**2**	**3**	**4**	**5**	**6**
1	1.000	0.396	0.414	0.289	0.436	0.443
2	0.396	1.000	0.344	0.432	0.405	0.444
3	0.414	0.344	1.000	0.339	0.363	0.382
4	0.289	0.432	0.339	1.000	0.193	0.517
5	0.436	0.405	0.363	0.193	1.000	0.284
6	0.443	0.444	0.382	0.517	0.284	1.000

Note: Extraction Method: Principal Axis Factoring. Rotation Method: Promax with Kaiser Normalization.

From the interpretation of the eigenvalues scree plot in Figure 30, it was decided to explore two possible solutions close to the scree plot cut from the elbow: that is, to extract six factors or seven factors.

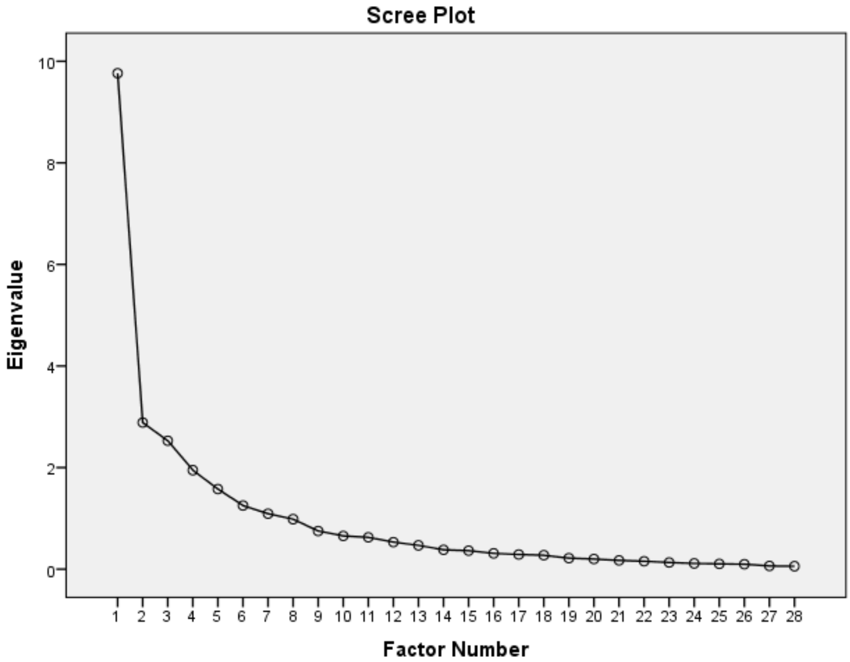

Figure 30 Eigenvalues scree plot for the antecedents constructs

First, seven factors were extracted assuming that sensing capabilities could be divided into two factors: namely, sensing customer needs (SCN) and sensing technological options (STO). The factors were correctly extracted, collecting the items that correspond to each variable. The solution explained the 67.83% of the total variance. However, the factor loadings of one item related to sensing technological options (STO3) and another from collaborating capabilities (CO1) were below the cut-off of 0.4.

In the second solution, six factors were extracted as initially defined. As presented in Table 43, when six factors were extracted, the items corresponding to sensing technological options and sensing customer needs were grouped into one factor, eliminating item STO3 (loading < 0.40). Since the main purpose of the research model was to measure the sensing capabilities of SMEs, it was decided to combine both constructs into a single construct as established in the research framework. The CO1 item was grouped under the variable EX instead of CO, thus it was decided to eliminate this item. This decision was made in the belief that CO1 could be measuring collaboration capabilities at a different level than the other two items. There was initial concern about the weakness of measuring a variable with only two items, but PLS-SEM works correctly with variables containing only two indicators (Hair et al., 2016). Thus, it was decided to measure collaboration capabilities with items CO2 and CO3 only. The solution explained 64.87% of the total variance, which was not far from the variance explained by the seven-factor solution.

Table 43 Pattern matrix for the antecedents constructs

Pattern Matrix[a]						
	Factor					
	1	2	3	4	5	6
MO1				.634		
MO2				.463		
MO3				.945		
MO4				.582		
IC1		.718				
IC2		.861				
IC3		.811				
IC4		.866				
IC5		.904				
STRC1			.976			
STRC2			.875			
STRC3			.842			
STRC4			.791			
SCN1					.534	
SCN2					.824	
SCN3					.521	
STO1					.478	
STO2					.438	
STO3						
EX1	.735					
EX2	.755					
EX3	.515					
EX4	.855					
EX5	.894					
EX6	.772					
CO1	.440					
CO2						.862
CO3						.806

Extraction Method: Principal Axis Factoring.
Rotation Method: Promax with Kaiser Normalization.
a. Rotation converged in seven iterations.

Finally, a comparison was made between items with low communalities (Table 41) and their factor loadings in the pattern matrix (Table 43). Because all items had appropriate factor loadings, it was decided to retain items with low communalities and assess them later in the analysis (i.e. in the assessment of the measurement model in PLS-SEM).

EFA of business model innovation

Following the same process applied in the previous EFA, the second EFA was conducted to measure the accuracy of the business model innovation (BMI) construct, containing items measuring value delivery (VDEL), value creation (VCRE) and value capture (VCAP) dimensions.

The KMO and Bartlett's tests results displayed in Table 44 indicate that the KMO value exceeded the 0.4 threshold, ranking the adequacy of the correlations "meritorious" (Kaiser y Rice, 1974). Bartlett's test of sphericity was highly significant (p-value of 0), confirming the appropriateness of the data for factor analysis.

Table 44 KMO and Bartlett's tests for the BMI construct

KMO and Bartlett's tests		
Kaiser-Meyer-Olkin (kmo) Measure of Sampling Adequacy.		0.863
Bartlett's test of sphericity	630.827	1585.187
	91	378
	0.000	0.000

Item's communalities displayed in Table 45 indicated that all the items had high communalities and therefore were well represented (Sun et al., 2019).

Table 45 Communalities for the BMI construct

Variables	Items	Initial	Extraction
Value delivery (VDEL)	VDEL1	0.583	0.643
	VDEL2	0.642	0.673
	VDEL3	0.688	0.765
	VDEL4	0.541	0.507
	VDEL5	0.620	0.792
	VDEL6	0.707	0.767
Value Creation (VCRE)	VCRE1	0.583	0.540
	VCRE2	0.701	0.741
	VCRE3	0.580	0.589
	VCRE4	0.666	0.737
Value Capture (VCAP)	VCAP1	0.513	0.510
	VCAP2	0.472	0.459
	VCAP3	0.676	0.844
	VCAP4	0.597	0.551

Extraction method: principal axis factoring.

Based on the eigenvalues scree plot shown in Figure 31, and in line with the theoretical conceptualisation, three factors were retained, which explained the 65.13% of the total variance.

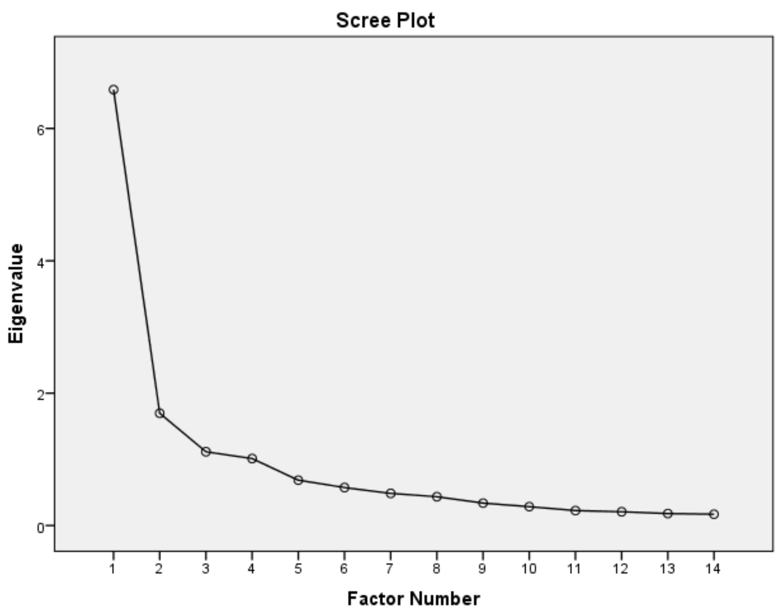

Figure 31 Eigenvalues scree plot for the BMI construct

Table 46 indicates that variables were correlated, and thus, orthogonal rotation was appropriate (Tabachnick y Fidell, 2012).

Table 46 Correlation matrix for the BMI construct

Factor Correlation Matrix			
Factor	**1**	**2**	**3**
1	1.000	.585	.426
2	.585	1.000	.528
3	.426	.528	1.000

Extraction method: principal axis factoring.
Rotation method: promax with Kaiser normalization.

Finally, as illustrated in Table 47, when running the analysis, two items in the value delivery dimension (VDEL4 and VDEL5) were deleted (loading < 0.40).

Table 47 Pattern matrix for the BMI construct

Pattern Matrix[a]			
	Factor		
	1	**2**	**3**
VDEL1	0.809		
VDEL2	0.738		
VDEL3	0.678		
VDEL4			
VDEL5			
VDEL6	0.505		
VCRE1		0.710	
VCRE2		0.830	
VCRE3		0.541	
VCRE4		0.732	
VCAP1			0.609
VCAP2			0.623
VCAP3			0.935
VCAP4			0.480

Extraction method: principal axis factoring.
Rotation method: Promax with Kaiser Normalization.
a. Rotation converged in eight iterations.

EFA of business model innovation tools

The last EFA assessed the self-developed scale for measuring business model innovation tools (BMIT). Again, KMO and Bartlett's tests resulted in a "meritorious" KMO value, indicating the adequacy of the correlations (Kaiser y Rice, 1974), and a highly significant value (p-value of 0) for the Bartlett's test of sphericity Table 48). Thus, the appropriateness of the data for factor analysis was confirmed.

Table 48 KMO and Bartlett's tests for the BMIT construct

KMO and Bartlett's tests		
Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy		0.847
Bartlett's Test of Sphericity	Approx. Chi-Square	464.981
	df	36
	Sig.	0.000

Four of the items (BMIT1, BMIT2, BMIT3 and BMIT9) presented low communalities (Table 49).

Table 49 Communalities of the BMIT construct

Communalities		
	Initial	Extraction
BMIT1	0.220	**0.189**
BMIT2	0.367	**0.335**
BMIT3	0.466	**0.377**
BMIT4	0.786	0.701
BMIT5	0.895	0.842
BMIT6	0.574	0.504
BMIT7	0.882	0.809
BMIT8	0.616	0.515
BMIT9	0.455	**0.463**

Extraction method: principal axis factoring.

When operationalising the variable BMIT (Table 28) it was established on the basis of the literature review that each item describing a set of tools could respond to a specific dimension of the business model innovation process (analysis, design and test). Thus, in addition to validating the scale, the EFA was meant to explore the option of creating a multidimensional construct relating specific tools to specific activities (analysis, design and test). However, as illustrated in Table 50, results of the EFA of the number of factors to be retained indicated a unique factor, thus suggesting that BMIT is a unidimensional construct.

Table 50 Factor matrix for BMIT construct

Factor Matrix[a]	
	Factor
	1
BMIT1	.435
BMIT2	.578
BMIT3	.614
BMIT4	.837
BMIT5	.917
BMIT6	.710
BMIT7	.900
BMIT8	.717
BMIT9	.681

Extraction method: principal axis factoring.
a. One factors extracted. Four iterations required.

Based on these results, it was decided to define the construct as a single factor to ensure item reliability and validity when applying PLS-SEM. Nevertheless, the theoretical dimensions defined during operationalisation of BMIT (Table 28) were maintained when performing fsQCA, once the reliability and validity of the items are confirmed.

5.2. Sample analysis

This section provides a detailed breakdown of the company and respondent characteristics to describe the main features of the study sample. The respondent characteristics include the number of years the respondent has been working at the company and the respondent's department or function, previous experience and training background. The company characteristics include the size of the SME in terms of staff headcount and turnover, the age of the company, the company's legal form, the company ownership, the number of business units, the customer sectors the company work with and the industry sector.

The distribution of the number of years the respondents had worked at their company is shown in Figure 32. As can be observed, 35% of the respondents had been involved in their company for more than 20 years, 29% between 11 and 20 years, and 17% between 5 and 10 years. An additional 20% of participants had been with their company for less than five years.

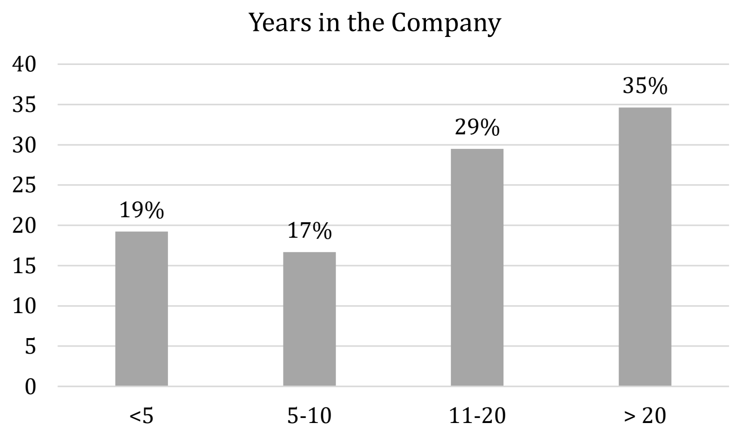

Figure 32 Number of years the respondents have been working in their company

The distribution of departments or functions among respondents is shown in Figure 33. Most respondents – 83% – were in management or on the board of directors, 4% worked in innovation and R&D, another 4% were in sales, and the remaining 9% had other functions in the company.

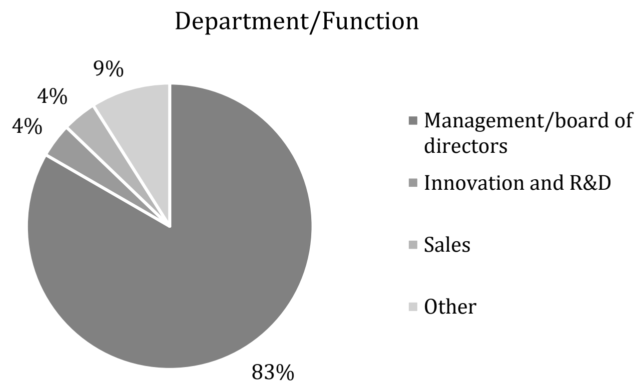

Figure 33 Position of respondents in the firm

The previous experience of respondents is illustrated in Figure 34. Among respondents, 58% had previous experience in SMEs, while only 2% had no previous experience, 20% had previously worked in large companies, and another 20% had worked in public or private R&D organisations.

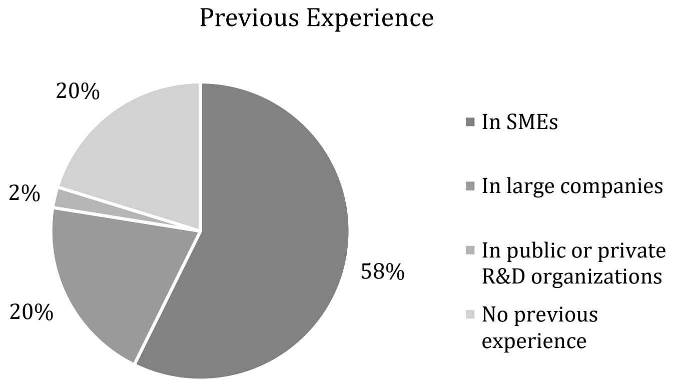

Figure 34 Previous experience of respondents

Figure 35 presents respondents' training background. A total of 45% have a background in economy and business, and 41% have training in science, engineering and architecture. An additional 5% of respondents have a background in humanities and social sciences, while the remaining 9% have other kinds of training.

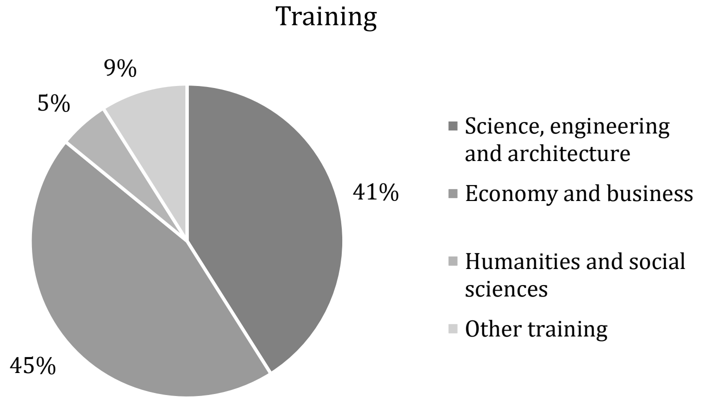

Figure 35 Training background of respondents

The analysis of respondent characteristics (Figure 32, Figure 33, Figure 34 and Figure 35) indicates they are widely knowledgeable about the situation in their company and the key issues addressed in this research.

As for company characteristics, the size of the SMEs was defined in terms of staff headcount and turnover based on the definition provided by the European Commission[7] (Table 51). Some 16.67% of the companies had employed fewer than 250 people and had a turnover of less than €50 million, indicating they would be classified as medium-sized companies. Another 78.21% had fewer than 50 people employed and a turnover of less than €10 million and therefore would be classified as small companies. The remaining 5.13% of the companies employed fewer than 10 people and had a turnover of less than €2 million, making them micro SMEs. Thus, the sample was mainly composed of small companies.

Table 51 Distribution of the sample by SME definition

Company category	Staff headcount	Turnover	Sample (%)
Medium-sized	< 250	≤ € 50 million	16.67%
Small	< 50	≤ € 10 million	78.21%
Micro	< 10	≤ € 2 million	5.13%

Company age is illustrated in Figure 36. Of the companies represented, 6% were less than five years old, 8% had been in business between 5 and 10 years, and 19% had operated for between 11 and 20 years. The proportion of companies with more than 20 years of business experience was noteworthy, as they comprised 67% of the sample. Thus, the sample was primarily representative of established firms.

[7]Definition of an SME. European Commission: https://ec.europa.eu/growth/smes/business-friendly-environment/sme-definition_en (June, 2020)

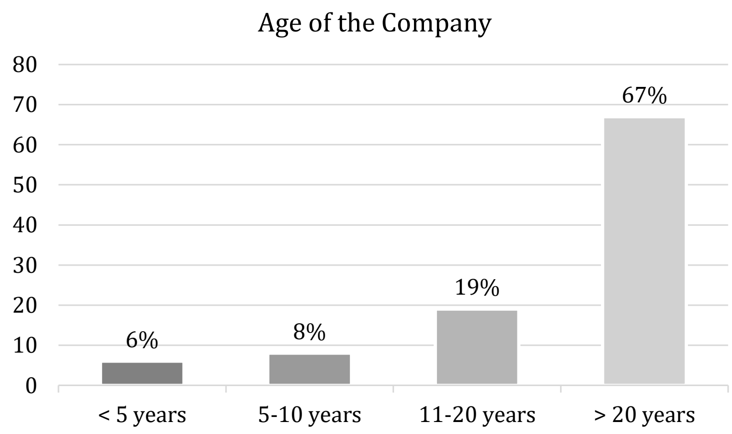

Figure 36 Distribution of the sample by age (years)

The legal form of the SMEs studied is displayed in Figure 37. Of the sample, 60% are limited companies, 36% are partnerships, and 14% are cooperatives. Considering that the SMEs within the sample are mostly small firms (Table 51) and that the legal forms of most are partnership or limited company, managerial decisions on business model innovation in these companies might be of great influence.

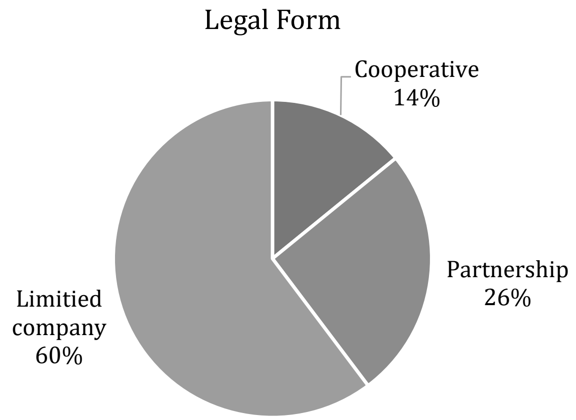

Figure 37 Distribution of the sample by legal form

With regard to the company ownership, Figure 38 shows that 47% of the sampled companies were family businesses, whereas only 36% were part of a business group. This data also suggests the importance of managers in determining SMEs' strategic approach to business model innovation.

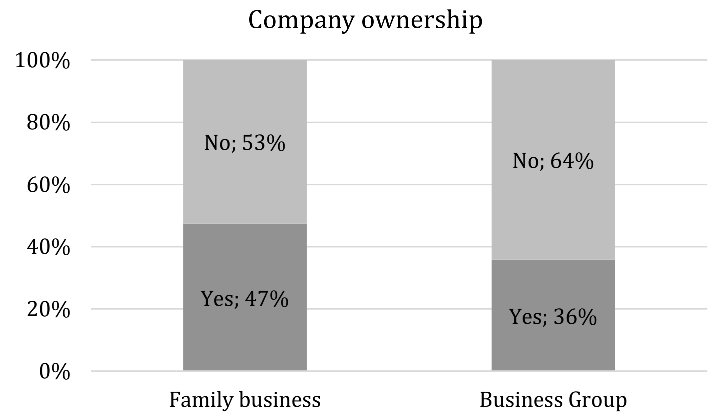

Figure 38 Distribution of the sample by companies ownership

The number of business units the SMEs operate is presented in Figure 39. Most of the companies – 69% – operated as a single business unit. Considering that the study sample consists primarily of small companies, it could be assumed that they most are also operating through a single business model, given their size limitations and resource scarcity (Snihur y Tarzijan, 2018).

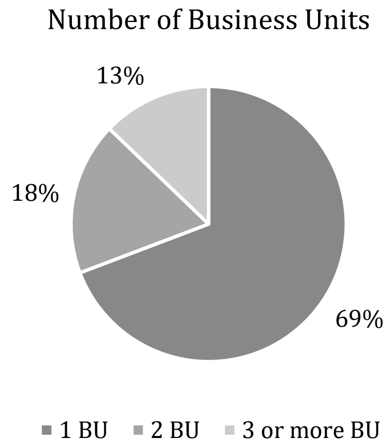

Figure 39 Distribution of the sample by number of business units

Additionally, in analysing these SMEs' customer sectors (Figure 40), it can be seen the firms are mainly specialised in four niche markets: advanced manufacturing (11%), energy (11%), automotive (10%) and steelworks and equipment (10%).

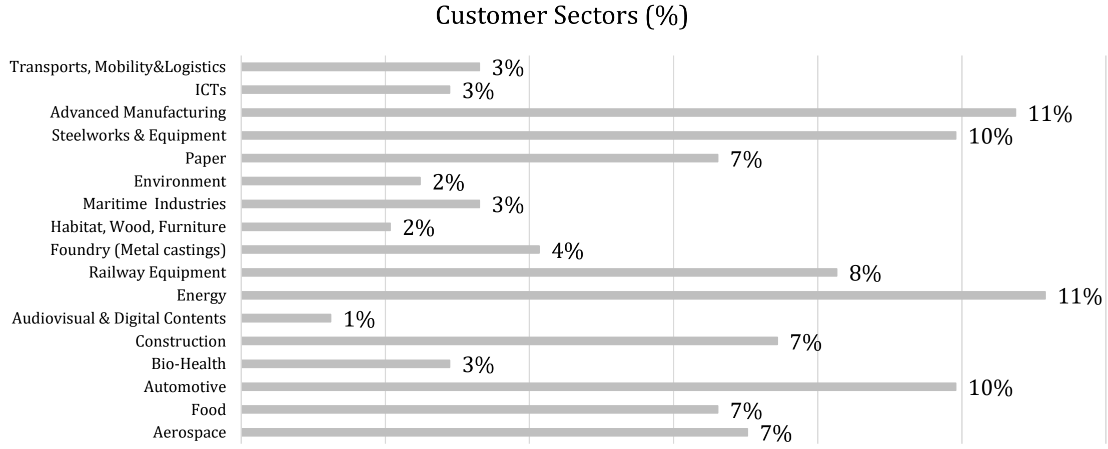

Figure 40 Customer sectors

Finally, in terms of the types of activities carried out by the SMEs in the sample, Table 52 presents the number of companies by activity sector based on the National Classification of Economic Activities (CNAE). The sample is mainly composed of SMEs from the manufacturing industry (58.97%), followed by those in the wholesale and retail trade industry (17.95%), information and communications industry (7.69%) and other industrial services (5.13%). This suggests that this sample of established SMEs operate in a context where business model innovation is gaining relevance (Orkestra, 2019).

Table 52 Number of companies by sector of activity

CNAE 2009 code	CNAE 2009 title	Nº of SMEs	%
C (10 – 33)	Manufacturing industry	46	58.97%
G (45 – 47)	Wholesale and retail trade	14	17.95%
J (58 – 63)	Information and communications	6	7.69%
S (94 – 96)	Other services	4	5.13%
F (41 – 43)	Construction	3	3.85%
M (69 – 75)	Professional, scientific and technical activities	3	3.85%
D (35)	Electricity and gas supply	1	1.28%
E (36 – 39)	Water supply and waste management	1	1.28%

5.3. PLS-SEM analyses

This section addresses the first and second research objectives, seeking by means of PLS-SEM to explore the effects of various antecedents on business model innovation and the impact of business model innovation on the competitiveness of SMEs. This section first describes the procedure followed and the evaluation criteria applied to perform the PLS-SEM analyses. Then, the analyses conducted are described. The analyses are developed in four stages, and four PLS-SEM models are developed for this purpose:

- PLS-SEM Model A: The first PLS model addresses the hypotheses related to the impact of business model innovation capabilities (sensing capabilities, experimentation capabilities, collaboration capabilities and strategizing capabilities) on business model innovation and the effect of business model innovation on business model advantage and firm performance (Figure 28).

- PLS-SEM Model B: The second PLS model focuses on the influence of innovation culture on business model innovation and further explores the mediating effect of business model innovation capabilities on the relationship between innovation culture and business model innovation (Figure 28).
- PLS-SEM Model C: The third PLS model examines the impact of managerial orientation on business model innovation, together with the mediating role of business model innovation capabilities in this relationship (Figure 28).
- PLS-SEM Model D: The last PLS model explores the influence of business model innovation tools on business model innovation (Figure 29).

The section ends with the validation of the research hypotheses and a discussion of the results.

5.3.1. PLS-SEM procedure

The PLS-SEM procedure followed in the present research is based on the guidelines of various authors (Hair et al., 2016; Manzano y Jiménez, 2017; Sarstedt et al., 2019) and encompasses multiples stages, as displayed in Figure 41.

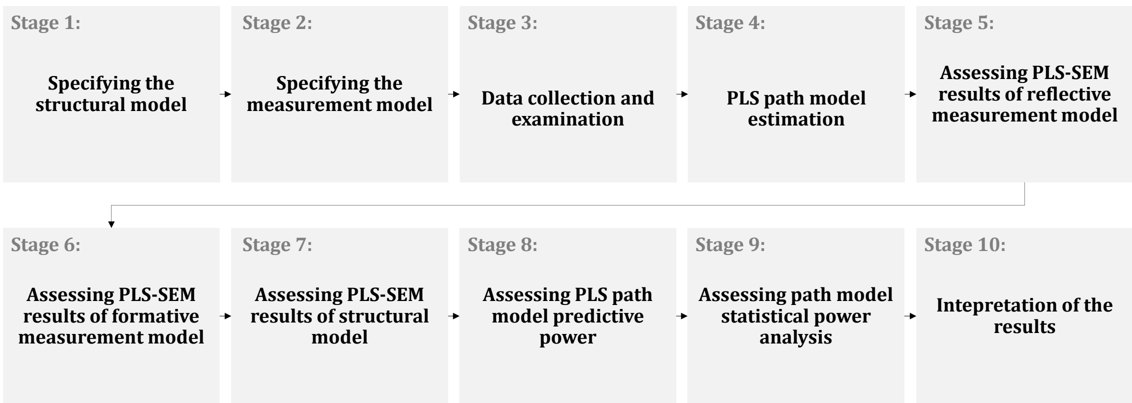

Figure 41 PLS-SEM procedure followed in this thesis

The first stage of the PLS-SEM procedure involves development of the structural model, commonly known as the inner model in PLS-SEM. The structural model describes the relationships between the variables, illustrating the research hypotheses. In defining this structural model, the relationships between independent and dependent variables within the research model are established. Independent variables (also known as predictor or exogenous variables) are those variables that influence the other variables within the path model (they point to another variable, but no arrow points at them). Dependent variables (also known as endogenous variables) are variables affected by at least one other variable (they have at least one arrow pointing to them). Variables that are placed between independent and dependent variables are also known as endogenous variables and can, as in the case of this thesis, act as mediator variables that intervene in the relationship between the independent and dependent variable.

The second stage of the PLS-SEM procedure is the specification of the measurement model, which is also referred to as the outer model in PLS-SEM and describes the relationship between the variables and the items used to measure it (Hair et al., 2016). As will be explained below, the measurement model can be reflective, formative or a combination of both in the form of higher-order constructs.

After the measurement model has been specified, data is collected and examined in the third stage. This step was described in section 5.1.

While the main purpose of PLS-SEM is to test the hypotheses contained in the structural model, it is first necessary to ensure that variables are correctly estimated by their items and that the measurement model exhibits a series of properties. In the fourth stage, the PLS-SEM algorithm and associated procedures (e.g. bootstrapping and blindfolding) are estimated. Once the required analysis has been run, the measurement models for reflective variables (stage five) and formative variables (stage six) are validated. Then, the results of the structural model are evaluated (stage seven). Once the PLS model has been evaluated, its predictive power is analysed (step eight), as is its statistical power (step nine). The last step involves the interpretation of the results, which are presented in this section after the four analyses conducted are explained.

The following paragraphs discuss considerations related to the PLS-SEM procedure and the evaluation criteria applied. First, the choices made to specify the measurement model are described. Criteria to assess the model are then established. Finally, the criteria for evaluating the structural model are presented.

Measurement model definition

In PLS-SEM, the measurement model is defined based on the way indicators are measured (reflectively or formatively) and the way the variables are dimensionalised (unidimensional or multidimensional variables).

The difference between reflective and formative measures lies in the causal relationship between the latent variable (unobserved) and the indicators (observed items), as illustrated in Figure 42.

In reflective measurement models (also referred to as mode A measurement in PLS-SEM), the causal relationship moves from the latent variable to the indicators, and therefore, a change in the latent variable will be reflected in all its indicators (Marin-Garcia y Alfalla-Luque, 2019). The indicators must be conceptually similar to each other, since they refer to the same theoretical construct. Reflective indicators are considered interchangeable, as they are only manifestations of the latent variable (Bollen, 2011; Jarvis et al., 2003). Various reflective items need to be present in the measurement model to make the estimation more reliable, but the addition or elimination of an indicator will not change the essential nature of the construct to be measured (Bollen, 2011; Roberts y Thatcher, 2009).

In formative measurement models (also referred to as Mode B measurement in PLS-SEM), the causal relationship goes from the indicators to the latent variable, since the indicators are considered to *form* or cause the latent variable (Diamantopoulos y Winklhofer, 2003; Martínez Ávila y Fierro Moreno, 2018). In formative models, each indicator represents a dimension of the meaning of the latent variable, so removing an indicator means that the variable loses part of its meaning.

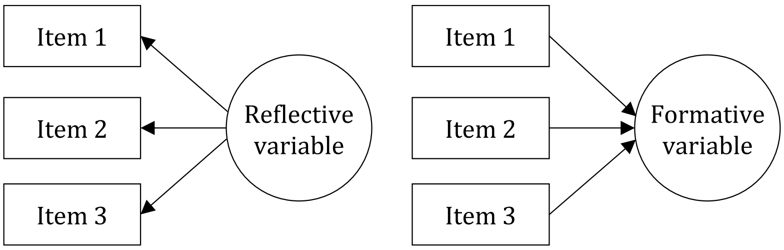

Figure 42 Reflective and formative variables in PLS-SEM

The selection of the measurement model for each latent variable is guided by the construct conceptualisation and the objective of the study (Hair et al., 2016). Overall, if the purpose is to test a hypotheses regarding a latent variable, the reflective model is likely to be appropriate, whereas if there is a special interest in identifying distinct drivers within the latent variable, the formative measurement would provide such nuanced facets of the construct.

As for the dimensionalisation of variables, when the entire domain of a variable can be represented through a set of indicators, the variable is defined as unidimensional, and can be directly measured as reflexive or formative. However, when constructs are built on multiple theoretical dimensions (multidimensional variables), the structural model involves two layers of constructs. These models are known as higher-order constructs or hierarchical component models (Hair et al., 2016), and the measurement mode (reflective or formative) must be specified for both the lower-order constructs (LOCs) and the higher-order constructs (HOCs). This lead to four different types of HOCs (Figure 43): reflective-reflective, reflective-formative, formative-reflective and formative-formative. Among these four, the first two types are the ones most applied in the current research (Sarstedt et al., 2019).

Thus, since the purpose of applying PLS-SEM is to test a set of hypotheses based on latent variables defined from existing literature and available empirical evidence, this thesis defines all the variables under study as reflective except for two HOCs:

business model innovation and business model innovation capabilities. Early studies suggest measuring business model innovation as a Type II construct (Clauss, 2017; Spieth y Schneider, 2016). In the same vein, various authors have demonstrated the suitability of measuring dynamic capabilities as Type II reflective-formative HOCs (Lee, 2017; Wilden et al., 2013; Wilden y Gudergan, 2017). Thus, business model innovation and business model innovation capabilities are defined as Type II reflective-formative HOCs.

To perform the PLS-SEM, this thesis follows the disjoint two-stage approach for the estimation of HOCs suggested by Sarstedt et al. (2019). In this approach, the measurement model assessment is developed in two main stages (Figure 41). In stage one, the measurement model is specified defining only the LOCs in reflective mode. The LOCs are validated, and their latent scores are saved. In stage two, a new path model containing the HOC is created, with the latent scores produced in the first stage now used as indicators of the HOC. The reliability and validity of the new formative HOC is validated. After the measurement model is validated, the structural model is analysed.

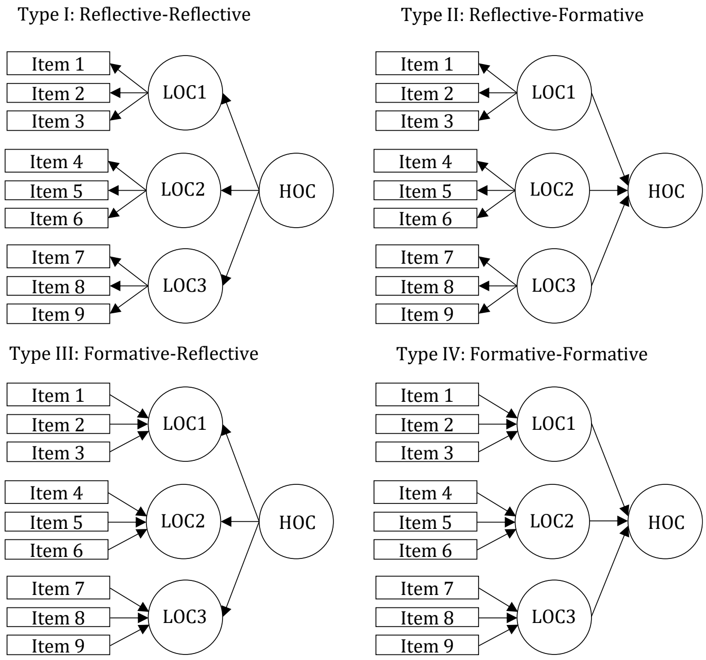

Figure 43 Four types of higher-order constructs (HOCs).
Adapted from Sarstedt et al. (2019)

Measurement model assessment criteria

Having specified how to model the study variables, the thesis now addresses the criteria used to assess the measurement model. Based on the disjoint two-stage approach, items were measured in two stages. In this subsection, first the steps and evaluation criteria developed to validate the LOCs in reflective mode are explained.

Then, the guidelines and criteria followed to assess the formative HOCs are described.

The evaluation criteria to validate reflective constructs were defined based on the guidelines of various authors (Hair et al., 2019, 2020; Manzano y Jiménez, 2017). Four aspects were assessed (Table 53): item loadings and their significance, convergent validity, internal consistency reliability and discriminant validity.

The first step in assessing the reflective measurement model is examining the indicator loadings and their significance. The indicator loadings quantify the strength of the relationship between indicators (Hair Jr et al., 2017). In PLS-SEM statistical significance is calculate through *bootstrapping*, which is a non-parametric procedure that resamples through replacement observations randomly drawn from the original dataset. Hair et al. (2016) recommends performing the bootstrapping procedure with 5,000 subsamples, with no sign changes, using the bias corrected and accelerated (BCa) confidence interval method, two-tailed type, with a significance level of 0.05 and a path weighting scheme to obtain the loading's significance. These recommendations were followed in all the analyses developed with PLS-SEM. The statistical significance calculated through bootstrapping can be evaluated based on three criteria: p-values, t-values and confidence intervals. To be significant for a two-tailed test at the 0.05 level, the standardized loadings should have a value of at least 0.40 (specific guidelines are explained in Table 53), with p-values below 0.05, t-statistics above ±1.96 and confidence intervals that exclude zero (Hair et al., 2020; Manzano y Jiménez, 2017).

Table 53 Reflective measurement model assessment criteria

Reflective assessment	Criteria
Items loadings and their significance	- If outer loading < 0.40, delete the reflective indicator but consider its impact on content validity. - If 0.40 ≤ outer loading < 0.708, analyse the impact of indicator deletion on internal consistency reliability (composite reliability, or CR) and convergent validity (average variance extracted, or AVE). - If outer loading ≥ 0.708; retain the reflective indicator. - Loadings significance: p-values < 0.05, t-statistic > ±1.96 and confidence intervals excluding zero.
Convergent validity	- Average variance extracted (AVE) > 0.50.
Internal consistency reliability	- Cronbach's alpha (α) and composite reliability (CR) > 0.70 (or 0.60 in exploratory research). - Maximum of 0.95 to avoid indicator redundancy.
Discriminant validity	- Heterotrait-monotrait correlation (HTMT): values below 0.85 (or 0.90 with conceptually similar constructs).

The second step in assessing the reflective measurement model is to analyse the convergent validity of each variable (Table 53), which is assessed through the average variance extracted (AVE). This measures the extent to which the construct converges to explain the variance of its items. The AVE must be 0.50 or greater, which indicates that the construct explains at least the 50% of the variance of its items.

The third step is assessing internal consistency reliability, which is evidenced through the Cronbach's alpha and the composite reliability (CR). Cronbach's alpha specifies the lower bound for internal consistency reliability, whereas CR represents the upper bound. The cut-off value is of 0.70 for both measurements, with a value of 0.60 accepted for exploratory research (Hair et al., 2019). Values above 0.95 should be checked to avoid indicator redundancy, which would compromise content validity.

The last criteria applied to assess the reflective measurement model concerns discriminant validity (Table 53), which verifies the distinctiveness of a construct. Discriminant validity is demonstrated when AVE values exceed the shared variance between the constructs (Hair et al., 2020). To calculate it, the heterotrait–monotrait correlation (HTMT) method is applied (Hair et al., 2020; Henseler et al., 2014). HTMT values must be lower than 0.85, or 0.90 when constructs are conceptually similar, to ensure discriminant validity (Hair et al., 2019).

To validate the formative HOCs (i.e. business model innovation and business model innovation capabilities constructs), two evaluation criteria were applied (Table 54): collinearity and the statistical significance of the loading weights (Hair et al., 2019; Hair Jr et al., 2017; Manzano y Jiménez, 2017).

Table 54 Formative measurement model assessment criteria

Formative assessment	Criteria
Collinearity	- Critical collinearity issues when variance inflation factor (VIF) ≥ 5. - Possible collinearity issues when VIF between 3 and 5. - Ideally VIF < 3.
Statistical significance of weights	- If weight is significant, retain the indicator. - When the weight is not significant but its loading is large (>0.50) and significant, indicator is retained; if loadings are small (<0.50) and non-significant, the indicator must be removed. - When the weight of an indicator is not significant and its loading is small (<0.50) but significant, the decision is up to the researcher.

Collinearity refers to the extent to which formative indicators are correlated, which in the case of formative variables is not expected and can therefore affect the validity of the formative measurement models. To ensure that collinearity is not a problem, variance inflation factors (VIFs) are calculated. Ideally, the VIF needs to be below 3 (Table 54).

The loading weights measure the contribution of the different items to the formative construct. These values should be above the cut-off value of 0.5 and should be statistically significant. As with the outer loadings in reflective measurement models, statistical significance is addressed in performing the bootstrapping procedure. The guidelines to retain or delete indicators are summarised in Table 54.

Structural model assessment criteria

The criteria for evaluating the measurement model have been established; below, the criteria for assessing the structural model are discussed. Standard assessment criteria for structural models in PLS-SEM involve the following (Table 55): the assessment of collinearity, the coefficient of determination (R^2), the blindfolding-based cross-validated redundancy measure (Q^2), and the statistical significance and relevance of the path coefficients (Hair et al., 2019). Additionally, the predictive power (Shmueli et al., 2019) and the statistical power of the path models were examined (Hair et al., 2019).

Table 55 Structural model assessment criteria

Assessment type	Criteria
Collinearity issues	- Critical collinearity issues when variance inflation factor (VIF) ≥ 5. - Possible collinearity issues when VIF between 3 and 5. - Ideally VIF < 3.
In-sample explanatory power	- As a rule of thumb, R^2 values of 0.75, 0.50 and 0.25 are considered substantial, moderate and weak. - Interpret R^2 values comparing them with related studies and models of similar complexity. - R^2 values of 0.90 and higher are typically indicative of overfit.
Predictive accuracy	- Values larger than zero are meaningful. - Values higher than 0, 0.25 and 0.50 depict low, moderate and high predictive accuracy of the PLS path model.
Statistical significance and relevance of the path coefficients	- The closer to 1, the stronger the relationship between variables. - Significance: p-values < 0.05, t-statistic > ±1.96.
Out-of-sample predictive power	- Q^2 values > 0 indicate that the model outperforms the most naïve benchmark. - Compare the MAE (or the RMSE) value with the LM value of each indicator. Check if the PLS-SEM analysis (compared to the LM) yields higher prediction errors in terms of RMSE (or MAE) for all (no predictive power), the majority of (low predictive power), a minority of or the same number of (medium predictive power), or none of the indicators (high predictive power).

Note: LM: naïve linear model; RMSE: root mean squared error; MAE: mean absolute error

Collinearity between constructs is assessed following the same criteria established for formative indicators, thus, ideally the VIF values should be close to 3. If collinearity is not an issue, R^2 values of the variables comprising the model are assessed.

The R^2 value is a measure of the variance of each of independent variable, suggesting the model's explanatory power. It is also referred to as in-sample predictive power (Rigdon, 2012). R^2 values range between 0 and 1, with values of 0.75, 0.50 and 0.25 considered to represent substantial, moderate and weak predictive power, respectively (Hair et al., 2016; Henseler et al., 2009). However, acceptable R^2 values are context-specific and can vary among disciplines. Therefore, Hair et al. (2019) suggests interpreting R^2 values based on the values from models of similar complexity in related studies. Thus, articles applying PLS-SEM to address business model innovation were analysed. This analysis is explained as part of the PLS analysis in subsection 5.3.2.

To assess the predictive accuracy of the path model, Stone-Geisser Q^2 values are calculated through a *blindfolding* procedure. According to Hair et al. (2016), the blindfolding should be run with a path weighting scheme and an omission distance of 7. These recommendations were followed in all the PLS-SEM analyses. Q^2 values need to be greater than zero. Values of 0, 0.25 and 0.50 indicate low, medium and high predictive relevance, respectively (Hair et al., 2019).

While R^2 measures the in-sample predictive power, a recent procedure, *PLSpredict,* has been used to assess the model's out-of-sample predictive power (Shmueli et al., 2019). This procedure generates holdout sample-based predictions based on *k*-fold cross-validation, where *k* represents the number of subgroups of the dataset that are randomly divided into subsets of equal size (Hair et al., 2019). Shmueli et al. (2019) suggest conducting the analysis with 10 folds and 10 replications. Then, the root-mean-square error (RMSE) and mean absolute error (MAE) values of the PLS-SEM are compared with those from the naïve linear model (LM) benchmark. When values for all the PLS-SEM RMSE (or MAE) indicators are lower than the LM RMSE (or MAE) indicators, the path model has high predictive power. When values for most of the PLS-SEM RMSE (or MAE) indicators are lower than the LM RMSE (or MAE) indicators, the path model has moderate predictive power. When values for a minority of the PLS-SEM RMSE (or MAE) indicators are lower than the LM RMSE (or MAE) indicators, the path model has a low predictive power. However, higher values of the PLS-SEM RMSE (or MAE) indicators compared with the values of the LM RMSE (or MAE) indicators, indicate a lack of predictive power for the path model (Ogbeibu et al., 2020).

As for the statistical significance and relevance of the path coefficients, PLS algorithm allows analysis of the relationships between the variables in the structural model and therefore, the underlying hypotheses suggested. Statistical significance is calculated based on the bootstrapping procedure following the same criteria defined for the measurement model. Note that path coefficients indicate the direct effect of one variable on another.

Since some of the hypotheses developed in this research address mediation effects, the specific indirect effects between variables must be considered along with the direct effects (path coefficients). The mediation analysis procedure is presented in Figure 44. If the indirect effect (*p1p2)* via the mediator variable (Y2) is significant, the variable is considered to be acting as a mediator; if the indirect effect is not significant, Y2 does not function as a mediator (Hair et al., 2016). Moreover, a mediator variable can fully or partially explain the relationship between the independent (Y1) and dependent variables (Y3). If the direct effect (*p3)* between these variables is also significant, then the mediator variable (Y2) explains only part of this relationship, whereas if the direct effect is not significant, Y2 fully explains the relationship between Y1 and Y3.

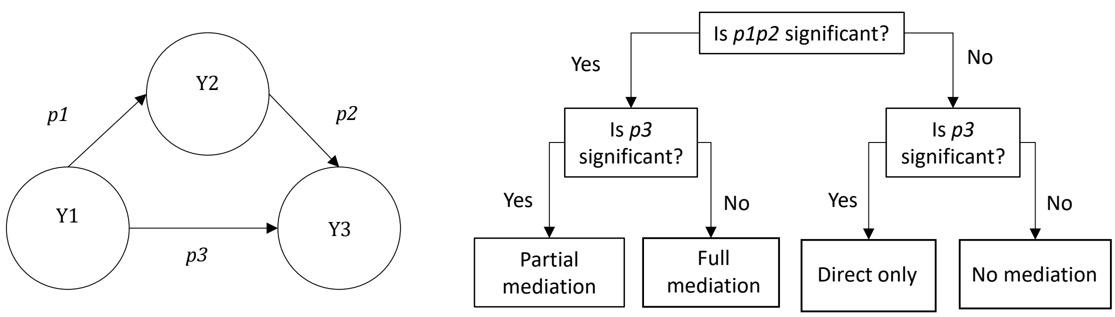

Figure 44 Mediation analysis procedure.
Adapted from Hair et al. (2016)

Finally, the statistical power of the model must be calculated to confirm that the sample size is sufficient for the extent of the effects found. Statistical power values above 0.80 with a significance level of 0.05 are recommended (Kaufmann y Gaeckler, 2015). The analysis was performed using the G*Power 3.1 software (Faul et al., 2007). In two-stage procedures such as those used in the present study, the power should be analysed in both stages and for all endogenous constructs (Marin-Garcia y Alfalla-Luque, 2019). The most unfavourable endogenous variable, that is, the one with a lower R^2 value and, at the same time, with more predictors, should be considered to examine the statistical power of the model (Marin-Garcia y Alfalla-Luque, 2019). Post-hoc power analysis in were performed in G*Power using the "Linear multiple regression: Fixed model, R^2 deviation from zero" statistical test from the “F test” family, a significance level of 0.05 and a total sample size of 78 (Marin-Garcia y Alfalla-Luque, 2019; Nitzl, 2016).

5.3.2. PLS-SEM Model A: Business model innovation capabilities, business model innovation and SME competitiveness

Having explained the procedure and criteria applied to conduct the PLS-SEM analyses, this subsection examines the first model using SmartPLS 3 (Ringle et al., 2015). As mentioned, the analyses were performed following the disjoint two-stage approach (Sarstedt et al., 2019). In stage one, the reflective lower-order constructs (LOCs) were assessed, while in stage two, the formative higher-order constructs (HOCs) and the structural model were assessed.

Stage one: assessment of the reflective lower-order constructs (LOCs)

In stage one of the disjoint two-stage approach (Sarstedt et al., 2019), the estimation and measurement model assessment for the LOCs was defined (Figure 45), which draws direct relationships between the four antecedent variables STRC (strategizing capabilities), SENC (sensing capabilities), CO (collaboration capabilities) and EC (experimentation capabilities), the three constructs comprising business model innovation dimensions, namely, VDEL (value delivery), VCRE (value creation) and VCAP (value capture) and the outcome variables BMA (business model advantage) and FP (firm performance). In this stage, the higher-order construct BMI (business model innovation), was not included in the model.

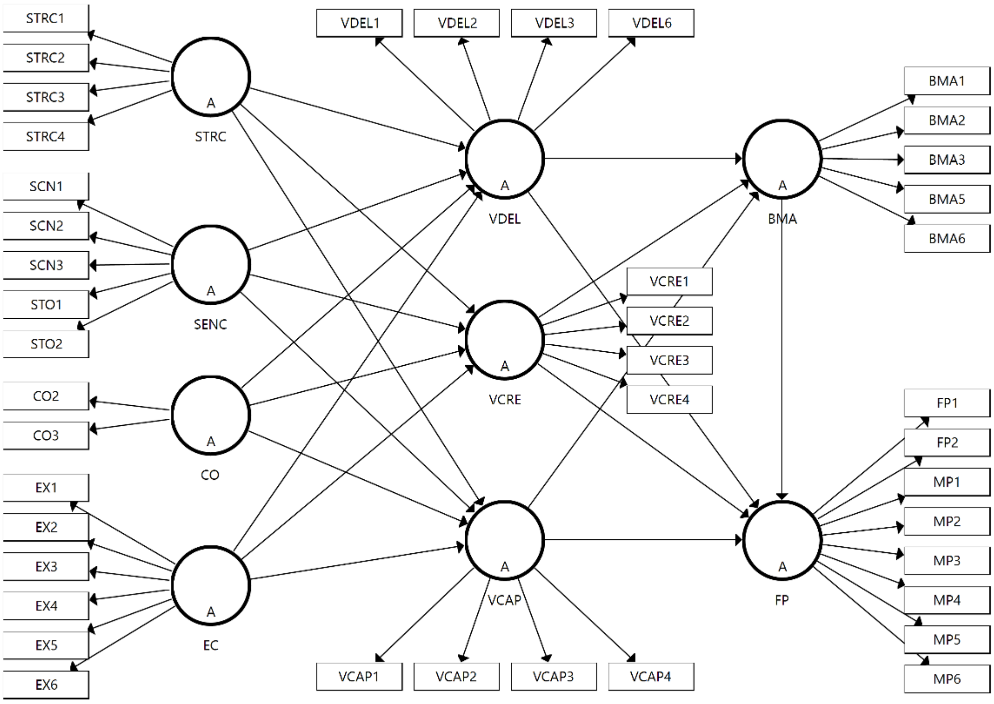

Figure 45 PLS path model for Model A

The evaluation of the measurement model followed the criteria for reflective variables, as all of the LOC were defined as reflective using mode A (Garson, 2016). The PLS algorithm[8] and the bootstrapping[9] procedure were run to obtain the outer loadings and their significance (p-values, t-values and confident intervals) for all the items (Hair et al., 2016). Additionally, latent variable scores of VDEL, VCRE and VCAP were saved to be used as manifest indicators of BMI in the next stage.

The outer loadings of the items and their significance were first examined, as most reliability and validity indicators are conditioned by them (Manzano y Jiménez, 2017). Items with loadings between 0.50 and 0.70 that did not meet the required thresholds for AVE value (> 0.5) were iteratively eliminated until all indicators met the criteria of consistency reliability and convergent validity (Ogbeibu et al., 2020). Table 56 displays the result of the analysis after refining the measurement model.

Five items with AVE values below 0.50 were deleted: one item from sensing capabilities (SCN3, AVE = 0.49), one item from business model advantage (BMA4, AVE = 0.46) and three items from firm performance (FP1, FP2 and MP1, AVE = 0.41).

[8] The PLS algorithm was run with a path weighting scheme with a maximum of 300 iterations and a stop criterion of 7.

[9] Bootstrapping procedure was performed with 5,000 samples, using the no sign changes option, BCa bootstrap confidence intervals, two-tailed testing at the 0.05 significance level and path weighting schemes.

Table 56 Assessment of the reflective constructs of the measurement model (Model A)

		Outer loadings	T Statistics (|O/STDEV|)	P Values	Confident intervals		Cronbach's Alpha	CR	AVE
		>0.708	>±1.96	< 0.05	2.5%	97.5%	0.70–0.90		>0.50
Business Model Advantage (BMA)	BMA1	0.722	8.045	0.000	0.500	0.850	0.757	0.837	0.508
	BMA2	0.787	13.788	0.000	0.645	0.871			
	BMA3	0.763	9.519	0.000	0.566	0.875			
	BMA5	0.634	5.763	0.000	0.377	0.798			
	BMA6	0.644	7.955	0.000	0.456	0.771			
Collaboration Capabilities (CO)	CO2	0.936	17.107	0.000	0.825	0.983	0.839	0.925	0.861
	CO3	0.920	16.416	0.000	0.797	0.969			
Experimentation capabilities (EC)	EX1	0.836	18.988	0.000	0.735	0.907	0.893	0.918	0.654
	EX2	0.828	18.088	0.000	0.724	0.902			
	EX3	0.643	6.811	0.000	0.425	0.796			
	EX4	0.859	28.136	0.000	0.789	0.909			
	EX5	0.878	32.599	0.000	0.818	0.922			
	EX6	0.787	15.594	0.000	0.676	0.870			
Strategizing capabilities (STRC)	STRC1	0.916	32.293	0.000	0.847	0.957	0.937	0.955	0.842
	STRC 2	0.936	52.267	0.000	0.897	0.967			
	STRC 3	0.939	57.528	0.000	0.901	0.964			
	STRC4	0.879	25.255	0.000	0.795	0.929			
Firm performance (FP)	MP2	0.643	7.239	0.000	0.419	0.766	0.768	0.843	0.520
	MP3	0.722	9.819	0.000	0.546	0.835			
	MP4	0.745	9.864	0.000	0.559	0.852			
	MP5	0.694	9.017	0.000	0.508	0.807			
	MP6	0.791	19.995	0.000	0.708	0.860			
Sensing Capabilities (SENC)	SCN1	0.782	9.414	0.000	0.575	0.897	0.740	0.833	0.556
	SCN2	0.698	5.909	0.000	0.392	0.851			
	STO1	0.702	5.374	0.000	0.373	0.872			
	STO2	0.794	8.400	0.000	0.558	0.916			
Value capture dimension (VCAP)	VCAP1	0.719	7.426	0.000	0.481	0.860	0.803	0.871	0.630
	VCAP2	0.739	8.969	0.000	0.538	0.857			
	VCAP3	0.888	28.238	0.000	0.810	0.931			
	VCAP4	0.817	14.957	0.000	0.680	0.890			
Value creation dimension (VCRE)	VCRE1	0.822	16.960	0.000	0.707	0.898	0.869	0.911	0.719
	VCRE2	0.887	34.958	0.000	0.829	0.930			
	VCRE3	0.830	15.338	0.000	0.703	0.912			
	VCRE4	0.851	17.431	0.000	0.736	0.925			
Value delivery dimension (VDEL)	VDEL1	0.808	13.229	0.000	0.659	0.899	0.836	0.890	0.670
	VDEL2	0.838	20.903	0.000	0.744	0.901			
	VDEL3	0.867	28.548	0.000	0.796	0.914			
	VDEL6	0.758	11.726	0.000	0.607	0.857			

Notes: CR: composite reliability, AVE: average variance extracted

The final set of items loaded above the recommended threshold of 0.708 (Hair et al., 2019) except for seven items (BMA5, BMA6, EX3, MP2, MP5, SCN2 and STO1), with the lowest loading value among these seven being 0.634. All the outer loadings were significant (p-value < 0.05, t values > ±1.96 and confidence intervals excluding zero), and all AVEs exceeded 0.50, confirming convergent validity.

Internal consistency reliability was supported, as both Cronbach's alpha and CR were within the satisfactory ranges of 0.70–0.90. Only one variable (STRC) exceeded the recommended threshold of CR (<0.95), with a value of 0.955. According to Hair et al. (2019) values above 0.95 are not recommended, since they may indicate item redundancy. Nevertheless, recent studies admitted CR values of 0.96 (Chung et al., 2019; Hsu y Chen, 2020; Ngo et al., 2019), and therefore, it was decided to maintain the construct as it was.

As for discriminant validity, HTMT ratios presented in Table 57 indicate that all of the values were lower than the threshold of 0.85, suggesting that the constructs were empirically distinct, confirming discriminant validity.

Table 57 Discriminant validity of reflective variables based on HTMT criteria (Model A)

	BMA	CO	EC	FP	STRC	SENC	VCAP	VCRE
BMA								
CO	0.36							
EC	0.67	0.56						
FP	0.76	0.33	0.52					
STRC	0.44	0.47	0.41	0.28				
SENC	0.41	0.44	0.50	0.50	0.46			
VCAP	0.50	0.20	0.36	0.31	0.55	0.44		
VCRE	0.64	0.33	0.52	0.54	0.63	0.53	0.67	
VDEL	0.60	0.27	0.69	0.65	0.50	0.57	0.54	0.76

Notes: BMA: business model advantage, CO: collaboration capabilities, EC: experimentation capabilities, FP: firm performance, STRC: strategizing capabilities, SENC: sensing capabilities, VCAP: value capture, VCRE: value creation, VDEL: value delivery.

Stage two: assessment of the formative higher-order construct and the structural model

After the reflective LOCs were validated, the formative higher-order construct BMI was next validated. In stage two, a second path model was developed, this time containing the higher-order construct BMI (Sarstedt et al., 2019). Latent variable scores for VDEL, VCRE and VCAP saved from the bootstrapping were used as manifest indicators of BMI (Figure 46). Mode B was used for estimating the BMI as a reflective-formative higher-order construct.

VIF values were analysed to evaluate the collinearity of BMI. VIF values were lower than the conservative threshold of 3 in the three items – VDEL (VIF = 1.52), VCRE (VIF = 2.03) and VCAP (VIF = 1.76) – confirming the absence of collinearity of the formative construct (Table 58).

Next, the bootstrapping procedure was run to evaluate the significance and relevance of the relationships between the lower-order components (VDEL, VCRE and VCAP) and their higher-order construct (BMI). Table 58 shows the outer loadings, outer weights, and their significance. Outer weights were pronounced and significant in both VDEL and VCRE, while VCAP's weight was much smaller (0.09) and non-significant. However, the absolute contribution of the lower-order constructs to BMI exceeded the minimum thresholds for the outer loadings values (>0.50), p-values (<0.05) and t values (> ±1.96). Since theoretical and conceptual studies widely support the idea that VCAP is one of the dimensions of BMI, VCAP was retained (Hair Jr et al., 2017).

Table 58 Assessment of the formative high order construct (Model A)

	Outer loadings	T statistics (|O/STDEV|)	p-values	Outer weights	T statistics (|O/STDEV|)	p-values	VIF
VCAP -> BMI	0.62	4.24	0.00	0.09	0.58	0.56	1.52
VCRE -> BMI	0.87	14.06	0.00	0.43	2.93	0.00	2.03
VDEL -> BMI	0.93	23.13	0.00	0.61	5.30	0.00	1.76

Note: VCAP: value capture, VCRE: value creation, VDEL: value delivery, BMI: business model innovation, VIF: variance inflation factor

Having validated the measurement model, the next step was to evaluate the structural model (Figure 46).

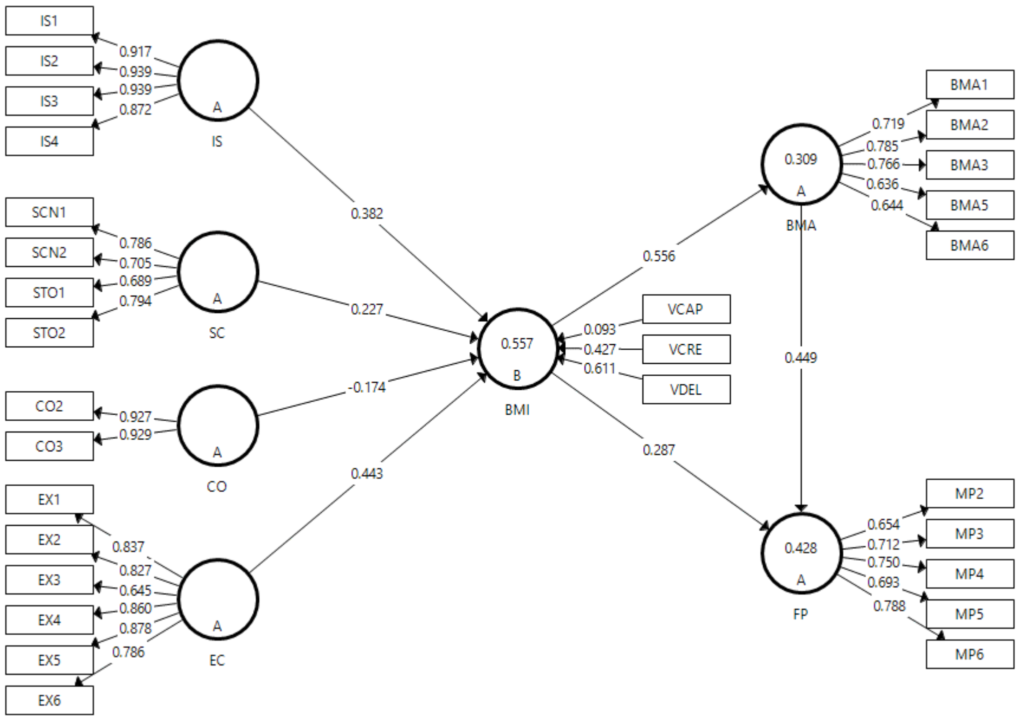

Figure 46 Structural model of Model A and PLS-SEM results

First, the collinearity of the inner model was evaluated to ensure that it would not bias the regression results (Table 59). The VIF values were below the ideal threshold of 3, ensuring that there were no collinearity issues between predictor constructs (Hair et al., 2019).

Table 59 Inner VIF values of the structural model (Model A)

	BMA	BMI	CO	EC	FP	STRC	SENC
BMA					1.45		
BMI	1.00				1.45		
CO		1.43					
EC		1.47					
FP							
STRC		1.38					
SENC		1.38					

Notes: BMA: business model advantage, BMI: business model innovation, CO: collaboration capabilities, EC: experimentation capabilities, FP: firm performance, STRC: strategizing capabilities, SENC: sensing capabilities

Since collinearity was not a problem, R^2 values of the endogenous constructs were assessed. R^2 values of 0.75, 0.50 and 0.25 commonly are considered substantial, moderate and weak, respectively (Hair et al., 2016; Henseler et al., 2009). Nevertheless, since R^2 depends on the number of predictors (i.e. the higher the number of predictor constructs, the higher the R^2) acceptable R^2 values should be determined based on the context of study (Raithel et al., 2012). In this vein, Hair et al. (2019) recommend interpreting the results by comparing them to related models of similar complexity. For this purpose, articles applying PLS-SEM to address business model innovation were analysed (Table 60) to identify models with a similar complexity and comparable sample characteristics (i.e. European firms, SMEs and similar sample size).

Table 60 Explanatory power of studies applying PLS-SEM in a similar context

Reference	Context	Construct, Number of predictors, R^2 values
Najmaei (2016)	- Sample of 87 manufacturing SMEs in Australia - Strategic management	- BMI, 2 preds., R^2 = 0.87 - Firm performance, 1 pred., R^2 = 0.87
Mütterlein and Kunz (2017)	- 50 German companies in media industry - Strategic entrepreneurship	- BMI: value creation, 2 preds., R^2 = 0.448 - BMI: value proposition, 2 preds., R^2 = 0.359 - BMI: value capture, 2 preds., R^2 = 0.031
Bouwman, Nikou, et al. (2018)	- 338 SMEs involved in social media and big data in Europe - Technology and innovation management	- BM experimentation, 1 pred., R^2 = 0.28 - BM practices, 1 pred., R^2 = 0.27 - Innovativeness, 2 preds., R^2 = 0.20 - Overall performance, 2 preds., R^2 = 0.15
Pucihar et al. (2019)	- Sample of 71 SMEs in Slovenia - Technology and innovation management	- Level of BMI, 3 preds., R^2 = 0.37 - BMI outcomes, 1 pred., R^2 = 0.31 - Business performance, 1 pred., R^2 = 0.08
Gatautis et al. (2019)	- Sample of 73 SMEs in Lithuania - Technology and innovation management	- Innovativeness, 1 pred., R^2 = 0.247 - Performance, 1 pred., R^2 = 0.254
Bouwman et al. (2019)	- Sample of 321 SMEs in Europe - Technology and innovation management	- Innovativeness, 2 preds., R^2 =0.33 - BM experimentation practices, 2 preds., R^2 = 0.13 - Overall firm performance, 2 preds., R^2 = 0.26
Clauss et al. (2019)	- 432 SMEs and large German firms from electronics industry - Strategic management	- Value proposition innovation, 1 pred., R^2 = 0.36 - Value creation innovation, 1 pred., R^2 = 0.40 - Value capture innovation, 1 pred., R^2 = 0.21 - Performance, 3 preds., R^2 = 0.32

Note: pred: predictor, BM: business model, BMI: business model innovation

After comparing the R^2 values from the path model under study (Table 61), which ranged between 0.309 and 0.557, to the values achieved in similar studies (Table 60), it was concluded that the model's R^2 values were moderately good.

Table 61 R-squared and R-squared adjusted values of the structural model (Model A)

	R-squared	R-squared adjusted
BMA	0.309	0.300
BMI	0.557	0.533
FP	0.428	0.412

Note: BMA: business model advantage, BMI: business model innovation, FP: firm performance

Once the explanatory power of the model had been checked, the predictive relevance of the model was calculated using the Stone-Geisser Q^2. This was done running the blindfolding procedure[10]. According to Hair et al. (2019), Q^2 values higher than 0, 0.25 and 0.50 indicate low, medium and high predictive relevance of

[10] The blindfolding procedure was performed with a path weighting scheme and an omission distance of 7.

the PLS-path model. Table 62 shows that all the Q^2 values were greater than zero, indicating predictive accuracy of the model.

Table 62 Stone-Geisser Q^2 values of the structural model (Model A)

	SSO	SSE	Q^2 (=1-SSE/SSO)
BMA	390.00	338.07	0.13
BMI	234.00	152.09	0.35
CO	156.00	156.00	
EC	468.00	468.00	
FP	390.00	309.60	0.21
STRC	312.00	312.00	
SENC	312.00	312.00	

Notes: BMA: business model advantage, BMI: business model innovation, CO: collaboration capabilities, EC: experimentation capabilities, FP: firm performance, STRC: strategizing capabilities, SENC: sensing capabilities, SSO: sum of the squared observations, SSE: sum of the squared prediction errors

To assess the out-of-sample predictive power, the PLS-Predict procedure with 10 folds and 10 replications was performed (Shmueli et al., 2019). The PLS Predict results for the PLS-SEM RMSE and MAE values were compared with those from the naïve LM benchmark. According to Shmueli et al. (2019), when PLS-SEM RMSE and MAE results aren lower than the LM RMSE and MAE results for all the indicators, the path model has high predictive power. Table 63 presents the results of the PLS Predict analysis, which validate the high predictive power of the model.

Table 63 PLS Predict analysis (Model A)

		BMA3	BMA1	BMA2	BMA6	BMA5	VCAP	VCRE	VDEL	MP2	MP6	MP5	MP3	MP4
RMSE	PLS	0.78	0.92	0.92	0.8	0.91	0.89	0.82	0.78	0.7	0.65	0.61	0.58	0.6
	LM	0.92	1.09	1.13	0.96	1.02	1.07	0.96	0.85	0.77	0.79	0.71	0.64	0.69
MAE	PLS	0.63	0.73	0.76	0.62	0.77	0.67	0.66	0.62	0.59	0.5	0.55	0.47	0.46
	LM	0.7	0.86	0.96	0.78	0.84	0.81	0.77	0.66	0.6	0.59	0.58	0.53	0.54

Note: RMSE: root-mean-square error, MAE: mean absolute error, PLS: partial least squares, LM: naïve linear model, BMA: business model advantage, VCAP: value capture, VCRE: value creation, VDEL: value delivery, MP: firm performance

Once the predictive and explanatory powers of the model were evaluated, path coefficients were explored (Figure 46). The bootstrapping procedure was performed to assess the significance of the path coefficients and evaluate their values. The results indicate that all relationships were positive and significant except for CO, which was found to have a negative and non-significant influence on BMI (Table 64). BMI had a positive and significant direct effect on FP ($\beta = 0.287$, $p = 0.019$) and on BMA ($\beta = 0.556$, $p = 0.000$). It was also found that BMA had a positive and significant direct effect on FP ($\beta = 0.449$, $p = 0.002$).

Table 64 Path coefficients (Model A)

Direct effects	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T Statistics (|O/STDEV|)	p-values
BMA -> FP	0.449	0.459	0.096	4.686	0.000
BMI -> BMA	0.556	0.582	0.096	5.795	0.000
BMI -> FP	0.287	0.286	0.122	2.355	0.019
CO -> BMI	-0.174	-0.152	0.096	1.814	0.070
EC -> BMI	0.443	0.441	0.113	3.924	0.000
STRC -> BMI	0.382	0.365	0.084	4.548	0.000
SENC -> BMI	0.227	0.236	0.099	2.304	0.021

Notes: BMA: business model advantage, BMI: business model innovation, CO: collaboration capabilities, EC: experimentation capabilities, FP: firm performance, STRC: strategizing capabilities, SENC: sensing capabilities

Specific indirect effects were also calculated to explore the mediation effect of BMA between BMI and FP, as displayed in Table 65. Thus, it was confirmed that the relationship BMI -> BMA -> FP was positive and significant (β = 0.250, p = 0.000), confirming the complementary partial mediation of BMA between BMI and FP (Baron y Kenny, 1986; Jiménez-Barreto et al., 2020).

Table 65 Specific indirect effects (Model A)

Indirect effects	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	p-values
CO -> BMI -> BMA	-0,097	-0,087	0,055	1,753	0,080
EC -> BMI -> BMA	0,246	0,258	0,083	2,976	0,003
STRC -> BMI -> BMA	0,213	0,212	0,059	3,625	0,000
SENC -> BMI -> BMA	0,126	0,136	0,060	2,101	0,036
CO -> BMI -> BMA -> FP	-0,043	-0,039	0,027	1,629	0,103
EC -> BMI -> BMA -> FP	0,111	0,120	0,050	2,199	0,028
STRC -> BMI -> BMA -> FP	0,096	0,097	0,035	2,699	0,007
BMI -> BMA -> FP	0,250	0,269	0,080	3,118	0,002
SENC -> BMI -> BMA -> FP	0,057	0,062	0,031	1,820	0,069
CO -> BMI -> FP	-0,050	-0,046	0,037	1,341	0,180
EC -> BMI -> FP	0,127	0,127	0,065	1,956	0,051
STRC -> BMI -> FP	0,110	0,103	0,049	2,236	0,025
SENC -> BMI -> FP	0,065	0,070	0,045	1,448	0,148

Notes: BMA: business model advantage, BMI: business model innovation, CO: collaboration capabilities, EC: experimentation capabilities, FP: firm performance, STRC: strategizing capabilities, SENC: sensing capabilities

Finally, the statistical power of the structural model was calculated to validate whether the sample size was sufficient for the extent of the effects found. The analysis was performed based on the criteria stated in subsection 5.3.1. The statistical power was analysed in both stages and for all endogenous constructs of the path model (Marin-Garcia y Alfalla-Luque, 2019). Thus, multiple power analyses were developed using the "Linear multiple regression: Fixed model, R^2 deviation from zero" statistical test from the "F test" family within G*Power 3.1 software (Faul et al., 2007), with a significance level of 0.05 and a total sample size of 78. For stage one, the most critical variable was VCAP, with four predictors and an R^2 value of 0.296, which was the lowest value in the path model. The results of the power analysis (Figure 47) showed a high statistical potential power (>0.99); therefore, the sample size of 78 was presumed sufficient to continue the analysis.

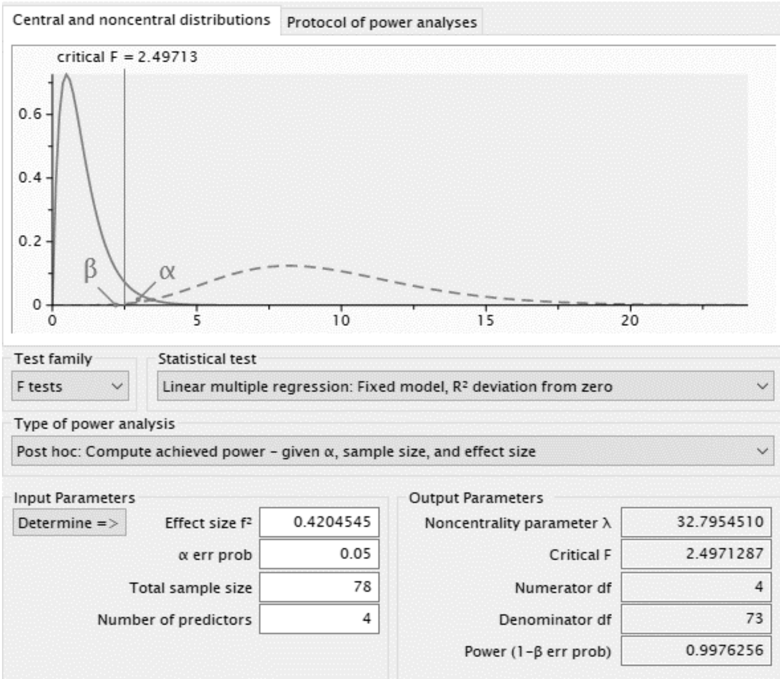

Figure 47 Statistical power test of VCAP in stage one (Model A)

For stage two, two different power analyses were conducted (Figure 48). In this case, the most critical variables were BMI, with four predictors and $R^2 = 0.557$, and BMA, with a single predictor and $R^2 = 0.309$. The results from both analyses indicated high statistical potential power (>0.99), and the sample size of 78 was presumed sufficient for this model.

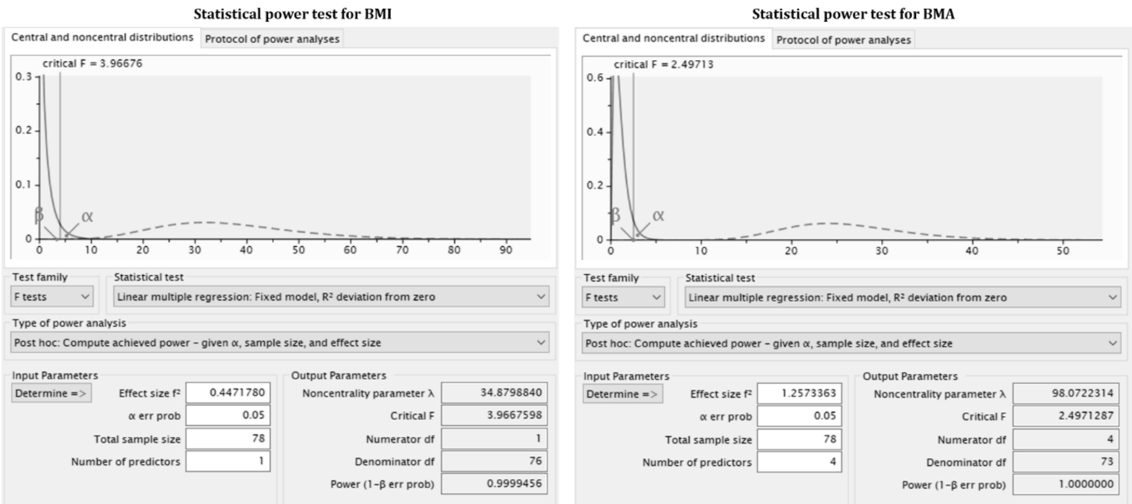

Figure 48 Statistical power test of BMI and BMA in stage two (Model A)

These analyses conclude the evaluation of Model A, which has analysed the effect of business model innovation capabilities on business model innovation and the effect of business model innovation on business model advantage and firm performance. In the following subsection, another PLS-SEM analysis is conducted to check Model B.

5.3.3. PLS-SEM Model B: Innovation culture, business model innovation and the mediating role of business model innovation capabilities

The main purpose of Model B was to assess the influence of innovation culture on business model innovation and to explore the mediating effect of business model innovation capabilities between innovation culture and business model innovation. Based on the results of the previous model (Model A), considering the complexity of the research model and the small size of the sample, the following decisions were taken when defining the path model for Model B:

- Since the individual relationships between each of the business model innovation capabilities (sensing capabilities, experimentation capabilities, collaboration capabilities and strategizing capabilities) and business model innovation had been previously validated, a higher-order construct (HOC) would be created to measure business model innovation capabilities as a single construct. This allowed for a more parsimonious model, reducing the complexity of establishing the relationships among innovative culture, business model innovation capabilities, business model innovation and its outcomes.
- Since in Model A the relationship between collaboration capabilities and business model innovation was not significant, it was decided to eliminate this variable when measuring the business model innovation capabilities HOC. Thus, business model innovation capabilities were measured through the lower-order constructs sensing capabilities, experimentation capabilities and strategizing capabilities.

The PLS-SEM analysis procedure for Model B was the same as that used in evaluating Model A.

Stage one: assessment of the reflective lower-order constructs (LOCs)

As presented in Figure 49 in stage one, the estimation and measurement model assessment for the LOCs was defined, drawing direct relationships between IC (innovative culture), STRC (strategizing capabilities), SENC (sensing capabilities), EC (experimentation capabilities) and the three constructs comprising BMI (business model innovation), namely, VDEL (value delivery), VCRE (value creation) and VCAP (value capture) without including the HOCs for BMIC (business model innovation capabilities) and BMI. Note that the items that did not work for Model A (i.e. BMA4 from business model advantage; FP1, FP2 and MP1 from firm performance; and SCN3 from sensing capabilities) are not included in the present model.

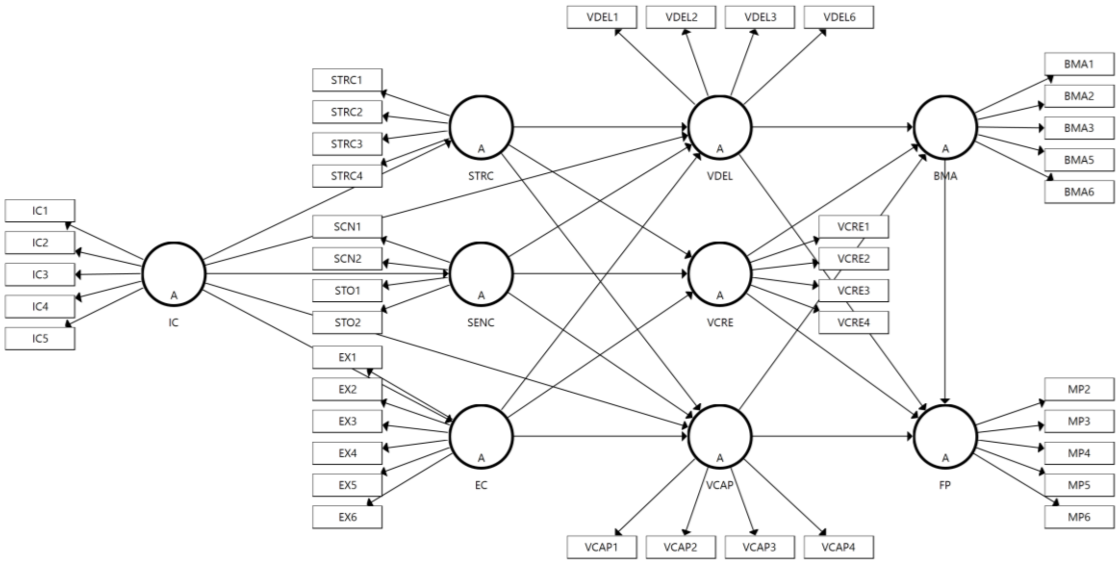

Figure 49 PLS path model for Model B

All the LOCs were defined as reflective using mode A, and the measurement model was evaluated based on criteria for reflective variables.

The PLS algorithm[11] and the bootstrapping[12] procedure were run to obtain the loading's significance (p-values, t-values and confident intervals) for all the items. Table 66 displays the results of the assessment of the measurement model. Outer loadings range between 0.634 and 0.939 and have significant values (p-value < 0.05, t values > ±1.96 and confidence intervals excluding zero). The AVE exceeded 0.50, confirming convergent validity. In addition, Cronbach's alpha and CR were above the minimum threshold of 0.70 confirming internal consistency reliability (Hair et al., 2019).

[11] The PLS algorithm was run with a path weighting scheme with a maximum of 300 iterations and a stop criterion of 7.

[12] Bootstrapping procedure was performed with 5,000 samples, using the no sign changes option, BCa bootstrap confidence intervals, two-tailed testing at the 0.05 significance level and path weighting schemes.

Table 66 Assessment of the reflective constructs of the measurement model (Model B)

		Outer loadings	T statistics (|O/STDEV|)	p-values	Confident intervals		Cronbach's Alpha	CR	AVE
		>0.708	>±1.96	< 0.05	2.5%	97.5%	0.70–0.90		>0.50
Business Model Advantage (BMA)	BMA1	0.721	8.075	0.000	0.468	0.841	0.757	0.837	0.508
	BMA2	0.787	13.166	0.000	0.629	0.866			
	BMA3	0.763	9.570	0.000	0.546	0.876			
	BMA5	0.634	5.933	0.000	0.341	0.789			
	BMA6	0.644	7.788	0.000	0.435	0.763			
Experimentation capabilities (EC)	EX1	0.841	20.377	0.000	0.732	0.903	0.893	0.919	0.655
	EX2	0.829	18.934	0.000	0.711	0.893			
	EX3	0.658	7.072	0.000	0.432	0.798			
	EX4	0.859	28.650	0.000	0.790	0.908			
	EX5	0.873	30.474	0.000	0.802	0.915			
	EX6	0.777	13.067	0.000	0.634	0.864			
Innovation culture (IC)	IC1	0.889	37.061	0.000	0.825	0.926	0.933	0.949	0.787
	IC2	0.918	43.521	0.000	0.860	0.949			
	IC3	0.871	26.989	0.000	0.791	0.924			
	IC4	0.884	20.265	0.000	0.767	0.937			
	IC5	0.872	18.605	0.000	0.743	0.931			
Strategizing capabilities (STRC)	STRC 1	0.915	31.765	0.000	0.423	0.767	0.937	0.955	0.842
	STRC 2	0.935	50.527	0.000	0.477	0.821			
	STRC 3	0.939	59.613	0.000	0.537	0.846			
	STRC 4	0.880	26.883	0.000	0.496	0.802			
Firm performance (FP)	MP2	0.644	7.280	0.000	0.677	0.850	0.768	0.843	0.519
	MP3	0.722	9.547	0.000	0.543	0.871			
	MP4	0.745	9.886	0.000	0.381	0.841			
	MP5	0.694	9.094	0.000	0.366	0.862			
	MP6	0.791	18.822	0.000	0.555	0.910			
Sensing Capabilities (SENC)	SCN1	0.765	9.451	0.000	0.841	0.954	0.740	0.833	0.557
	SCN2	0.687	5.779	0.000	0.892	0.966			
	STO1	0.717	6.091	0.000	0.901	0.962			
	STO2	0.809	9.831	0.000	0.797	0.929			
Value capture dimension (VCAP)	VCAP1	0.730	8.018	0.000	0.477	0.847	0.803	0.871	0.630
	VCAP2	0.729	9.000	0.000	0.506	0.840			
	VCAP3	0.888	27.741	0.000	0.809	0.932			
	VCAP4	0.817	15.202	0.000	0.673	0.889			
Value creation dimension (VCRE)	VCRE1	0.821	16.884	0.000	0.694	0.890	0.869	0.911	0.719
	VCRE2	0.887	34.166	0.000	0.821	0.927			
	VCRE3	0.829	14.941	0.000	0.682	0.904			
	VCRE4	0.852	17.803	0.000	0.724	0.922			
Value delivery dimension (VDEL)	VDEL1	0.805	13.002	0.000	0.625	0.891	0.836	0.890	0.670
	VDEL2	0.838	21.150	0.000	0.744	0.901			
	VDEL3	0.866	28.303	0.000	0.785	0.911			
	VDEL6	0.762	11.835	0.000	0.594	0.856			

Notes: CR: composite reliability, AVE: average variance extracted

Regarding discriminant validity, HTMT ratios indicated that all of the values were below the threshold of 0.85 (Table 67). Based on these results, it was established that the constructs were empirically distinct.

Table 67 Discriminant validity of reflective variables based on HTMT criteria (Model B)

	BMA	EC	FP	IC	STRC	SENC	VCAP	VCRE	VDEL
BMA									
EC	0,67								
FP	0,76	0,52							
IC	0,40	0,45	0,53						
STRC	0,44	0,41	0,28	0,40					
SENC	0,41	0,50	0,50	0,58	0,46				
VCAP	0,50	0,36	0,31	0,22	0,55	0,44			
VCRE	0,64	0,52	0,54	0,41	0,63	0,53	0,67		
VDEL	0,60	0,69	0,65	0,54	0,50	0,57	0,54	0,76	

Notes: BMA: business model advantage, EC: experimentation capabilities, FP: firm performance, IC: innovation culture, STRC: strategizing capabilities, SENC: sensing capabilities, VCAP: value capture, VCRE: value creation, VDEL: value delivery.

Stage two: assessment of the formative higher-order constructs and the structural model

Once reflective LOCs had been validated, BMIC and BMI higher-order constructs were addressed. A second path model containing the above variables was built. Latent variable scores of STRC, SENC, and EC were used as formative indicators of BMIC, VDEL, VCRE and VCAP were used to measure BMI (Figure 50). Mode B was used for estimating both reflective-formative higher-order constructs.

VIF values were analysed to address collinearity issues of both constructs. The VIF values were lower than the conservative threshold of 3 in the three items EC (VIF = 1.29), SENC (VIF = 1.40) and STRC (VIF = 1.35) of the BMIC construct and in the three items VDEL (VIF = 1.70), VCRE (VIF = 2.10) and VCAP (VIF = 1.55) of BMI, confirming the absence of collinearity of both formative constructs (Table 68).

After the bootstrapping procedure, the significance and relevance of the relationships between the lower-order components and their higher-order construct were then validated. Table 68 shows the outer loadings, the outer weights and their significance. All the indicators from BMIC (SENC, EC, STRC) and two indicators of BMI (VDEL and VCRE) showed significant weights, while VCAP's weight was much smaller (0.02) and non-significant. Based on the criteria used for Model A, VCAP was retained, because its absolute contribution to BMI exceeded the minimum threshold of 0.50 for the outer loadings values, with a significant p-value (<0.05), and it is theoretically supported.

Table 68 Assessment of the formative high-order constructs (Model B)

	Outer loadings	T statistics (|O/STDEV|)	p-values	Outer weights	T statistics (|O/STDEV|)	p-values	VIF
EC -> BMIC	0,82	11,02	0,00	0,50	3,69	0,00	1,29
SENC -> BMIC	0,79	9,57	0,00	0,40	3,14	0,00	1,40
STRC -> BMIC	0,75	7,44	0,00	0,37	3,13	0,00	1,35
VCAP -> BMI	0,57	3,58	0,00	**0,02**	**0,15**	**0,88**	1,55
VCRE -> BMI	0,86	12,61	0,00	0,44	3,05	0,00	2,10
VDEL -> BMI	0,94	24,83	0,00	0,65	5,39	0,00	1,70

Note: EC: experimentation capabilities, SENC: sensing capabilities, STRC: strategizing capabilities, BMIC: business model innovation capabilities, VCAP: value capture, VCRE: value creation, VDEL: value delivery, BMI: business model innovation, VIF: variance inflation factor

After the validation of the measurement model, the structural model was assessed. Figure 50 presents the path model for Model B in stage two. The structural model was evaluated using the procedure used for Model A.

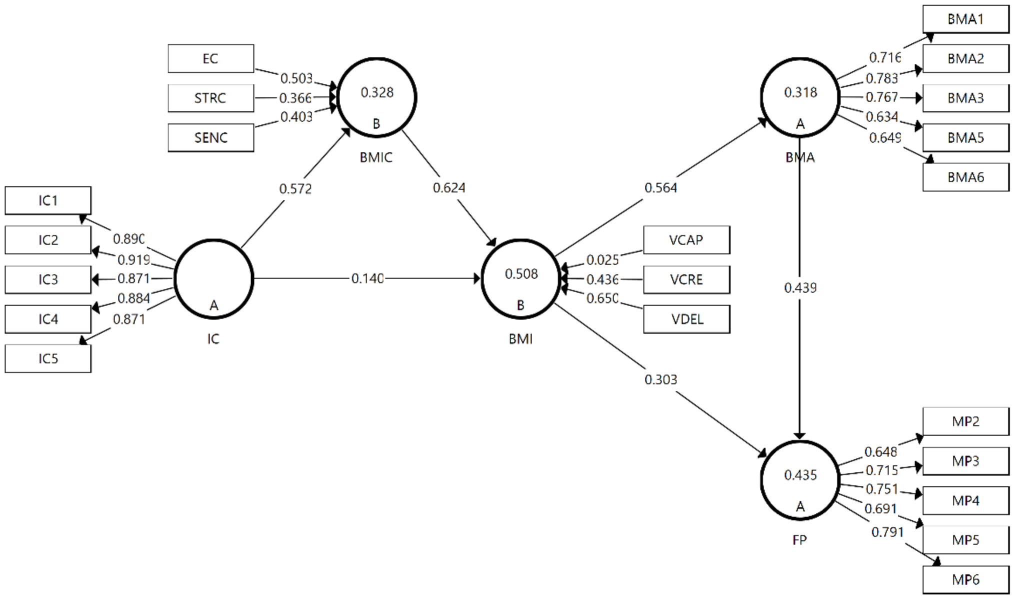

Figure 50 Structural model of Model B and PLS-SEM results

First, VIF values of the variables were checked. As shown in Table 69, they were all below 3, and therefore, no collinearity issues were found between predictor constructs.

Table 69 Inner VIF values of the structural model (Model B)

	BMA	BMI	BMIC	FP	IC
BMA				1.47	
BMI	1.00			1.47	
BMIC		1.49			
FP					
IC		1.49	1.00		

Note: BMA: business model advantage, BMI: business model innovation, BMIC: business model innovation capabilities, FP: firm performance, IC: innovation culture, VIF: variance inflation factor

Next, R^2 values of the endogenous constructs were assessed and are displayed in Table 70. R^2 values ranged between 0.32 and 0.51. After comparing these results with the rules of thumb (Hair et al., 2016; Henseler et al., 2009) and with the R^2 values achieved in similar studies (Table 60) it was concluded that these R^2 values were moderately good (Table 70).

Table 70 R-squared and R-squared adjusted values of the structural model (Model B)

	R-squared	R-squared adjusted
BMA	0.32	0.31
BMI	0.51	0.50
BMIC	0.33	0.32
FP	0.43	0.42

Note: BMA: business model advantage, BMI: business model innovation, BMIC: business model innovation capabilities, FP: firm performance

The predictive relevance of the model was then calculated based on the Stone-Geisser Q^2 by running the blindfolding procedure[13]. Table 71 indicates that Q^2 values were between 0.14 and 0.31, indicating the predictive accuracy of the model (Hair et al., 2019).

Table 71 Stone-Geisser Q^2 values of the structural model (Model B)

	SSO	SSE	Q^2 (=1-SSE/SSO)
BMA	390.00	336.49	0.14
BMI	234.00	161.49	0.31
BMIC	156.00	189.53	0.19
FP	390.00	308.30	0.21
IC	390.00	390.00	

Notes: BMA: business model advantage, BMI: business model innovation, BMIC: business model innovation capabilities, FP: firm performance, IC: innovation culture, SSO: sum of the squared observations, SSE: sum of the squared prediction errors

In addition, the out-of-sample predictive power was assessed with the PLS-Predict procedure with 10 folds and 10 replications (Shmueli et al., 2019). The results in Table 72 comparing the PLS-SEM RMSE and MAE values with the naïve LM benchmark suggest that the model had a medium predictive power, since most of the PLS values were lower than LM values.

Table 72 PLS predict analysis (Model B)

	RMSE		MAE	
	PLS	**LM**	**PLS**	**LM**
BMA2	**0.95**	**0.92**	**0.80**	**0.79**
BMA5	**0.92**	**0.91**	**0.78**	**0.72**
BMA1	0.99	1.03	0.81	0.85
BMA3	0.82	0.86	0.65	0.68
BMA6	0.82	0.85	0.66	0.68
VCRE	93.78	95.48	74.14	76.74
VCAP	97.16	101.11	76.14	78.31
VDEL	88.62	91.21	68.15	71.97
EC	92.60	96.03	75.14	78.36
SENC	86.59	88.65	61.16	63.73
STRC	82.38	86.21	62.88	66.91
MP4	0.59	0.60	0.46	0.47
MP3	0.56	0.57	0.48	0.47
MP6	0.63	0.65	0.51	0.51
MP5	0.63	0.66	0.58	0.58
MP2	0.72	0.70	0.60	0.59

Note: RMSE: root-mean-square error, MAE: mean absolute error, PLS: partial least squares, LM: naïve linear model, BMA: business model advantage, VCAP: value capture, VCRE: value creation, VDEL: value delivery, EC: experimentation capabilities, SENC: sensing capabilities, STRC: strategizing capabilities, MP: firm performance

Next, path coefficients and their significance were explored using the bootstrapping procedure. Table 73 illustrates the results, which indicate that all the relationships were positive and significant except for IC, which has a positive but not significant influence on BMI.

To assess the mediation effect of BMIC between IC and BMI, specific indirect effects were evaluated. Table 73 indicates that IC has a positive and significant effect on

[13] The blindfolding procedure was performed with a path weighting scheme and an omission distance of 7

BMIC (β = 0.572, p = 0.000), whereas it has no significant direct effect on BMI (β = 0.140, p = 0.257).

Table 73 Path coefficients (Model B)

	Original Sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	p-values
BMA -> FP	0.439	0.445	0.096	4.585	0.000
BMI -> BMA	0.564	0.590	0.096	5.899	0.000
BMI -> FP	0.303	0.305	0.122	2.497	0.013
BMIC -> BMI	0.624	0.641	0.098	6.395	0.000
IC -> BMI	**0.140**	**0.124**	**0.123**	**1.135**	**0.257**
IC -> BMIC	0.572	0.585	0.078	7.372	0.000

Note: BMA: business model advantage, FP: firm performance, BMI: business model innovation, BMIC: business model innovation capabilities, IC: innovation culture

Results of the analysis of the specific indirect effect IC -> BMIC -> BMI (Table 74) indicate that the relationship is positive and significant. Therefore, it is concluded that the effect of IC on BMI is fully mediated by BMIC.

Table 74 Specific indirect effects (Model B)

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	p-values
BMIC -> BMI -> BMA	0.35	0.38	0.09	3.81	0.00
IC -> BMIC -> BMI -> BMA	0.20	0.22	0.07	3.03	0.00
IC -> BMI -> BMA	0.08	0.07	0.07	1.10	0.27
IC -> BMIC -> BMI	**0.36**	**0.38**	**0.09**	**4.01**	**0.00**
BMIC -> BMI -> BMA -> FP	0.15	0.17	0.06	2.54	0.01
IC -> BMIC -> BMI -> BMA -> FP	0.09	0.10	0.04	2.40	0.02
BMI -> BMA -> FP	0.25	0.26	0.08	3.11	0.00
IC -> BMI -> BMA -> FP	0.03	0.03	0.03	1.06	0.29
BMIC -> BMI -> FP	0.19	0.19	0.08	2.34	0.02
IC -> BMIC -> BMI -> FP	0.11	0.12	0.06	1.89	0.06
IC -> BMI -> FP	0.04	0.04	0.05	0.91	0.36

Note: BMA: business model advantage, FP: firm performance, BMI: business model innovation, BMIC: business model innovation capabilities, IC: innovation culture

Finally, as in Model A, the statistical power was tested to validate the sample size in both stages and for all endogenous constructs of the path model (Marin-Garcia y Alfalla-Luque, 2019). Multiple post-hoc power analyses were performed using the "Linear multiple regression: Fixed model, R^2 deviation from zero" statistical test from the "F test" family within G*Power 3.1 software (Faul et al., 2007), with a significance level of 0.05 and a total sample size of 78. The endogenous variables with lower R^2 values and, at the same time, more predictors were identified in both the stage one and stage two path models. In stage one, the most critical variable was STRC, with one predictor and an R^2 value of 0.143 (Figure 51). The results show a statistical power of 0.945, indicating that a sample of 78 observations is sufficient for this model.

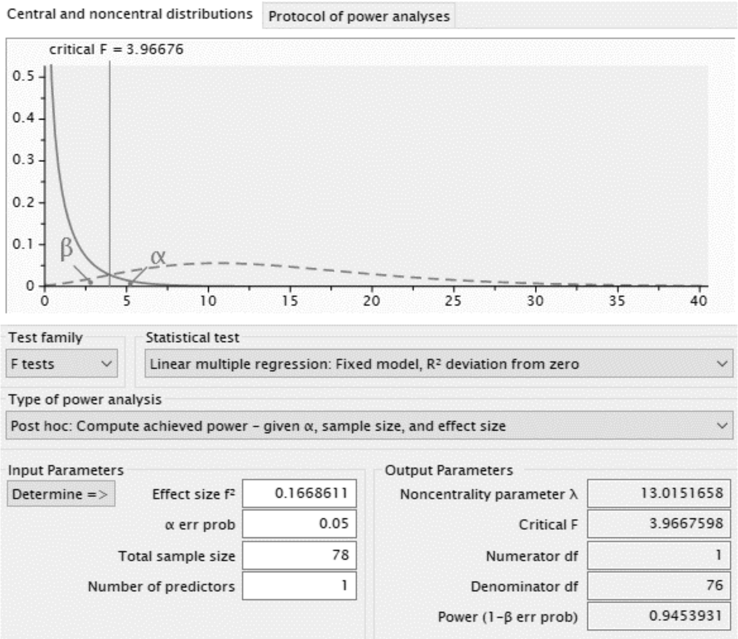

Figure 51 Statistical power test of STRC in stage one (Model B)

In stage two, the most critical variable was BMA construct, with one predictor and an R^2 value of 0.318 (Figure 52). The results of the analysis indicate a high statistical power (>0.99), indicating that a sample of 78 observations is sufficient to conclude the PLS-SEM analysis.

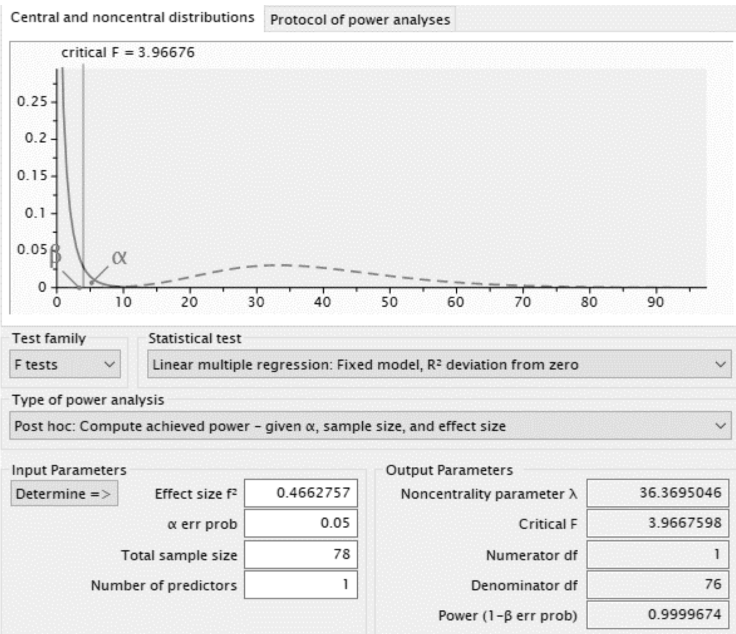

Figure 52 Statistical power test of BMA in stage two (Model B)

These analyses conclude the evaluation of Model B, which has been focused on examining the mediating role of innovation culture between business model innovation capabilities and business model innovation. In the following subsection, a new PLS-SEM analysis is conducted to check Model C.

5.3.4. PLS-SEM Model C: Managerial orientation, business model innovation and the mediating role of business model innovation capabilities

A new PLS-SEM analysis was conducted to evaluate Model C to explore the influence of managerial orientation on BMI, emphasising the mediation role of business model innovation capabilities between managerial orientation and business model innovation. The criteria and procedure followed for the development of the PLS-SEM analysis was the same as those used with Model B. Thus, business model innovation capabilities were measured as a higher-order construct which encompasses strategizing capabilities, sensing capabilities and experimentation capabilities as lower-order constructs.

Stage one: assessment of the reflective lower order constructs (LOCs)

As presented in Figure 53 in stage one, the estimation and measurement model assessment for the LOCs was defined drawing direct relationships between MO (managerial orientation), STRC (strategizing capabilities), SENC (sensing capabilities), EC (experimentation capabilities) and the three constructs comprising BMI (business model innovation), VDEL (value delivery), VCRE (value creation) and VCAP (value capture) without including the higher-order constructs for BMIC (business model innovation capabilities) and BMI. Items deleted during the purification of the measurement model in Model A (i.e. BMA4 from business model advantage; FP1, FP2 and MP1 from firm performance; and SCN3 from sensing capabilities) were excluded from the path model.

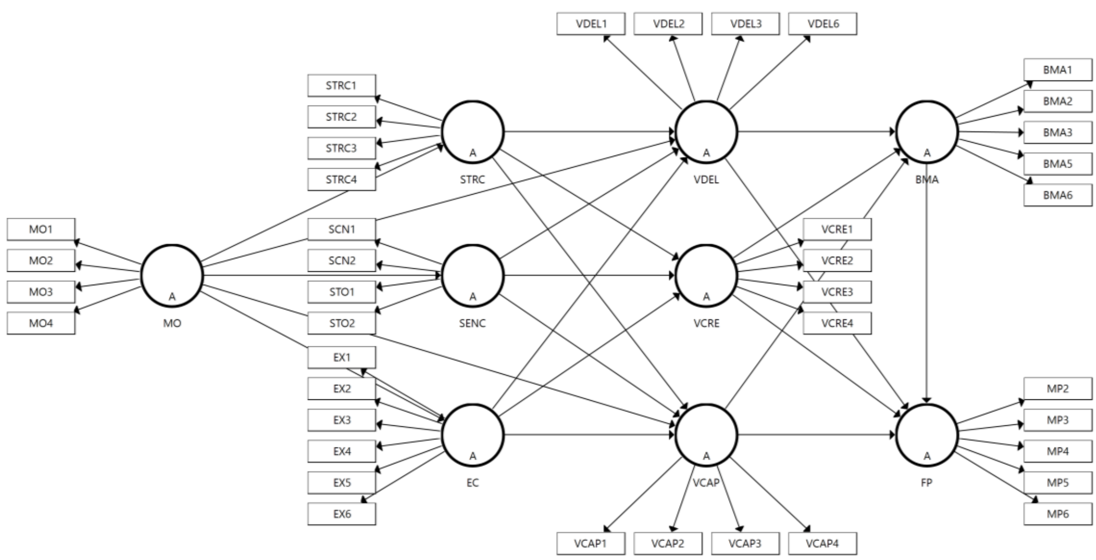

Figure 53 PLS path model for Model C in stage one

All the LOCs were defined as reflective using mode A and the measurement model was evaluated based on criteria for reflective variables. The PLS algorithm[14] and the bootstrapping[15] procedure were run to obtain the loading's significance (p-values, t-values and confident intervals) for all the items.

The results of the assessment of the measurement model are presented in Table 75. Outer loadings range between 0.524 and 0.94 and have significant values (p-value < 0.05, t values > ±1.96 and confidence intervals excluding zero). The AVE exceeded 0.50, confirming convergent validity. In addition, Cronbach's alpha and CR were above the minimum threshold of 0.70, confirming internal consistency reliability.

Table 75 Assessment of the reflective constructs of the measurement model (Model C)

		Outer loadings	T statistics (|O/STDEV|)	p-values	Confident intervals		Cronbach's alpha	CR	AVE
		>0.708	>±1.96	< 0.05	2.5%	97.5%	0.70–0.90		>0.50
Business Model Advantage (BMA)	BMA1	0.721	7.835	0.000	0.496	0.851	0.757	0.837	0.508
	BMA2	0.787	13.137	0.000	0.651	0.872			
	BMA3	0.763	9.589	0.000	0.565	0.877			
	BMA5	0.634	5.754	0.000	0.369	0.801			
	BMA6	0.644	7.873	0.000	0.461	0.777			
Experimentation capabilities (EC)	EX1	0.837	19.054	0.000	0.741	0.907	0.893	0.919	0.655
	EX2	0.832	19.717	0.000	0.742	0.901			
	EX3	0.656	7.158	0.000	0.437	0.799			
	EX4	0.854	25.956	0.000	0.778	0.907			
	EX5	0.873	29.236	0.000	0.804	0.917			
	EX6	0.785	14.623	0.000	0.661	0.868			
Strategizing capabilities (STRC)	STRC1	0.914	30.956	0.000	0.122	0.768	0.937	0.955	0.842
	STRC2	0.935	50.223	0.000	0.540	0.872			
	STRC3	0.940	63.941	0.000	0.838	0.945			
	STRC4	0.880	26.429	0.000	0.741	0.929			
Managerial orientation (MO)	MO1	0.524	3.225	0.001	0.416	0.766	0.80	0.86	0.61
	MO2	0.765	8.642	0.000	0.534	0.831			
	MO3	0.916	15.769	0.000	0.537	0.848			
	MO4	0.868	12.071	0.000	0.503	0.807			
Firm performance (FP)	MP2	0.643	7.295	0.000	0.701	0.859	0.768	0.843	0.519
	MP3	0.722	9.569	0.000	0.538	0.882			
	MP4	0.745	9.673	0.000	0.383	0.853			
	MP5	0.694	9.194	0.000	0.366	0.878			
	MP6	0.791	18.848	0.000	0.587	0.922			
Sensing Capabilities (SENC)	SCN1	0.769	8.395	0.000	0.842	0.958	0.740	0.833	0.557
	SCN2	0.703	5.698	0.000	0.892	0.966			
	STO1	0.709	5.628	0.000	0.906	0.965			
	STO2	0.801	9.162	0.000	0.798	0.930			
Value capture dimension (VCAP)	VCAP1	0.728	8.022	0.000	0.502	0.860	0.803	0.871	0.630
	VCAP2	0.735	8.981	0.000	0.531	0.856			
	VCAP3	0.888	28.634	0.000	0.805	0.930			
	VCAP4	0.815	14.486	0.000	0.679	0.890			
Value creation dimension (VCRE)	VCRE1	0.821	16.476	0.000	0.707	0.897	0.869	0.911	0.719
	VCRE2	0.887	34.000	0.000	0.830	0.930			
	VCRE3	0.829	15.056	0.000	0.704	0.911			
	VCRE4	0.852	17.375	0.000	0.735	0.927			
Value delivery dimension (VDEL)	VDEL1	0.806	12.723	0.000	0.656	0.898	0.836	0.890	0.670
	VDEL2	0.838	20.916	0.000	0.743	0.901			
	VDEL3	0.866	28.257	0.000	0.795	0.915			
	VDEL6	0.760	11.454	0.000	0.600	0.857			

Notes: CR: composite reliability, AVE: average variance extracted

[14] The PLS algorithm was run with a path weighting scheme with a maximum of 300 iterations and a stop criterion of 7.

[15] Bootstrapping procedure was performed with 5,000 samples, using the no sign changes option, BCa bootstrap confidence intervals, two-tailed testing at the 0.05 significance level and path weighting schemes.

Regarding discriminant validity, HTMT ratios were below the threshold of 0.85 (Table 76). These results established that the constructs were empirically distinct.

Table 76 Discriminant validity of reflective variables based on HTMT criteria (Model C)

	BMA	EC	FP	STRC	MO	SENC	VCAP	VCRE	VDEL
BMA									
EC	0.67								
FP	0.76	0.52							
STRC	0.44	0.41	0.28						
MO	0.34	0.35	0.32	0.43					
SENC	0.41	0.50	0.50	0.46	0.35				
VCAP	0.50	0.36	0.31	0.55	0.19	0.44			
VCRE	0.64	0.52	0.54	0.63	0.26	0.53	0.67		
VDEL	0.60	0.69	0.65	0.50	0.33	0.57	0.54	0.76	

Notes: BMA: business model advantage, EC: experimentation capabilities, FP: firm performance, STRC: strategizing capabilities, MO: managerial orientation, SENC: sensing capabilities, VCAP: value capture, VCRE: value creation, VDEL: value delivery.

Stage two: assessment of the formative higher-order construct and the structural model

After validating the reflective LOCs, BMIC and BMI formative HOCs were addressed following the procedure used for Model B (see subsection 5.3.3 for details). Figure 54 presents the path model for stage two.

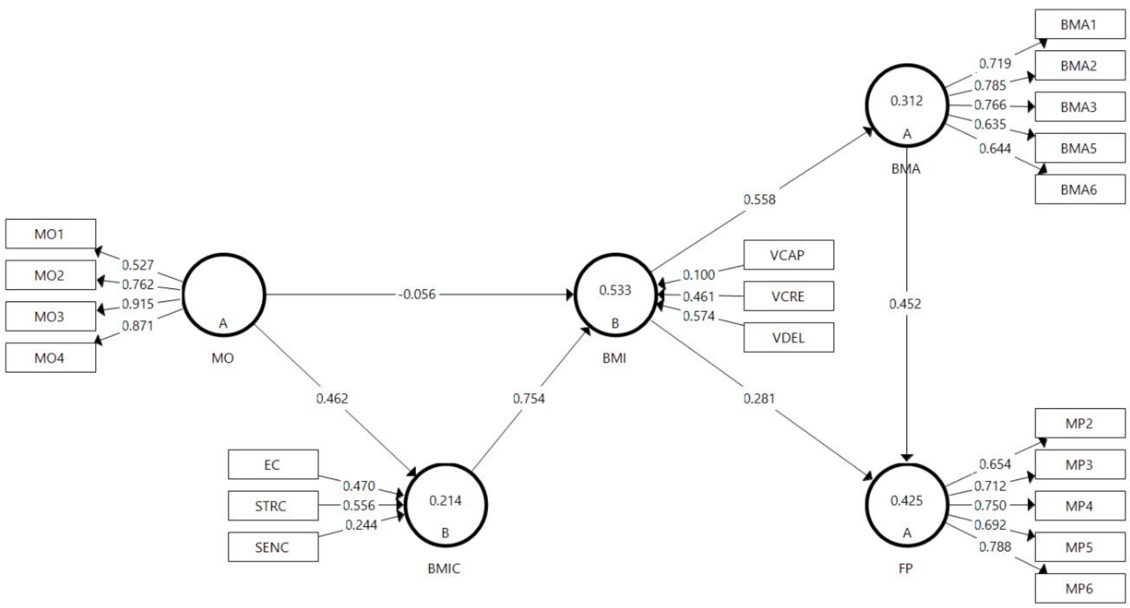

Figure 54 Structural model of Model C and PLS-SEM results

Validation of BMIC and BMI higher-order constructs is illustrated in Table 77. VIF values range between 1.28 and 2.03, confirming the absence of collinearity of both formative constructs.

The significance and relevance of the relationships between the LOCs and their higher-order construct were validated using a bootstrapping procedure. For BMIC, EC and STRC had significant weights, whereas the weight of SENC was non-significant. Nevertheless, since the outer load of SENC exceeded the minimum threshold of 0.50 for the outer loadings values, with significant p-value (<0.05) and t-values (> ±1.96), the validity of BMIC as an higher-order construct was confirmed. The BMI construct validation produced values similar to those seen with previous models. VCAP's weight was much smaller (0.10) than the cut-off of 0.40 and non-significant. Again, VCAP was retained since its absolute contribution to BMI exceeded the minimum threshold of 0.50 for the outer loadings values, with a significant p-value (<0.05), and it is theoretically supported.

Table 77 Assessment of the formative high-order constructs (Model C)

	Outer loadings	T statistics (|O/STDEV|)	p-values	Outer weights	T statistics (|O/STDEV|)	p-values	VIF
EC -> BMIC	0.79	9.37	0.00	0.47	3.18	0.00	1.31
SENC -> BMIC	0.84	8.78	0.00	0.56	4.52	0.08	1.36
STRC -> BMIC	0.68	6.81	0.00	0.24	1.73	0.00	1.28
VCAP -> BMI	0.63	4.33	0.00	0.10	0.61	0.54	1.52
VCRE -> BMI	0.89	14.81	0.00	0.46	3.24	0.00	2.03
VDEL -> BMI	0.92	21.35	0.00	0.57	4.74	0.00	1.76

Note: EC: experimentation capabilities, SENC: sensing capabilities, STRC: strategizing capabilities, BMIC: business model innovation capabilities, VCAP: value capture, VCRE: value creation, VDEL: value delivery, BMI: business model innovation, VIF: variance inflation factor

The structural model was evaluated using the same procedure used for Model A and Model B. VIF values of the inner model shown in Table 78 indicate no collinearity issues among predictor constructs (VIF < 3).

Table 78 Inner VIF values of the structural model (Model C)

	BMA	BMI	EC	FP	MO
BMA				1.45	
BMI	1.00			1.45	
BMIC		1.27			
FP					
MO		1.27	1.00		

Note: BMA: business model advantage, BMI: business model innovation, BMIC: business model innovation capabilities, FP: firm performance, MO: managerial orientation, VIF: variance inflation factor

Table 79 presents the R^2 values of the endogenous constructs. R^2 values range between 0.21 and 0.53 and were considered moderately good based on the rules of thumb (Hair et al., 2016; Henseler et al., 2009) and the R^2 values achieved in similar studies (Table 60).

Table 79 R-squared and R-squared adjusted values of the structural model (Model C)

	R-squared	R-squared adjusted
BMA	0.31	0.30
BMI	0.53	0.52
BMIC	0.21	0.20
FP	0.42	0.41

Note: BMA: business model advantage, BMI: business model innovation, BMIC: business model innovation capabilities, FP: firm performance

The predictive relevance of the model was calculated based on the Stone-Geisser Q^2 by running the blindfolding procedure[16]. Table 80 indicates that Q^2 values were between 0.13 and 0.35, indicating the predictive accuracy of the model (Hair et al., 2019).

Table 80 Stone-Geisser Q2 values of the structural model (Model C)

	SSO	SSE	Q^2 (=1-SSE/SSO)
BMA	390.00	337.50	0.13
BMI	234.00	152.05	0.35
BMIC	234.00	208.84	0.11
FP	390.00	310.14	0.20
MO	312.00	312.00	

Notes: BMA: business model advantage, BMI: business model innovation, BMIC: business model innovation capabilities, FP: firm performance, MO: managerial orientation, SSO: sum of the squared observations, SSE: sum of the squared prediction errors

Next, the out-of-sample predictive power was assessed with the PLS-Predict procedure with 10 folds and 10 replications. Almost all items had PLS-SEM RSME and MAE values lower than the naïve LM benchmark values. This established that the model had moderate predictive power (Shmueli et al., 2019).

Table 81 PLS predict analysis (Model C)

	RMSE		MAE	
	PLS	**LM**	**PLS**	**LM**
BMA6	0.84	0.88	**0.688**	**0.686**
BMA3	0.85	0.88	0.688	0.690
BMA1	0.98	1.01	0.798	0.801
BMA2	0.95	0.98	0.781	0.794
BMA5	0.95	1.00	0.819	0.849
VCAP	1.02	1.02	0.801	0.816
VCRE	1.00	1.01	**0.813**	**0.805**
VDEL	0.99	1.02	0.768	0.794
EC	0.98	1.00	0.814	0.821
STRC	0.93	0.93	**0.734**	**0.721**
SENC	0.99	1.01	0.740	0.760
MP6	0.67	0.70	0.548	0.576
MP3	0.58	0.61	0.503	0.530
MP2	**0.73**	**0.72**	**0.621**	**0.584**
MP4	0.62	0.64	0.487	0.501
MP5	0.64	0.67	0.589	0.611

Note: RMSE: root-mean-square error, MAE: mean absolute error, PLS: partial least squares, LM: naïve linear model, BMA: business model advantage, VCAP: value capture, VCRE: value creation, VDEL: value delivery, EC: experimentation capabilities, STRC: strategizing capabilities, SENC: sensing capabilities, MP: firm performance

Path coefficients (direct effects) and the specific indirect effects and their significance were explored using the bootstrapping procedure. Table 82 presents the direct effects between variables and their significance levels. The results for relationships previously validated in Model A are maintained, with all being positive and significant, whereas MO has a negative and non-significant influence on BMI (β = -0.06, p = 0.607).

[16] The blindfolding procedure was performed with a path weighting scheme and an omission distance of 7.

Moving to the mediation effect of BMIC, Table 82 shows that MO is positively and significantly related to BMIC (β = 0.75, p = 0.257).

Table 82 Path coefficients (Model C)

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	t statistics (|O/STDEV|)	p-values
BMA -> FP	0.45	0.46	0.10	4.70	0.000
BMI -> BMA	0.56	0.58	0.10	5.87	0.000
BMI -> FP	0.28	0.28	0.12	2.30	0.021
BMIC -> BMI	0.75	0.76	0.08	9.81	0.000
MO -> BMI	-0.06	-0.06	0.11	0.51	0.607
MO -> BMIC	0.46	0.49	0.09	5.33	0.000
BMA -> FP	0.45	0.46	0.10	4.70	0.000

Note: BMA: business model advantage, FP: firm performance, BMI: business model innovation, BMIC: business model innovation capabilities, MO: managerial orientation

Moreover, the results in Table 83 indicate that the specific indirect effect MO -> BMIC -> BMI is positive and significant (β = 0.35, p = 0.000). Thus, full mediation is established.

Table 83 Specific indirect effects (Model C)

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	t statistics (|O/STDEV|)	p-values
BMIC -> BMI -> BMA	0.42	0.45	0.09	4.71	0.000
MO -> BMIC -> BMI -> BMA	0.19	0.22	0.06	3.16	0.002
MO -> BMI -> BMA	-0.03	-0.04	0.07	0.47	0.636
MO -> BMIC -> BMI	0.35	0.37	0.08	4.20	0.000
BMIC -> BMI -> BMA -> FP	0.19	0.21	0.06	2.94	0.003
MO -> BMIC -> BMI -> BMA -> FP	0.09	0.10	0.04	2.39	0.017
BMI -> BMA -> FP	0.25	0.27	0.08	3.15	0.002
MO -> BMI -> BMA -> FP	-0.01	-0.02	0.03	0.45	0.655
BMIC -> BMI -> FP	0.21	0.21	0.10	2.23	0.026
MO -> BMIC -> BMI -> FP	0.10	0.11	0.05	1.87	0.061
MO -> BMI -> FP	-0.02	-0.02	0.03	0.47	0.641

Note: BMA: business model advantage, FP: firm performance, BMI: business model innovation, BMIC: business model innovation capabilities, MO: managerial orientation

Lastly, as in previous models, multiple post hoc analyses to test the statistical power were carried out using the "Linear multiple regression: Fixed model, R^2 deviation from zero" statistical test from the “F test” family within G*Power 3.1 software (Faul et al., 2007), with a significance level of 0.05 and a total sample size of 78. The endogenous variables with lower R^2 values and a large number of predictors were identified in both the stage one and stage two path models (Marin-Garcia y Alfalla-Luque, 2019).

The statistical power of the structural model in stage one for the most critical variable, SENC, with one predictor and a R^2 value of 0.08, leaded to a statistical power of 0.73 (Figure 55), being below the standard cut-off 0.80 (Hair et al., 2019).

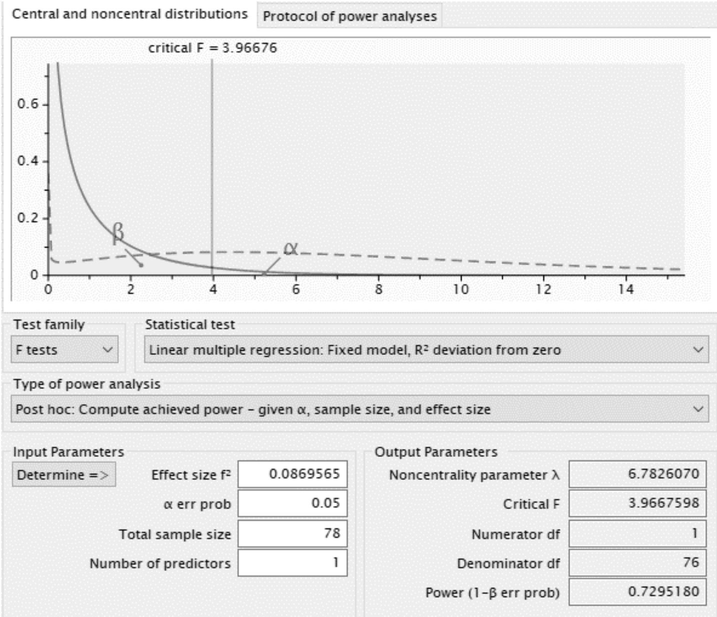

Figure 55 Statistical power test of SENC in stage one (Model C)

A second analysis was conducted to examine the statistical power of the structural model in stage two. The most critical variable in this stage was BMIC, with one predictor and an R^2 value of 0.214. The statistical power achieved was 0.995 (Figure 56), which exceeded the minimum needed to support the magnitude of the effects of the structural model (>0.80).

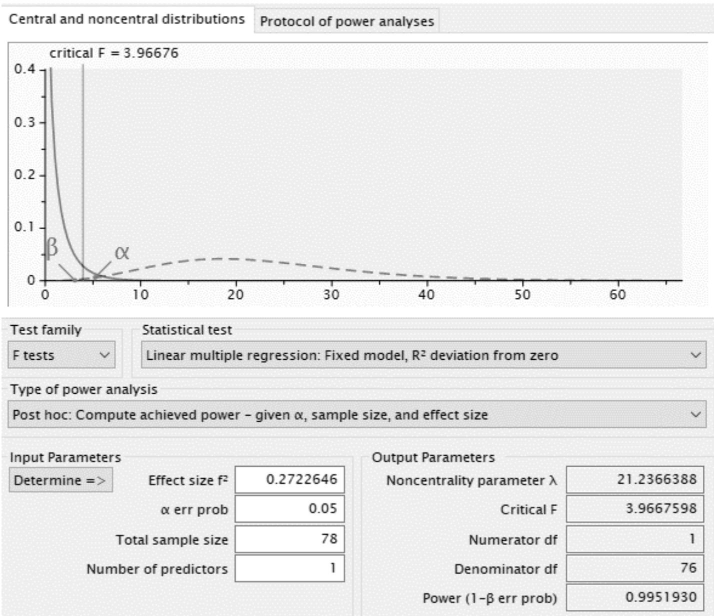

Figure 56 Statistical power test of BMIC in stage two (Model C)

Based on these results, Model C should be interpreted with some caution, and therefore, the assessment of the role of managerial orientation should be addressed through complementary analysis, such as fsQCA. These analyses conclude the evaluation of Model C. The following subsection describes the last PLS-SEM analysis.

5.3.5. PLS-SEM Model D: Business model innovation tools and business model innovation

Model D was developed to assess the influence of using business model innovation tools (BMIT) in business model innovation (BMI). Since Model D is a more parsimonious model, the BMI construct was not established as a higher-order construct. Instead, the path model drew direct relationships from BMIT to VDEL (value delivery), VCRE (value creation) and VCAP (value capture) constructs (Figure 57). This allowed a more detailed result regarding the influence of BMIT on each of the BMI dimensions. The measurement model was first assessed, and then the structural model was explored.

Assessment of the measurement model

The measurement model was evaluated based on the criteria for reflective variables as all the variables were defined as reflective using Mode A. PLS algorithm was run with a path weighting scheme with a maximum of 300 iterations and a stop criterion of 7. The bootstrapping procedure was performed with 5,000 samples, using the no sign changes option, BCa bootstrap confidence intervals, two-tailed testing at the 0.05 significance level and path weighting schemes. Table 84 presents the results of the assessment of the measurement model.

Table 84 Assessment of the measurement model (Model D)

		Outer loadings	T statistics (|O/STDEV|)	p-values	Confident intervals		Cronbach's alpha	CR	AVE
		>0.708	>±1.96	< 0.05	2.5%	97.5%	0.70–0.90		>0.50
Business Model Innovation Tools (BMIT)	BMIT1	0.538	4.685	0.000	0.288	0.728	0.901	0.921	0.569
	BMIT2	0.658	8.325	0.000	0.467	0.778			
	BMIT3	0.657	8.001	0.000	0.467	0.781			
	BMIT4	0.846	20.850	0.000	0.746	0.910			
	BMIT5	0.902	34.911	0.000	0.838	0.946			
	BMIT6	0.758	12.230	0.000	0.612	0.854			
	BMIT7	0.891	36.094	0.000	0.835	0.930			
	BMIT8	0.748	10.543	0.000	0.595	0.860			
	BMIT9	0.712	12.348	0.000	0.582	0.817			
Value capture dimension (VCAP)	VCAP1	0.748	7.099	0.000	0.454	0.882	0.803	0.868	0.624
	VCAP2	0.680	5.752	0.000	0.403	0.848			
	VCAP3	0.855	17.178	0.000	0.719	0.913			
	VCAP4	0.863	16.283	0.000	0.738	0.943			
Value creation dimension (VCRE)	VCRE1	0.814	16.986	0.000	0.715	0.881	0.869	0.910	0.718
	VCRE2	0.885	29.700	0.000	0.817	0.931			
	VCRE3	0.840	21.802	0.000	0.750	0.904			
	VCRE4	0.848	14.867	0.000	0.706	0.924			
Value delivery dimension (VDEL)	VDEL1	0.795	11.229	0.000	0.627	0.891	0.836	0.890	0.669
	VDEL2	0.838	19.297	0.000	0.739	0.899			
	VDEL3	0.840	17.408	0.000	0.723	0.902			
	VDEL6	0.798	14.700	0.000	0.655	0.877			

Notes: CR: composite reliability, AVE: average variance extracted

All the outer loadings exceeded the minimum threshold of 0.40, with most of them above 0.708, and they were statistically significant (p-value < 0.05, t values > ±1.96 and confidence intervals excluding zero). In addition, AVE values were above 0.50 in all variables, confirming convergent validity. Cronbach's alpha and CR were with the satisfactory range of 0.70–0.90, supporting the internal reliability of the indicators.

HTMT scores, indicating discriminant validity, are presented in Table 85. HTMT ratios were below 0.85, suggesting that the constructs were empirically distinct. This established discriminant validity.

Table 85 Discriminant validity of reflective variables based on HTMT criteria (Model D)

	BMIT	VCAP	VCRE	VDEL
BMIT				
VCAP	0,40			
VCRE	0,57	0,67		
VDEL	0,51	0,54	0,76	

Assessment of the structural model

Once the measurement model was validated, the structural model was evaluated (Figure 57).

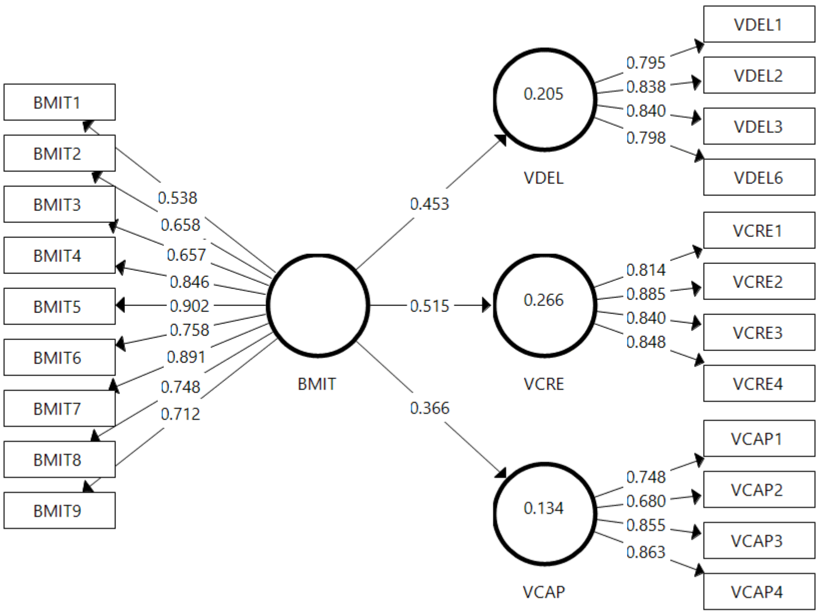

Figure 57 PLS path model for Model D

First, collinearity of the inner model was evaluated to ensure that it would not bias the regression results. VIF values of 1 were far below the threshold of 3, confirming a lack of collinearity issues.

Table 86 Inner VIF values of the structural model (Model D)

	BMIT	VCAP	VCRE	VDEL
BMIT		1.00	1.00	1.00
VCAP				
VCRE				
VDEL				

Note: BMIT: business model innovation tools, VCAP: value capture, VCRE: value creation, VDEL: value delivery, VIF: variance inflation factor

R^2 values of the three dimensions comprising BMI ranged from 0.13 to 0.27 and were considered moderately good in comparison with similar studies of business model innovation (Table 60).

Table 87 R Square and R Square adjusted values of the structural model (Model D)

	R Square	R Square Adjusted
VCAP	0.13	0.12
VCRE	0.27	0.26
VDEL	0.21	0.19

Note: VCAP: value capture, VCRE: value creation, VDEL: value delivery

To calculate the predictive relevance of the model, the Stone-Geisser Q^2 was calculated by running the blindfolding procedure with a path weighting scheme with an omission distance of 7. The results displayed in Table 88 indicate that Q^2 values were greater than zero, indicating predictive accuracy of the model (Hair et al., 2019).

Table 88 Stone-Geisser Q2 values of the structural model (Model D)

	SSO	SSE	Q^2 (=1-SSE/SSO)
BMIT	702,00	702,00	
VCAP	312,00	291,09	0,07
VCRE	312,00	256,83	0,18
VDEL	312,00	273,99	0,12

Note: BMIT: business model innovation tools, VCAP: value capture, VCRE: value creation, VDEL: value delivery, SSO: sum of the squared observations, SSE: sum of the squared prediction errors

In addition, the PLS-Predict procedure with 10 folds and 10 replications was performed (Shmueli et al., 2019). The PLS- RMSE and MAE values were compared with those from the naïve LM benchmark. As can be seen in Table 89, all PLS values were lower than LM values, suggesting a high predictive power for Model D (Shmueli et al., 2019).

Table 89 PLS predict analysis (Model D)

		VCAP1	VCAP2	VCAP3	VCAP4	VCRE1	VCRE2	VCRE3	VCRE4	VDEL1	VDEL2	VDEL3	VDEL6
RMSE	PLS	0,93	1,02	0,95	0,92	0,99	1,00	0,94	0,89	0,88	0,83	0,91	0,99
	LM	0,99	1,12	1,02	1,01	1,09	1,03	1,02	0,94	0,97	0,89	1,02	1,04
MAE	PLS	0,76	0,84	0,78	0,76	0,76	0,82	0,76	0,71	0,73	0,67	0,74	0,81
	LM	0,81	0,91	0,79	0,83	0,81	0,82	0,78	0,76	0,81	0,70	0,84	0,85

Once the predictive and explanatory power of the model had been evaluated, path coefficients were explored. The bootstrapping procedure was applied to assess the significance of path coefficients and evaluate their values. Table 90 shows that BMIT has a positive and significant influence on the three dimensions of BMI, with its effect on VCRE (β = 0.515, p = 0.000) being the strongest, followed by VDEL (β = 0.453, p = 0.000) and VCAP (β = 0.3.66, p = 0.001).

Table 90 Path coefficients (Model D)

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	p-values
BMIT -> VCAP	0.366	0.401	0.104	3.501	0.001
BMIT -> VCRE	0.515	0.538	0.073	7.021	0.000
BMIT -> VDEL	0.453	0.477	0.082	5.509	0.000

Finally, the statistical power test was conducted. A post hoc analysis was performed using the "Linear multiple regression: Fixed model, R^2 deviation from zero" statistical test from the "F test" family within G*Power 3.1 software (Faul et al., 2007), with a significance level of 0.05 and a total sample size of 78, considering the endogenous variable with the lowest R^2 value, VCAP ($R^2 = 0.134$). The result of the analysis is presented in Figure 58. The power achieved was 0.92, above the threshold of 0.80. Therefore, it was assumed that the sample size of 78 was sufficient for this model.

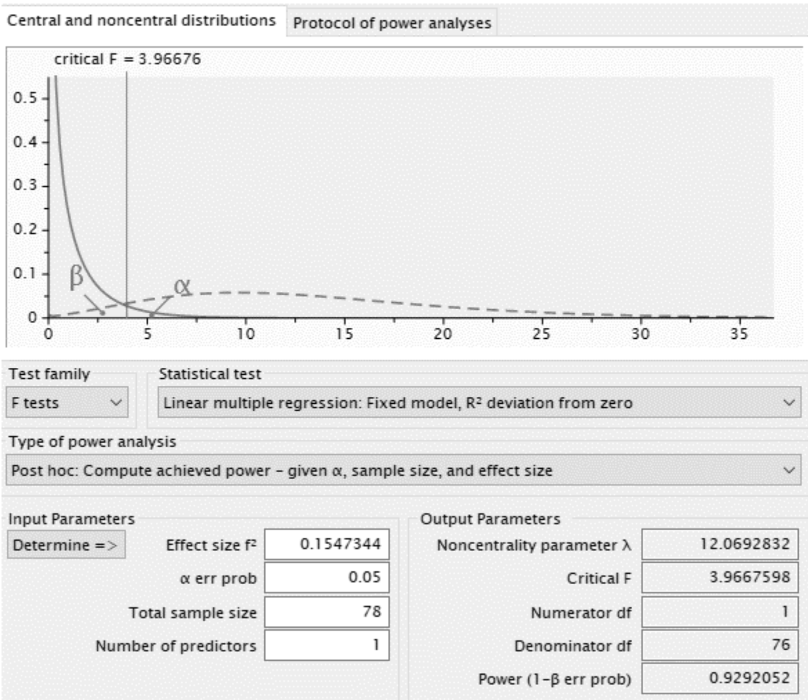

Figure 58 Statistical power test of critical endogenous construct VCAP (Model D)

These analyses conclude the evaluation of Model D. The results of the four PLS-SEM analyses are interpreted and discussed in the following subsection.

5.3.6. PLS-SEM results and discussion of findings

This subsection discusses and interprets the results obtained from the four PLS-SEM analyses of the roles of antecedents and the performance implications of business model innovation. The eleven hypotheses analysed (Table 91) are discussed below and include eight supported hypotheses, two partially supported hypotheses (H5 and H7), and one hypothesis (H3) with an unexpected result.

Table 91 Research hypotheses and results

PLS model	Hypothesis	Result
Model A	H1: Sensing capabilities positively influence business model innovation in SMEs.	Supported
Model A	H2: Experimentation capabilities positively influence business model innovation in SMEs.	Supported
Model A	H3: Collaboration capabilities positively influence business model innovation in SMEs.	Not supported
Model A	H4: Strategizing capabilities positively influence business model innovation in SMEs.	Supported
Model B	H5: Innovation culture positively influences business model innovation in SMEs.	Partially supported
Model B	H6: Business model innovation capabilities mediate the relationship between innovation culture and business model innovation in SMEs.	Supported
Model C	H7: Managerial orientation positively influences business model innovation in SMEs.	Partially supported
Model C	H8: Business model innovation capabilities mediate the relationship between managerial orientation and business model innovation in SMEs.	Supported
Models A, B, C	H9: Business model innovation positively influences firm performance in SMEs.	Supported
Models A, B, C	H10: Business model advantage mediates the relationship between business model innovation and firm performance in SMEs.	Supported
Model D	H11: Business model innovation tools positively influence business model innovation in SMEs.	Supported

The discussion is developed in three blocks. First, the influence of business model innovation capabilities, innovation culture and managerial orientation on business model innovation is addressed. Next, the competitive implications of business model innovation are covered. Finally, the effect of business model innovation tools on business model innovation is discussed.

The effect of business model innovation capabilities, innovation culture and managerial orientation on business model innovation

Overall, the results are significant in terms of the effect of business model innovation capabilities on business model innovation in SMEs. These findings are in agreement with those from prior studies on the relevance of a firm's dynamic capabilities in continuously adapting the business model to environmental challenges to stay competitive (Achtenhagen et al., 2013; Cavalcante, 2014; Čirjevskis, 2019; Foss y Saebi, 2017; Halecker et al., 2014; Hock-Doepgen et al., 2020; Hock et al., 2016; Inigo et al., 2017; Kiani et al., 2019; Mezger, 2014; Ricciardi et al., 2016; Teece, 2017; Vicente et al., 2018; Voelpel et al., 2004). On the one hand, sensing capabilities, experimentation capabilities and strategizing capabilities showed a positive and statistically significant effect on business model innovation, findings which support hypotheses H1, H2 and H4. Among these, experimentation capabilities had the greatest impact on business model innovation, followed by strategizing capabilities and then sensing capabilities. On the other hand, collaboration capabilities had a negative and non-significant effect on business model innovation, an effect that was not expected, and thus hypothesis H3 was not supported.

Regarding experimentation capabilities, this study suggests that SMEs with the ability to explore, ideate, probe and test new or alternative business logics are more likely to innovate their existing business model. These results further support the idea that experimenting and exploring new landscapes are relevant in facing uncertainty and adapting an existing business model to fast-changing environments to stay competitive. Thus, the results provide empirical evidence for the belief that experimentation-based approaches such as effectuation, discovery-driven or trial-and-error learning are key for successful business model innovation (Cavalcante, 2014; Chesbrough, 2010; McGrath, 2010; Sosna et al., 2010). They are also consistent with qualitative findings from prior research (Achtenhagen et al., 2013; Heikkilä, Bouwman y Heikkilä, 2018) and with results from quantitative research that found a positive relationship between experimentation and business model innovation in SMEs (Bouwman et al., 2019; Lopez-Nicolas et al., 2020; Torkkeli et al., 2015).

As for strategizing capabilities, the PLS results suggest that the ability to design an innovation strategy and establish a plan to implement it might facilitate business model innovation in SMEs. In accordance with these results, previous studies have shown that SMEs' strategic goals influence business model innovation (Heikkilä, Bouwman y Heikkilä, 2018) and that causation processes, which encompass designing and planning business strategies, foster business model innovation (Torkkeli et al., 2015). These results are also in line with prior research that highlights the relevance of having a formal and structured strategy for business model innovation (Lindgren, 2012). Thus, it seems that although it is usually believed that SMEs are more likely to innovate based on intuition than on a structured strategy, formal processes of strategy formulation and execution that define business model innovation in large companies might also be applied in SMEs (Chesbrough, 2010; Cortimiglia et al., 2016; Heikkilä, Bouwman y Heikkilä, 2018; Teece, 2010).

With respect to sensing capabilities, PLS results confirm findings from previous qualitative studies that show the relevance of sensing customer needs and technological options for business model innovation (Achtenhagen et al., 2013; Čirjevskis, 2019; Inigo et al., 2017; Mezger, 2014; Ricciardi et al., 2016; Vicente et al., 2018). The finding of a positive effect of sensing capabilities on business model innovation is in line with prior research that found that sensing shifts in environmental trends (Clauss et al., 2019; Hock et al., 2016) and capabilities and skills developed by a company to proactively search and detect opportunities (Guo et al., 2017) have a significant and positive effect on business model innovation.

Regarding the impact of collaboration capabilities, in contrast to earlier findings (Hock-Doepgen et al., 2020; Liao et al., 2019; Ricciardi et al., 2016; Van de Vrande et al., 2009; Yun y Jung, 2015), this study found no evidence that SMEs' ability to exchange knowledge with external partners influences business model innovation. A possible explanation to this result might be the nature of SMEs. For instance, prior research suggested that the limitations of SMEs in terms of their internal resources might affect their ability to conduct R&D activities and to establish cooperative relationships with external agents such as universities or technology centres (Kaufmann y Tödtling, 2002; Olazaran et al., 2009). In line with this, early studies found that the smaller the size of an SME, the less collaboration it engaged in (Teirlinck et al., 2010; Van de Vrande et al., 2009). Since 83% of the SMEs in the present study sample are micro or small firms (section 5.2), this could be one of the reasons for the lack of collaboration. Other research has suggested that the innovation process in SMEs is mainly based on internal knowledge (Freel, 2000; Freel y Harrison, 2006; Kaufmann y Tödtling, 2000) and that collaboration in SMEs is more relevant in the commercialisation stage than it is in early stages of innovation (Hossain, 2015; Van de Vrande et al., 2009; Van Hemert et al., 2013). Therefore, collaboration capabilities might be influencing not business model innovation but the commercialisation of new products and services. In line with this, a recent survey by Orkestra indicates that Basque SMEs, and particularly manufacturing firms, do not usually collaborate with external agents when facing digital transformation and growth (Rego et al., 2019). Therefore, Basque SMEs might not be collaborating in business model innovation either. Nonetheless, the current findings on collaboration capabilities may be somewhat limited by the operationalisation of the construct, which may not be capturing the complexity of collaboration capability, and therefore, further research should be done to provide more reliable findings.

The PLS analyses have also explored the roles of innovation culture and managerial orientation with regard to business model innovation capabilities and business model innovation. The results indicate that the direct effect of innovation culture on business model innovation is positive but non-significant. Furthermore, this relationship was fully mediated by business model innovation capabilities. These findings suggest that innovation culture alone may not be sufficient to promote business model innovation in SMEs but may influence the business model innovation capabilities required to reconfigure the business model. Therefore, the hypothesis relating innovation culture with business model innovation was only partially supported (H5), whereas the hypothesis about the mediating role of business model innovation capabilities was supported (H6).

These findings are in line with earlier studies that showed how a firm's underlying culture has an influence on business model innovation capabilities, which in turn, drive an SME's propensity for business model innovation (Hock et al., 2016). Prior research also suggested that creative culture positively affects strategic flexibility during business model innovation (Bock et al., 2012). Organisational culture can increase a company's ability to detect and exploit market opportunities, positively affecting business model innovation (Bashir y Verma, 2019; Doz y Kosonen, 2010). In this sense, innovation culture might create the right climate for the deployment of dynamic capabilities required for business model innovation. This thought is consistent with dynamic capabilities theory, which suggests that a firm's dynamic capabilities are rooted in the organisational culture (Hock et al., 2016; Schoemaker et al., 2018; Teece, 2007; Vicente et al., 2018). Furthermore, empirical research has shown that organisational culture drives the dynamic capabilities of a firm (Anand et al., 2009; Fainshmidt y Frazier, 2017; Matzler, Abfalter, et al., 2013).

Managerial orientation did not have a significant effect on business model innovation, and business model innovation capabilities fully mediated this relationship. In this sense, the results suggest that managerial orientation is also completely transmitted to business model innovation through business model innovation capabilities. Thereby, the hypothesis relating managerial orientation with business model innovation was partially supported (H7), whereas the hypothesis about the mediating role of business model innovation capabilities was supported (H8).

A possible explanation for these results is that managerial decisions influence the kind of abilities the firm develops to address business model innovation, which is in line with the behavioural approach of dynamic capabilities theory (Helfat y Martin, 2015; Schilke et al., 2018; Teece et al., 1997; Zahra et al., 2006). These findings agree with prior research that demonstrated that managerial decisions about resource allocation and risk-taking attitudes foster firms' sensing and seizing capabilities related to business model innovation (Guo et al., 2013). The findings also support prior research indicating a positive relationship between managerial orientation and dynamic capabilities (Jiang y Mavondo, 2009).

However, the results on the mediating roles of innovation culture and managerial orientation should be taken with some caution. When analysing the mediation effects, we ensured that the sample size was sufficiently large for a statistical power of 80% in most of the PLS-SEM models. Nonetheless, the PLS model analysing the mediating role of business model innovation capabilities between managerial orientation and business model innovation achieved a statistical power of only 0.73 for the structural model in stage one (Figure 55). According to Rucker et al. (2011) "the smaller the sample, the more likely mediation (when present) is to be labelled full as opposed to partial because […] direct effect is more easily rendered non-significant" (p. 364). Therefore, these effects should be further explored with a larger sample of data.

In summary, our research emphasises the role of business model innovation capabilities as an extension of the dynamic capabilities of the firm that are key to fostering business model innovation in SMEs. The results also stress the relevance of building an innovation culture and adopting a management orientation that encourages a long-term vision, risk taking and investment in innovation, since these factors may promote development of the capabilities needed to innovate the business model. In addition, our results reinforce the roles sensing, strategizing and experimentation capabilities play as key intermediaries between SMEs' management, culture and business model innovation.

The competitive implications of business model innovation

With respect to the competitive implications of business model innovation, these results indicate that business model innovation has a positive and significant effect on firm performance. Additionally, business model advantage was found to exercise complementary partial mediation (Baron y Kenny, 1986) between business model innovation and firm performance. These results indicate that a portion of the effect of business model innovation on firm performance is mediated through business model advantage (Nitzl et al., 2016). Therefore, hypotheses H9 and H10 were both supported (Table 91). These findings also support the previously assumed importance of business model innovation for competitive advantage and superior firm performance (Foss y Saebi, 2018; Roaldsen, 2014; Teece, 2010; Zott et al., 2011).

The findings highlight the role of business model advantage, as part of firm performance seems to be explained by the business model advantage achieved through business model innovation. Thus, apparently SMEs that first create a distinctive advantage could appropriate value from business model innovation (Mahadevan, 2004; McGrath et al., 1996; Wirtz y Daiser, 2017). A possible explanation for this is that while business model innovation can trigger the process of value creation, SMEs would appropriate value depending on their ability to sustain over time the distinct advantage the business model achieves through innovation (Mahadevan, 2004). Thus, these findings empirically reinforce the thought that when it is valuable, rare and difficult to imitate, the business model may itself become a competitive advantage, leading to superior performance (Casadesus-Masanell y Joan E Ricart, 2010; Chesbrough, 2010; Teece, 2010). It is encouraging to compare these results with those provided by Anwar (2018), who found that the competitive advantage of SMEs partially mediates the relationship between business model innovation and firm performance.

The findings of a positive effect of business model innovation on SME performance are in line with prior research showing a positive and significant relationship between the two (Bouwman et al., 2019; Cucculelli y Bettinelli, 2015; Guo et al., 2017; Huang et al., 2013; Pucihar et al., 2019).

It should be noted that firm performance was mainly assessed through perceived market performance, which includes market share growth, customer satisfaction, customer loyalty, attraction of new customers, and new value delivery to customers (Homburg y Pflesser, 2000), since items measuring return growth, profit growth and sales growth were excluded during the validation of the measurement model. Nevertheless, the results are in accord with previous studies that also observed inconsistencies regarding financial and market performance measures when evaluating the performance implications of business model innovation. For instance, Pedersen et al. (2018) found that business model innovation had a positive but non-significant effect on increases in sales, earnings and market share. Asemokha et al.

(2019), in turn, found that business model innovation positively and significantly impacted firm image building, competence, and capability development, while the relationship between business model innovation and both profitability and return on investment were non-significant in the international performance of SMEs.

A possible explanation for this evidence is that business model innovation requires a large and risky investment in resource and capabilities. Thus, although business model innovation may lead to new value for the market, thereby improving market performance, it might also involve costs that result in lower financial performance (Aspara et al., 2010; Cucculelli y Bettinelli, 2015; Pedersen et al., 2018). Moreover, business model innovation can take years, making it difficult to measure its impact on the financial performance at any given point in time. In this sense, Foss and Saebi (2017) state that business model innovation interacts with firm performance through multiple and complex links that manifest differently over time and may even be intertwined, making it difficult to study their relationship in the given state of development of the field.

Two interpretations can be derived from the results regarding the competitive implications of business model innovation. First, business model innovation might allow a more efficient reconfiguration of the value chain, expansion into new customer segments, or creation of new revenue streams. Thus, regardless of whether the resulting business model is differentiated from that of competitors, it will have a positive impact on firm performance. Second, if business model innovation creates a strategic differentiation, the business model advantage will lead to superior firm performance. Overall, these results suggest that although business model innovation can be a challenging task, it can also provide SMEs with a new source of competitive advantage that may help them to differentiate themselves from competitors and improve their firm performance. Thus, business model innovation could be viewed as a key driver for SME competitiveness in today's fast-changing environment.

The effect of business model innovation tools on business model innovation

The last analysis performed using PLS-SEM explored the effect of the use of business model innovation tools on the three dimensions of business model innovation. The results confirmed that all relationships were positive and significant, supporting hypothesis H11. Thus, SMEs that make greater use of business model innovation tools are more likely to innovate their value delivery, value creation and value capture dimensions. In addition, these results indicate that the use of business model innovation tools mostly strongly affects value creation, followed by value delivery and finally value capture.

Bearing in mind these results, it seems that the use of tools may help SMEs to reflect on which key activities need to be modified, how to reconfigure the value chain, and how to identify and integrate new stakeholders, positively influencing innovation in value creation (Bocken S.; Rana, P.; Evans, S. et al., 2013; França et al., 2016; Geissdoerfer et al., 2016; Osterwalder y Pigneur, 2010).

Regarding the value delivery dimension, business model innovation tools might support SMEs in identifying customers' unmet needs, developing new value propositions, identifying new customer segments and ideating new ways of delivering value, leading to the innovation of value delivery (Balocco et al., 2019; Geissdoerfer et al., 2016; Iriarte et al., 2018; Osterwalder, 2014; Osterwalder y Pigneur, 2010; Pynnönen et al., 2008, 2012).

As for the third dimension, value capture, business model innovation tools facilitate examining the viability of the business model and might help SMEs explore new ways of reducing costs and identify new revenue streams, thus having a positive impact on innovation related to value capture (Batocchio et al., 2017; Bouwman et al., 2012; Breuer, 2013; De Reuver et al., 2013; Gordijn et al., 2001; Heikkilä, Bouwman, Heikkilä, Solaimani, et al., 2016; Osterwalder y Pigneur, 2010).

Business model tooling is emerging as a relevant area of business model innovation literature that is gaining acceptance, but to date has been mainly addressed based on conceptual work and case studies (Athanasopoulou y De Reuver, 2020; Bouwman et al., 2020; Schwarz y Legner, 2020). In addition, previous studies have reflected some concern about SMEs' lack of familiarity with business model innovation tools, given their importance in business model innovation (Heikkilä, Bouwman, Heikkilä, Haaker, et al., 2016; Trapp et al., 2018). Furthermore, Rumble and Mangematin (2015) found that SMEs implementing multi-sided business models did it through imitation and heuristic reasoning rather than by using visualisation, creativity and design tools. The present findings add new insights and provide empirical evidence of the relevance of applying tools for business model innovation in SMEs. In addition, these findings support prior studies in innovation management that found a positive and significant relationship between innovation management tools and techniques and both radical and incremental innovation (Albors-Garrigos et al., 2018; Igartua et al., 2014).

5.4. FsQCA analyses

This section presents the analyses conducted using fsQCA after the research hypotheses had been tested using PLS-SEM. FsQCA was applied to obtain more fine-grained results regarding how certain conditions combine to lead to business model innovation in SMEs. The fsQCA procedure is explained below, and then the two analyses are performed to explore the research propositions (subsection 4.4.3).

5.4.1. FsQCA procedure

The fsQCA procedure was developed based on five main stages (Figure 59) that encompass current recommended practices (Greckhamer et al., 2018; Schneider y Wagemann, 2012).

Figure 59 FsQCA procedure followed in this thesis

In the first stage, the configurational model is developed, which involves the selection of conditions and outcomes to explore the research proposition. Data calibration is performed in the second stage. In the third stage, necessary conditions are analysed, followed by the analysis of sufficient conditions. Sufficient conditions can be analysed using either standard analysis or enhanced standard analysis. Finally, the results are interpreted and discussed. The following paragraphs discuss considerations related to these stages and the associated evaluation criteria.

Build the configurational model

The first step develops the configurational model to respond to the research propositions the author has established. For this, the conditions and outcomes of interest must be specified. Authors (Greckhamer et al., 2018; Marx y Dusa, 2011; Rihoux y Ragin, 2008) recommend defining no more than seven conditions to be included in the fsQCA. For fsQCAs with small or medium sample sizes, a limited number of conditions (4–7) reduces the number of possible configurations, providing better results.

Data calibration

The second step is the data calibration process, in which the raw data collected through the questionnaire is calibrated with fuzzy-set membership scores. Dușa (2019) defines five ways to calibrate fuzzy sets: (1) direct assignment, (2) direct method for “s-shaped” functions, (3) direct method for “bell-shaped” functions, (4) the indirect method and (5) the totally fuzzy and relative (TFR) method. When calibrating ordinal variables such as Likert scales, the most widely used method is direct assignment (C. Ragin, 2008, pp. 104–105). This method involves specifying three anchors, one for full membership (value = 0.95), one for the crossover point (value = 0.50) and one for full non-membership (value = 0.05), based on the percentiles (i.e. 75th, 50th and 25th) of the sample data (Salam et al., 2017).

However, this method has been criticized by some fsQCA methodologists (Dușa, 2019; Schneider y Wagemann, 2012). Likert scales are constructed from a negative end (strongly disagree) to a positive end (strongly agree), thus acquiring a bipolar nature. However, fuzzy sets are unipolar, since they are assigned according to the degree of membership of a case to a condition or outcome. According to Dușa, (2019), mechanically transforming a bipolar scale into fuzzy sets can be conceptually problematic.

To overcome this issue, a novel method that adapts the TFR method developed by Cheli and Lemmi (1995) has been recently suggested for dealing with the calibration of Likert scales (Dușa, 2019; Habib et al., 2020). This method uses an empirical cumulative distribution function on the observed data. The resulting fuzzy scores are not mechanically equally spaced between 0 and 1; instead their distribution depends on the particular distribution of the data, ensuring adequate fuzzy-set values even for highly skewed data from ordinal scales (Dușa, 2019). In this thesis, the TFR method is applied to calibrate the data for the two models examined in this research.

Analysis of necessary conditions

After the study variables have been transformed into fuzzy-set scores, the third step analyses necessary conditions. Necessary conditions are those that may not be sufficient to cause the outcome on their own but are important enough to be an essential part of the causal combination (Schneider y Wagemann, 2012). Thus, whatever the causal path is, if the outcome is present, the necessary conditions will also be present. That is, the result cannot occur in the absence of the conditions (Greckhamer y Gur, 2019).

Note that unlike correlation, sets are asymmetric, and therefore, just because a condition is necessary for an outcome does not automatically mean that its absence is necessary for the absence of the outcome. Most often it is another condition which is necessary for the absence of the outcome (Dușa, 2019). For this reason, a necessity analysis usually checks for both the presence and the absence of each condition (Greckhamer y Gur, 2019).

For a necessity analysis, consistency and coverage thresholds must first be established (Rihoux y Ragin, 2008). Consistency measures how closely a perfect subset relation (between a configuration and an outcome) is approximated (Rihoux y Ragin, 2008). In necessity analysis, the higher the consistency score, the higher the potential of a condition to be empirically relevant for the outcome. Therefore, a consistency benchmark of 0.9 or higher is recommended (Schneider y Wagemann, 2012).

Coverage indicates the empirical relevance of a condition or configuration of conditions (Schneider y Wagemann, 2012). For a condition or set of conditions to be necessary, coverage values of at least 0.60 should be achieved (Dușa, 2019). In addition, Schneider and Wagemann (2012) suggest another parameter of fit, called relevance of necessity (RoN), which measures the relevance of the solution provided by fsQCA. Dușa (2019) recommends RoN values above 0.6.

Analysis of sufficient conditions

After the necessary conditions have been analysed, the fourth step is to conduct the analysis of sufficiency. Sufficiency indicates a condition is sufficient for an outcome, since the outcome always occurs when the condition is present; in other words, the condition is never present in the absence of the outcome. Thus, sufficient conditions are those that guarantee the outcome will occur, but the outcome could also result from other conditions (Rihoux y Ragin, 2008). For that reason, the analysis of sufficiency is the main objective of the QCA, since it provides the minimal configurations of conditions that are sufficient for the outcome of interest (Dușa, 2019).

In a sufficiency analysis, all the possible configurations among conditions that lead to the outcome are first displayed in a data matrix, termed a truth table. Each case of the study sample is related to one row of the truth table according to its membership in the conditions sets (Ragin, 2008; Schneider y Wagemann, 2012). Thus, the truth table has 2^k rows (k represents the number of causal conditions being studied and the number 2 describes the two possible states, presence or absence, in which the condition may occur). Next, Boolean algebra is applied to logically minimize the truth table and identify the configurations that are consistently linked to the outcome by sufficient relations (Greckhamer y Gur, 2019; Rihoux y Ragin, 2008).

For this purpose, the truth table is first refined by establishing consistency, coverage and proportional reduction in inconsistency (PRI) benchmarks. The application of thresholds provides a new truth table, this time showing the configurations included in the outcome set, and those that are not included (configurations below the established benchmarks). As in the case of necessary conditions, the consistency scores in a sufficiency analysis indicate the degree to which empirical configurations are linked to the outcome, while coverage scores assess the empirical relevance of each configuration (Greckhamer et al., 2018). The PRI indicates inconsistencies by identifying configurations that are simultaneously included in both the outcome and its absence (Greckhamer et al., 2018).

For sufficiency analysis, the minimum consistency benchmark needs to be equal to or greater than 0.8. If all the consistency scores in the raw truth table are above this value, then the consistency threshold is established by following natural breaks in the data (Ragin, 2008). For the frequency threshold, or coverage, the threshold for medium-sized samples (e.g. 10–50 cases) is usually established as 1, although it can be higher for larger samples in order to focus only on relevant cases (Russo y

Confente, 2019). PRI scores should be above 0.5; values below this indicate significant inconsistency (Greckhamer et al., 2018).

Once truth table is refined, the next step is to conduct the logical or Boolean minimization process to find the minimal configurations that are sufficient for the outcome to occur. The logical minimization of the truth table is performed by applying the Quine–McCluskey algorithm (McCluskey, 1956; Quine, 1952). Through an iterative process, the algorithm logically minimizes the conjunctions that are sufficient for the outcome and similar to each other producing prime implicants, meaning the final minimal expressions. The algorithm then excludes logically redundant prime implicants: that is, those that can be omitted without leaving any row of the truth table with a sufficient configuration uncovered (Schneider y Wagemann, 2012).

Since QCA addresses limited diversity by examining configurations that do not exist in the empirical data (unobserved configuration), the analysis of counterfactuals is performed when conducting the sufficiency analysis (Misangyi et al., 2016). Counterfactuals are causal configurations that have no empirical evidence because of limited diversity in social phenomena. They are unobserved configurations which, if observed, could contribute to the minimization process to reduce the complexity of the solution (Dușa, 2019). Thus, in the logical minimization process, fsQCA allows the definition of simplifying assumptions about counterfactuals or logical remainders[17] that are meant to assess how different assumptions impact the configurations that are consistently sufficient for the outcome (Greckhamer et al., 2018). The researcher can exclude these counterfactuals, which results in a conservative solution based only on empirical observations, or can incorporate counterfactuals as simplifying assumptions, which results in a parsimonious (all counterfactual included) or intermediate (some counterfactuals included) solution (Fiss, 2011; Schneider y Wagemann, 2012).

Two main analyses can be differentiated based on how the counterfactuals are treated (i.e. included, filtered or excluded): the standard analysis suggested by Ragin and Sonnett (2005) and further developed by C. Ragin (2008), and the enhanced standard analysis proposed by Schneider and Wagemann (2013) as an extension of the standard analysis.

Standard analysis procedure

The assumption underlying the standard analysis is that not all the remainders can be used as counterfactuals (Dușa, 2019). Any remainder has the potential to make a solution simpler, but some remainders will support well-established theoretical

[17] The terms *logical remainders* and *counterfactuals* are synonyms and are used interchangeably in this thesis.

assumptions (easy counterfactuals), whereas others may contradict our knowledge about the phenomenon under study (difficult counterfactuals).

When a phenomenon is studied, research is usually guided by expectations of how causal conditions will contribute to the outcome's occurrence. These expectations are based on insights provided by established theory and are called *directional expectations*. In this vein, a remainder that contradicts the directional expectations should be filtered from the logical minimization process (Ragin, 2008). Standard analysis is a procedure built around this idea. It produces three types of solutions: conservative, intermediate and parsimonious.

In the conservative solution, all remainders are excluded, providing a solution supported only by empirical evidence. This solution is the most complex one. The parsimonious solution, by contrast, includes all the remainders in the minimization process, both easy and difficult counterfactuals, providing the simplest solution. In the intermediate solution, the researcher, based on directional expectations, selects the remainders to be included in the minimization process. Simplifying assumptions based on easy counterfactuals, the ones aligned with current knowledge, are thus included, and the difficult counterfactuals are filtered from the final solution.

Based on the standard analysis, Fiss (2011) proposed "configuration charts" which display the model achieved and the resultant configurations from the intermediate and parsimonious solutions. The chart displays the core conditions, which are part of both parsimonious and intermediate solutions, and peripheral conditions (or complementary conditions), which are only part of the intermediate solution. Core conditions are those which evidence indicates have a strong relationship with the outcome, whereas peripheral conditions are those which evidence shows have a weaker link with the outcome (Fiss, 2011). Consequently, in a configuration, core conditions are commonly surrounded by peripheral conditions which highlight their main features (Leischnig y Geigenmüller, 2018). These charts are extensively used to report fsQCA results. They are explained in more detail in the analysis of the models in the present research (subsection 5.4.2).

Together with the charts, the overall consistency and coverage scores of the model are also provided. The former indicates the combined consistency of all paths included in a model, whereas the latter measures the combined coverage of all consistent configurations (Greckhamer y Gur, 2019). The recommended benchmarks for informative models are a consistency above 0.75 and a coverage above 0.25 (Woodside, 2013).

Enhanced standard analysis procedure

As described above, in the standard analysis, some remainders are included in the minimization process as simplifying assumptions differentiated as easy or difficult counterfactuals to provide a parsimonious or intermediate solution. Untenable assumptions, however, are not treated. In response, Schneider and Wagemann

(2013) extended the standard analysis by providing a procedure to deal with untenable assumptions, producing *enhanced* parsimonious and intermediate solutions.

Untenable assumptions are those assumptions about logical remainders that are implausible or incoherent. Dușa (2019) suggested excluding three types of untenable assumptions when performing the enhanced standard analysis: (1) contradictory simplifying assumptions, (2) simultaneous subset relations and (3) incoherent counterfactuals among necessary and sufficient conditions.

Contradictory simplifying assumptions use the same remainders as prime implicants for both the presence and the absence of the outcome. Simultaneous subset relations are conditions or configurations of conditions that are sufficient for both the outcome and its absence. Lastly, when a condition is necessary for an outcome, its negation cannot be at the same time sufficient to produce the same outcome (Dușa, 2019). Therefore, when necessary conditions arise during the analysis of necessity, assumptions incoherent with these conditions should be avoided in the analysis of sufficiency (Schneider y Wagemann, 2012). The rest of the process follows the same procedure as the standard analysis.

This thesis performed the enhanced standard analysis to remove untenable assumptions from the minimization process, with the aim of providing parsimonious and intermediate solutions that were more theoretically and logically coherent (Habib et al., 2020). The fsQCA analyses are performed and interpreted below.

5.4.2. FsQCA analysis

After explaining the fsQCA procedure, this subsection develops the two fsQCAs conducted in this research. In line with the research objectives and to complement the results of the PLS-SEM analyses, the first analysis (FsQCA A) explores how managerial orientation, innovation culture, strategizing capabilities, sensing capabilities and experimentation capabilities are combined to achieve business model innovation in SMEs. The second analysis (FsQCA B) examines the configurations of business model innovation tools that lead to business model innovation.

FsQCA was conducted with RStudio software and the R package “QCA”, version 3.6 (Dușa, 2019). The code can be found in Appendix D.

FsQCA A: Analysis of driver configurations leading to business model innovation

The first fsQCA explores how MO (managerial orientation), IC (innovation culture), STRC (strategizing capabilities), SENC (sensing capabilities) and EC (experimentation capabilities) are combined to achieve BMI (business model innovation) in SMEs. To transform the 5-point Likert scales into fuzzy set membership scores, the TFR method was applied (Duşa, 2019). After calibrating all the items, the average fuzzy score of each variable was calculated across its items (Habib et al., 2020).

The next step after data calibration was to identify necessary conditions among all the conditions and their negations. For a condition to be considered necessary, the consistency benchmark (incl) should be 0.9, the relevance of necessity (RoN) should be 0.6 and the coverage benchmark (Cov) should be 0.6. The results of the necessity analysis displayed in Table 92 indicate one condition, SENC, as necessary for BMI to occur (incl = 0.913), while the remaining conditions were below the benchmarks. Note that capital letters indicate the presence of the condition while lowercase letters indicate its absence.

Table 92 Analysis of necessity of fsQCA A

	Conditions	incl	RoN	cov
1	mo	0.509	0.911	0.842
2	MO	0.819	0.788	0.834
3	ic	0.419	0.922	0.821
4	IC	0.873	0.715	0.811
5	strc	0.417	0.895	0.772
6	STRC	0.880	0.764	0.841
7	senc	0.368	0.932	0.816
8	SENC	0.913	0.670	0.804
9	ec	0.455	0.911	0.819
10	EC	0.885	0.792	0.858

Note: Capital letters indicate the presence of the condition, while lowercase letters indicate its absence. MO: managerial orientation, IC: innovation culture, STRC: strategizing capabilities, SENC: sensing capabilities, EC: experimentation capabilities, incl: consistency score, RoN: relevance of necessity, Cov: coverage scores

After necessary conditions were identified, the truth table was built and sufficiency analysis was performed using logical minimization. Since the configurational analysis involved five conditions (MO, IC, STRC, SENC and EC), the raw truth table contained 32 rows. To refine the raw truth table, the consistency, PRI and coverage benchmarks were established.

The refined truth table is presented in Table 93. Since the lowest consistency score (row 1, inclS = 0.870) was above the minimum benchmark of 0.8, the consistency threshold was established at 0.93 by following natural breaks in the data (Ragin, 2008). The PRI consistency benchmark was defined as 0.5. Based on the recommendations for medium-sized samples, the minimum frequency threshold was established as two to avoid including configurations supported by a single observation (Greckhamer et al., 2018; To et al., 2019). The refined truth table (Table

93) retained 87.2% of the cases for analysis, which was above the recommended level of 80% (Greckhamer et al., 2018; Ragin y Fiss, 2008).

The refined truth table (Table 93) was first sorted by the outcome value (OUT), and then by consistency scores (incl), which are presented in descending order. N indicates the number of cases associated with each configuration. From the 32 logically possible configurations of sufficient conditions, 10 rows containing 60 cases were positively linked with the outcome (OUT=1). Two configurations encompassing eight cases leading to the negation of the outcome (OUT=0). Finally, 20 rows containing ten configurations with one case each, and ten configurations without empirical support, were classified as logical reminders (OUT=?).

Table 93 Truth Table of FsQCA A

Row	MO	IC	STRC	SENC	EC	OUT	n	incl	PRI
16	0	1	1	1	1	1	6	0.982	0.938
24	1	0	1	1	1	1	2	0.978	0.902
32	1	1	1	1	1	1	30	0.972	0.937
12	0	1	0	1	1	1	4	0.970	0.765
8	0	0	1	1	1	1	2	0.968	0.844
18	1	0	0	0	1	1	2	0.957	0.538
28	1	1	0	1	1	1	5	0.957	0.742
31	1	1	1	1	0	1	3	0.950	0.756
25	1	1	0	0	0	1	4	0.940	0.497
27	1	1	0	1	0	1	2	0.936	0.450
11	0	1	0	1	0	0	4	0.911	0.342
1	0	0	0	0	0	0	4	0.870	0.188
30	1	1	1	0	1	?	1	0.982	0.875
22	1	0	1	0	1	?	1	0.971	0.779
15	0	1	1	1	0	?	1	0.968	0.793
10	0	1	0	0	1	?	1	0.963	0.458
20	1	0	0	1	1	?	1	0.962	0.586
29	1	1	1	0	0	?	1	0.958	0.631
7	0	0	1	1	0	?	1	0.953	0.761
2	0	0	0	0	1	?	1	0.942	0.313
4	0	0	0	1	1	?	1	0.936	0.389
3	0	0	0	1	0	?	1	0.888	0.181
5	0	0	1	0	0	?	0	-	-
6	0	0	1	0	1	?	0	-	-
9	0	1	0	0	0	?	0	-	-
13	0	1	1	0	0	?	0	-	-
14	0	1	1	0	1	?	0	-	-
17	1	0	0	0	0	?	0	-	-
19	1	0	0	1	0	?	0	-	-
21	1	0	1	0	0	?	0	-	-
23	1	0	1	1	0	?	0	-	-
26	1	1	0	0	1	?	0	-	-

Note: MO: managerial orientation, IC: innovation culture, STRC: strategizing capabilities, SENC: sensing capabilities, EC: experimentation capabilities, OUT: output value, n: number of cases in configuration, incl: consistency score, PRI: proportional reduction in inconsistency

Following the guidelines for enhanced standard analysis, contradictory simplifying assumptions and simultaneous subset relations were excluded from the logical reminders to be used in the minimization process (Dușa, 2019). Incoherent counterfactuals were avoided, excluding the negation of the necessary condition sensing capabilities (senc).

In addition, to calculate the enhanced intermediate solution, the directional expectations of the conditions were specified. Based on the research hypotheses and the PLS-SEM results, it was assumed that the presence of all causal conditions (managerial orientation, innovation culture, strategizing capabilities, sensing capabilities and experimentation capabilities) lead to business model innovation in SMEs.

The configuration chart was created following the guidelines provided by Fiss (2011) and combining the enhanced parsimonious and intermediate solutions. In Table 94, the three configurations that were consistently linked to business model innovation in the SMEs under study are presented.

Black circles indicate the presence of a condition. Large circles indicate that conditions are part of both parsimonious and intermediate solutions (core conditions), while small circles indicate conditions are just part of the intermediate solution (peripheral conditions). Blank spaces indicate that a condition is not relevant for the configuration.

Regarding core conditions, two combinations of relevant conditions can be seen: (1) the conjunction of IC (innovation culture), SENC (sensing capabilities) and EC (experimentation capabilities), which is both the intermediate and parsimonious solution in the first path, and (2) the combination of STRC (strategizing capabilities) and SENC (sensing capabilities), which are complemented by EC (experimentation capabilities) in the second path and by MO (managerial orientation) and IC (innovation culture) in the third path (Table 94).

Table 94 Drivers configurations that lead to business model innovation

Configuration	1	2	3
Managerial orientation (MO)			•
Innovation culture (IC)	●		•
Strategizing capabilities (STRC)		●	●
Sensing capabilities (SENC)	●	●	●
Experimentation capabilities (EC)	●	•	
Consistency	0.947	0.948	0.938
Proportional reduction in inconsistency (PRI)	0.895	0.898	0.868
Raw coverage	0.781	0.765	0.685
Unique coverage	0.063	0.047	0.030
Overall solution consistency	0.908		
Overall solution PRI	0.830		
Overall solution coverage	0.858		

The solution above also reports the consistency, proportional reduction in inconsistency (PRI) and coverage scores for each path and the overall solution. Overall solution consistency was 0.908, and overall solution coverage was 0.85, exceeding the recommended thresholds of 0.75 for consistency and 0.25 for coverage. These results suggest the adequacy of the explanatory model for BMI (Greckhamer et al., 2018).

Consistency scores of the three configurations ranged from 0.938 to 0.948, indicating that all the configurations were sufficient for BMI. Regarding the coverage of the configurations, two indexes are provided. Raw coverage refers to the number of outcomes explained only by a solution, while unique coverage indicates the number of outcomes that are unique to a path (Ragin, 2008). The raw coverage values were between 0.781 and 0.685, providing information about the relevance of the conditions. Each configuration accounted for a large proportion of the outcome (To et al., 2019).

FsQCA B: Analysis of tool configurations leading to business model innovation

The second fsQCA examined the causal configurations of BMIT (business model innovation tools) linked to BMI (business model innovation) and its dimensions: that is, VDEL (value delivery), VCRE (value creation) and VCAP (value capture). Thus, fsQCA was performed for four different outcomes. Again, items measured through 5-point Likert scales were calibrated into fuzzy set membership scores using the TFR method. Since the number of items encompassed in the variable BMIT exceeds the maximum number of conditions recommended when analysing small to medium-sized samples (Greckhamer et al., 2018; Marx y Dusa, 2011; Rihoux y Ragin, 2008), it was decided to reduce them to a suitable number of conditions (4–7).

The items assessing BMIT were therefore grouped based on their impact on the business model innovation process (analysis, design and test). This decision was based on the literature review, a discussion with academicians and various workshops with SMEs. Nine items were reduced to five conditions (Table 95) by averaging the fuzzy scores of each condition across its items (Habib et al., 2020).

Table 95 Definition of conditions related to business model innovation tools

<table>
<tr><th>Code</th><th>Items</th><th>BMI process</th><th>Condition</th></tr>
<tr><td>BMIT1</td><td>The prospective exploration of opportunities.
For example: technological surveillance, trend-watching, scenarios, roadmapping, etc.</td><td>Analysis</td><td rowspan="2">TOOLA1</td></tr>
<tr><td>BMIT2</td><td>Identifying improvements and help in making strategic decisions.
For example: SWOT analysis (weaknesses, threats, strengths and opportunities), Porter's five forces model, value chain analysis, stakeholder map, etc.</td><td>Analysis</td></tr>
<tr><td>BMIT3</td><td>The identification, understanding and segmentation of clients and their needs, expectations and problems.
For example: interviews, focus group, empathy map, personas, stakeholder map, etc.</td><td>Analysis and design</td><td rowspan="3">TOOLA2</td></tr>
<tr><td>BMIT4</td><td>The analysis of the value proposal and its alignment with the needs, expectations and problems of the clients.
For example: canvas of the value proposal, value map, product or service portfolio, etc.</td><td>Analysis and design</td></tr>
<tr><td>BMIT5</td><td>The systemic and integral evaluation of our current value proposition and business model.
For example: canvas of the business model, canvas of the value proposition or other similar models, business plan, simulation-based methodologies, business model patterns, etc.</td><td>Analysis and design</td></tr>
</table>

Code	Items	BMI process	Condition
BMIT6	The creative generation of new ideas of products, services, value proposition or business model. *For example: brainstorming, mental maps, lateral thinking, etc.*	Design	TOOLD
BMIT7	The design of new value propositions and business models. *For example: canvas of the business model, canvas of the value proposition or other similar models, business plan, simulation-based methodologies, business model patterns, etc.*	Design	
BMIT8	Testing and validating of hypotheses or ideas related to the value proposition or business model. *For example: benchmarking, rapid prototyping, usability tests, experimentation, simulations, minimum viable product, use of indicators, etc.*	Test	TOOLT
BMIT9	We apply agile methodologies based on iteration, learning and experimentation for the development and validation of new value propositions and business models. *For example: design thinking, lean start-up, scrum, kanban, agile, etc.*	Test	

Once conditions were defined and calibrated, analysis proceeded of necessary conditions among all the conditions and their negation for the four outcomes (BMI, VDEL, VCRE and VCAP). Consistency (incl ≥ 0.9), relevance of necessity (RoN ≥ 0.6) and coverage (Cov ≥ 0.6) benchmarks were established, and the necessity analysis was performed. As can be seen in Table 96, the analysis revealed that no single condition or its negation was necessary for BMI or any of its dimensions (VDEL, VCRE and VCAP). The highest consistency values are found for TOOLA1 and range between 0.830 and 0.858.

Table 96 Necessary conditions for VDEL, VCRE, VCAP and BMI

	Outcome: VDEL			Outcome: VCRE			Outcome: VCAP			Outcome: BMI		
Conditions	**incl**	**RoN**	**cov**	**incl**	**RoN**	**cov**	**incl**	**RoN**	**cov**	**incl**	**RoN**	**cov**
toola1	0.436	0.910	0.812	0.423	0.887	0.760	0.439	0.901	0.793	0.444	0.908	0.808
TOOLA1	0.830	0.744	0.818	0.847	0.731	0.805	0.839	0.727	0.801	0.858	0.753	0.827
toola2	0.527	0.861	0.787	0.511	0.833	0.736	0.524	0.845	0.758	0.531	0.854	0.775
TOOLA2	0.748	0.833	0.848	0.783	0.840	0.856	0.761	0.823	0.836	0.775	0.843	0.859
toold	0.497	0.870	0.784	0.484	0.846	0.736	0.492	0.854	0.752	0.501	0.864	0.773
TOOLD	0.773	0.815	0.843	0.808	0.820	0.849	0.795	0.812	0.840	0.804	0.828	0.857
toolt	0.495	0.876	0.791	0.490	0.858	0.755	0.505	0.872	0.783	0.504	0.875	0.788
TOOLT	0.780	0.810	0.842	0.800	0.802	0.833	0.778	0.784	0.814	0.800	0.813	0.845

Note: Capital letters indicate the presence of the condition while lowercase letters indicate its absence. incl: consistency score, RoN: relevance of necessity, cov: coverage score, VDEL: value delivery, VCRE: value creation, VCAP: value capture, BMI: business model innovation. For a decription of the conditions see Table 95

After necessary conditions were identified, four truth tables were created, one for each outcome, and the sufficiency analysis was performed through logical minimization. The configurational analysis involved four conditions (TOOLA1, TOOLA2, TOOLD and TOOLT), thus the four data matrices contained 16 rows. To refine the raw truth tables, the consistency threshold was established at 0.89 for the analysis of three of the outcomes (VDEL, VCRE and BMI) and at 0.88 for the analysis of VCAP, based on natural breaks in the data (Ragin, 2008). The PRI consistency benchmark was defined at 0.5, and the minimum frequency threshold was established at two (Greckhamer et al., 2018; To et al., 2019). All the truth tables retained 77 of the 78 cases, exceeding the recommended minimum number of observations (Greckhamer et al., 2018; Ragin y Fiss, 2008).

The truth table developed for the outcome VDEL is shown in Table 97. The truth table is sorted first by the outcome value (OUT), and then according to consistency scores (incl) in descending order. N indicates the number of cases associated with each configuration. From the 16 logically possible configurations of sufficient conditions for all the outcomes, 10 rows containing 64 cases were positively linked with the outcome (OUT=1) One configuration (row 1), encompassing 13 cases, led to the negation of the outcome (OUT=0), and the other six rows contained logical remainders (OUT=?).

Table 97 Truth table of VDEL (value delivery)

Row	TOOLA1	TOOLA2	TOOLD	TOOLT	OUT	n	incl	PRI
15	1	1	1	0	1	2	0.955	0.821
12	1	0	1	1	1	4	0.950	0.827
14	1	1	0	1	1	5	0.942	0.793
13	1	1	0	0	1	3	0.938	0.743
10	1	0	0	1	1	4	0.932	0.742
8	0	1	1	1	1	7	0.931	0.765
9	1	0	0	0	1	6	0.912	0.671
16	1	1	1	1	1	30	0.912	0.835
2	0	0	0	1	1	3	0.898	0.605
1	0	0	0	0	0	13	0.814	0.501
7	0	1	1	0	?	1	0.949	0.753
3	0	0	1	0	?	0	-	-
4	0	0	1	1	?	0	-	-
5	0	1	0	0	?	0	-	-
6	0	1	0	1	?	0	-	-
11	1	0	1	0	?	0	-	-

Note: OUT: outcome, n: number of cases in configuration, incl: consistency score, PRI: proportional reduction in inconsistency. For a decription of the conditions (TOOLA1, TOOLA2, TOOLD, TOOLT) see Table 95

The truth table developed for the outcome VCRE is illustrated in Table 98. The truth table is sorted first by the outcome values and then the consistency scores (in descending order). N indicates the number of cases associated with each configuration. As in the previous truth table, from the 16 logically possible configurations, 10 rows containing 64 cases were positively linked with the outcome (OUT=1). One configuration, encompassing 13 cases, led to the negation of the outcome (OUT=0), and the other six rows contained logical remainders (OUT=?).

Table 98 Truth table of VCRE (value creation)

Row	TOOLA1	TOOLA2	TOOLD	TOOLT	OUT	n	incl	PRI
15	1	1	1	0	1	2	0.961	0.850
12	1	0	1	1	1	4	0.951	0.816
14	1	1	0	1	1	5	0.944	0.782
13	1	1	0	0	1	3	0.940	0.747
8	0	1	1	1	1	7	0.940	0.812
10	1	0	0	1	1	4	0.932	0.730
16	1	1	1	1	1	30	0.927	0.864
9	1	0	0	0	1	6	0.907	0.636
2	0	0	0	1	1	3	0.895	0.567
1	0	0	0	0	0	13	0.772	0.383
7	0	1	1	0	?	1	0.941	0.737
3	0	0	1	0	?	0	-	-
4	0	0	1	1	?	0	-	-
5	0	1	0	0	?	0	-	-
6	0	1	0	1	?	0	-	-
11	1	0	1	0	?	0	-	-

Note: OUT: outcome, n: number of cases in configuration, incl: consistency score, PRI: proportional reduction in inconsistency. For a decription of the conditions (TOOLA1, TOOLA2, TOOLD, TOOLT) see Table 95

The truth table developed for the outcome VCAP is presented in Table 99. The truth table is sorted first by the outcome values and then the consistency scores (in descending order). N indicates the number of cases associated with each configuration. Similar to the above results, of the 16 logically possible configurations, 10 rows containing 64 cases were positively linked with the outcome (OUT=1). One configuration (row 1), encompassing 13 cases, led to the negation of the outcome (OUT=0), and the other six rows contained logical remainders (OUT=?).

Table 99 Truth table of VCAP (value capture)

Row	TOOLA1	TOOLA2	TOOLD	TOOLT	OUT	n	incl	PRI
12	1	0	1	1	1	4	0.965	0.866
14	1	1	0	1	1	5	0.960	0.836
15	1	1	1	0	1	2	0.956	0.840
10	1	0	0	1	1	4	0.936	0.724
8	0	1	1	1	1	7	0.924	0.752
13	1	1	0	0	1	3	0.920	0.696
16	1	1	1	1	1	30	0.905	0.821
9	1	0	0	0	1	6	0.903	0.644
2	0	0	0	1	1	3	0.889	0.519
1	0	0	0	0	0	13	0.827	0.504
7	0	1	1	0	?	1	0.961	0.830
3	0	0	1	0	?	0	-	-
4	0	0	1	1	?	0	-	-
5	0	1	0	0	?	0	-	-
6	0	1	0	1	?	0	-	-
11	1	0	1	0	?	0	-	-

Note: OUT: outcome, n: number of cases in configuration, incl: consistency score, PRI: proportional reduction in inconsistency. For a decription of the conditions (TOOLA1, TOOLA2, TOOLD, TOOLT) see Table 95

The truth table developed for the outcome BMI is displayed in Table 100. The truth table is sorted first by the outcome values and then the consistency scores (in descending order). N indicates the number of cases associated with each configuration. Again, 10 rows containing 64 cases were positively linked with the outcome (OUT=1) One configuration (row 1), encompassing 13 cases, led to the negation of the outcome (OUT=0), and the other six rows contained logical remainders (OUT=?).

Table 100 Truth table of BMI (business model innovation)

Row	TOOLA1	TOOLA2	TOOLD	TOOLT	OUT	n	incl	PRI
12	1	0	1	1	1	4	0.968	0.861
15	1	1	1	0	1	2	0.967	0.842
14	1	1	0	1	1	5	0.961	0.820
8	0	1	1	1	1	7	0.954	0.801
10	1	0	0	1	1	4	0.945	0.738
16	1	1	1	1	1	30	0.944	0.887
13	1	1	0	0	1	3	0.942	0.716
9	1	0	0	0	1	6	0.928	0.661
2	0	0	0	1	1	3	0.904	0.496
1	0	0	0	0	0	13	0.827	0.410
7	0	1	1	0	?	1	0.962	0.773
3	0	0	1	0	?	0	-	-
4	0	0	1	1	?	0	-	-
5	0	1	0	0	?	0	-	-
6	0	1	0	1	?	0	-	-
11	1	0	1	0	?	0	-	-

Note: OUT: outcome, n: number of cases in configuration, incl: consistency score, PRI: proportional reduction in inconsistency. For a decription of the conditions (TOOLA1, TOOLA2, TOOLD, TOOLT) see Table 95

In carrying out the analysis for contradictory simplifying assumptions and simultaneous subset relations, no untenable counterfactual was found in any of the solutions. Therefore, the standard analysis was conducted, defining the easy counterfactuals to be included in the minimization to obtain the intermediate solution.

Based on the research hypotheses and the PLS-SEM results, it was assumed that the presence of all the conditions would help SMEs to achieve business model innovation. Directional expectations of the conditions were specified, including the presence of the four conditions as easy counterfactuals.

The parsimonious and intermediate solutions for the four outcomes are described below. Since no more than three equifinal solutions were achieved, the results were not displayed in the form of configuration charts (Fiss, 2011; Greckhamer et al., 2018). Table 101 illustrates the sufficiency analysis of the four outcomes, which provided the same configurations for both parsimonious and intermediate solutions. Based on these results, two core conditions emerge as potential sufficient paths linked to BMI: (1) TOOLA1 (tools oriented to prospective exploration of opportunities and making strategic decisions) and (2) TOOLT (tools or methodologies for testing and validating value propositions and business model-related ideas).

Table 101 Tools configurations linked to VDEL, VCRE, VCAP and BMI

	Outcome: VDEL		Outcome: VCRE		Outcome: VCAP		Outcome: BMI	
	TOOLA1	TOOLT	TOOLA1	TOOLT	TOOLA1	TOOLT	TOOLA1	TOOLT
Consistency	0.818	0.842	0.805	0.833	0.801	0.814	0.827	0.845
PRI	0.709	0.745	0.684	0.725	0.682	0.695	0.705	0.730
Raw coverage	0.830	0.780	0.847	0.800	0.839	0.778	0.858	0.800
Unique coverage	0.118	0.067	0.115	0.068	0.116	0.055	0.114	0.057
Overall Solution consistency	0.790		0.776		0.763		0.787	
Overall Solution PRI	0.679		0.652		0.636		0.653	
Overall Solution coverage	0.897		0.915		0.894		0.915	

Notes: PRI: Proportional reduction in inconsistency, VDEL: value delivery, VCRE: value creation, VCAP: value capture, BMI: business model innovation. For a decription of the conditions TOOLA1 and TOOLT see Table 95

The overall solution consistency and coverage values are above the recommended benchmarks in all the solutions (consistency ≥ 0.75 and coverage ≥ 0.25). Consistency scores of the eight configurations range between 0.801 and 0.845, indicating that all the configurations were sufficient for BMI. Regarding the configurations' raw coverage, the solutions achieve scores between 0.778 and 0.858, accounting for a large proportion of the outcome (To et al., 2019).

5.4.3. FsQCA results and discussion

This subsection discusses and interprets the results obtained from the two configurational analyses related to the antecedents for business model innovation in SMEs (subsection 4.4.3). Both fsQCA results confirm that multiple, equally effective configurations of business model innovation antecedents exist, responding to a causation process, an effectuation process or both (Sarasvathy, 2001).

The discussion is developed in two blocks. First, the configurations of business model innovation capabilities, innovation culture and managerial orientation leading to business model innovation are covered. Then, the configurations of business model innovation tools leading to business model innovation are discussed.

Configurations of business model innovation capabilities, innovation culture and managerial orientation to achieve business model innovation in SMEs

As for the combination of innovation culture, managerial orientation and business model innovation capabilities, fsQCA results indicate that SMEs might achieve business model innovation through three different paths.

The first configuration, which obtained the highest consistency and coverage values, indicates that the combination of innovation culture, sensing capabilities and experimentation capabilities is sufficient to lead to business model innovation in SMEs. It therefore suggests that these factors lead to business model innovation regardless of whether the firm is successfully strategizing and regardless of whether the managerial orientation is long-term, risk-taking and investment-oriented.

This configuration seems to reflect the arguments of Chesbrough (2010), who suggested that business model innovation should be supported by an effectuation process. He also stated that business model innovation should be based on experimentation, which allows for capturing and interpreting new data that will facilitate the reformulation of the analysis on new business model opportunities. In line with his view, experimentation and sensing are interrelated, while organisational culture would support the effectuation process. Later studies have also support this approach. For example, Mezger (2014) indicated that the abilities to sense and seize business model opportunities are part of an iterative process of experimentation and continuous learning that fosters business model innovation.

Similarly, Cavalcante (2014) suggested that the preliminary stage of business model innovation, which is based on a process of experimentation and learning, allows the firm to develop the capabilities to reassess, renew and reconfigure the existing business model, while emphasising the relevance of the organisational culture in making the firm ready for change. Achtenhagen et al. (2013) also highlighted sensing capabilities, experimentation capabilities and organisational culture among the critical capabilities for business model innovation. Thus, the present research extends prior knowledge based on case studies on the role of business model innovation capabilities and organisational culture from a configurational approach. The results, therefore, emphasise the relevance of the combination of these factors, in addition to the positive effects they have on business model innovation on their own, which were previously shown in PLS-SEM analyses.

The second configuration with the highest consistency and coverage values suggests that strategizing and sensing capabilities are core conditions that lead to business model innovation, with experimentation capabilities as a peripheral condition. Thus, in this configuration, the managerial orientation and innovation culture are of little relevance for business model innovation if firms have deployed the required capabilities just mentioned. This path represents SMEs following a process mostly based on a causal logic, mainly using strategic planning and sensing capabilities to address business model innovation (Brenk et al., 2019; Sarasvathy, 2001; Tesch y A Brillinger, 2017).

The third configuration identified presents strategizing and sensing capabilities as core conditions for business model innovation together with managerial orientation and innovation culture. These findings are closely aligned with the results obtained by PLS-SEM, which indicate that managerial orientation and innovation culture do not directly influence business model innovation but do foster the development of business model innovation capabilities in the firm. Furthermore, whether the firm is experimenting has little importance for business model innovation in this configuration. This path reflects a pure causation process, where strategizing and sensing business opportunities are key capabilities for business model innovation (Torkkeli et al., 2015). Such a strong orientation towards a more planning-oriented approach might be particularly appropriate to address the uncertainty in how to reconfigure the existing business model, providing a familiar initial orientation for SMEs, as it reflects the traditional process of new product development (Futterer et al., 2018).

Additionally, sensing capabilities was found to be a necessary condition for business model innovation and therefore, it is an essential condition in each of the configurations. This findings are in line with the PLS-SEM results and confirm the the relevance of sensing customer needs and technological options for business model innovation (Achtenhagen et al., 2013; Čirjevskis, 2019; Inigo et al., 2017; Mezger, 2014; Ricciardi et al., 2016; Vicente et al., 2018).

To summarise, the present research adds new insights by showing how capabilities based on causal (sensing and strategizing) and effectual (experimentation) logics combine through different paths to lead to business model innovation. This is consistent with prior research following a quantitative approach that found that both effectuation and causation processes positively impact business model innovation and, moreover, that companies usually combine the two (Broekhuizen et al., 2018; Futterer et al., 2018; Torkkeli et al., 2015).

Configurations of business model innovation tools to achieve business model innovation in SMEs

Using fsQCA to analyse the possible configurations related to the use of tools to achieve business model innovation reveal two paths that are equally effective. These two configurations influence the three business model innovation dimensions (i.e. value delivery, value creation and value capture). Therefore, it seems that SMEs are approaching business model innovation from an integrative view, which is evidence of the need for addressing value delivery, value creation and value capture from a systemic perspective (Foss y Saebi, 2018; Teece, 2010).

Interestingly, those two paths can be clearly distinguished as causation or effectuation processes (Tesch y AS Brillinger, 2017). The first path indicates prospective and analysis techniques are sufficient for business model innovation. This configuration stresses the use of tools such as scenario planning or roadmapping and analytical techniques, such as PESTLE or SWOT, to support business model innovation process following a causal logic.

The second path suggests that agile methodologies are sufficient for business model innovation. This path highlights the use of these methodologies based on iteration, learning and experimentation (i.e. design thinking or lean start-up) and the use of tools for testing and validating new business model ideas to support the business model innovation process following an effectuation logic.

Emphasising the causation-effectuation approach, and combining these results with the three configurations identified in the first fsQCA (related to innovation culture, managerial orientation and business model innovation capabilities), we argue that these analyses complement each other. For instance, SMEs following a causation process mostly based on sensing and strategizing capabilities could support those capabilities with the use of prospective and analytic tools. On the other hand, SMEs deploying sensing and experimentation capabilities over strategizing could be following a learning-by-doing logic supported by agile methodologies that fosters creative thinking, experimentation and prototype testing.

5.5. Additional analyses: mean differences between business model innovation and business innovation

Having evaluated the hypotheses and propositions related to the first three objectives, in this section the chapter addresses the last objective of this thesis: to explore the relationships between business model innovation and business innovation. For this purpose, the mean difference among variables measuring business innovation and business model innovation were analysed through a t-test for independent samples analysis (Mooi y Sarstedt, 2019). These analyses were complemented with further statistical tests (t-test and Pearson's chi-square test) exploring the influence of business units on both business model innovation and business innovation.

5.5.1. Differences between business model innovation and business innovation

The first analysis developed focused on the mean differences concerning business model innovation, and its dimensions (value delivery, value creation and value capture) were analysed as they relate to business innovation. For this purpose, the means for business model innovation and its dimensions were calculated. The differences in their means were then analysed, taking into account whether the SMEs had also introduced another type of innovation. Types of business innovation were measured on a dichotomous scale (yes and no) based on the operationalisation described in subsection 4.5.2, which includes product innovation (INNOPROD); service innovation (INNOSERV); process innovation (INNOPROC); marketing-related innovation activities (in promotion and communication [INNOMARPC] and in sales and distribution [INNOMARSD]); organisational innovation (INNORG); and the acquisition of advanced machinery, equipment or software (INNOADQ).

The first t-test analysed mean differences in BMI (business model innovation) and its dimensions, VDEL (value delivery), VCRE (value creation) and VCAP (value capture) in terms of whether or not the firm had introduced product innovations (Table 102). As can be observed, 60.26% of SMEs had introduced product innovations in the last three years, compared to 39.74% who had not. The companies that had introduced product innovations had higher mean values in BMI, and specifically in VDEL and VCRE while mean values were lower for VCAP.

Table 102 BMI and its dimensions' means regarding product innovation

		N	Mean	Std. Deviation	Std. Error Mean
VDEL	YES	47 (60.26%)	3.5426	0.79796	0.11639
	NO	31 (39.74%)	3.3548	0.74379	0.13359
VCRE	YES	47 (60.26%)	3.1649	0.88814	0.12955
	NO	31 (39.74%)	3.1518	0.88695	0.15930
VCAP	YES	47 (60.26%)	3.0479	0.86074	0.12555
	NO	31 (39.74%)	3.0887	0.63426	0.11392
BMI	YES	47 (60.26%)	3.2518	0.69797	0.10181
	NO	31 (39.74%)	3.1984	0.66443	0.11934

Note: Std: standard, BMI: business model innovation, VDEL: value delivery, VCRE: value creation, VCAP: value capture

The statistical significances of the mean differences are indicated in Table 103. To examine this statistical significance, first the Levene's test p-values were observed. Thus, for p-values > 0.05, the significance level of the mean differences (Sig. [2-tailed]) presented in the upper row (equal variances assumed, EVA) was examined, whereas for p-values < 0.05, the Sig. (2-tailed) values of the lower row (equal variance not assumed, EVNA) were chosen (Mooi y Sarstedt, 2019). The row selected for analysing the significance level in each table is marked in bold.

Table 103 *t*-test applied to BMI and its dimensions in relation to product innovation

		Levene's test for equality of variances		**t-test for equality of means**						
		F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% confidence interval of the difference	
									Lower	Upper
VDEL	**EVA**	**.000**	**.999**	**1.044**	**76**	**.300**	**.18771**	**.17979**	**-.17036**	**.54579**
	EVNA			1.059	67.477	.293	.18771	.17718	-.16590	.54133
VCRE	**EVA**	**.361**	**.550**	**.064**	**76**	**.949**	**.01313**	**.20539**	**-.39593**	**.42219**
	EVNA			.064	64.425	.949	.01313	.20533	-.39701	.42327
VCAP	**EVA**	**2.877**	**.094**	**-.227**	**76**	**.821**	**-.04084**	**.18030**	**-.39993**	**.31826**
	EVNA			-.241	74.988	.810	-.04084	.16953	-.37856	.29688
BMI	**EVA**	**.083**	**.774**	**.337**	**76**	**.737**	**.05334**	**.15848**	**-.26230**	**.36897**
	EVNA			.340	66.565	.735	.05334	.15686	-.25980	.36647

Note: BMI: business model innovation, VDEL: value delivery, VCRE: value creation, VCAP: value capture, EVA: Equal variances assumed; EVNA: Equal variances not assumed

The results indicate that the differences in means between constructs were not statistically significant (sig. [2-tailed] > 0.05) for any of the variables (VDEL, VCRE, VCAP and BMI) with respect to product innovation. In other words, the conclusion supported is that there is no difference in business model innovation, nor in any of its three dimensions, between SMEs that have introduced product innovations and SMEs that have not.

The second t-test analysed mean differences in BMI and its dimensions related to whether the firm had introduced service innovations or not (Table 104). As can be observed, 44.87% of SMEs introduced this type of innovation while 55.13% did not. SMEs that had introduced new or improved services showed a higher mean value in BMI and in all its dimensions (VDEL, VCRE and VCAP).

Table 104 BMI and its dimensions' means regarding service innovation

		N	Mean	Std. Deviation	Std. Error Mean
VDEL	YES	35 (44.87%)	3.743	0.780	0.132
	NO	43 (55.13%)	3.244	0.708	0.108
VCRE	YES	35 (44.87%)	3.320	0.855	0.145
	NO	43 (55.13%)	3.029	0.892	0.136
VCAP	YES	35 (44.87%)	3.221	0.835	0.141
	NO	43 (55.13%)	2.936	0.705	0.108
BMI	YES	35 (44.87%)	3.428	0.667	0.113
	NO	43 (55.13%)	3.070	0.657	0.100

Note: Std: standard, BMI: business model innovation, VDEL: value delivery, VCRE: value creation, VCAP: value capture

The statistical significance of the mean differences are described in Table 105. The results indicate that the difference in means between VCRE and VCAP were not statistically significant [sig. (2-tailed)> 0.05] with respect to service innovation. However, the results support the assumption that there is a significant difference between the mean of VDEL and BMI between the SMEs that have introduced service innovations and the ones that have not.

Table 105 *t*-test applied to BMI and its dimensions in relation to service innovation

		Levene's test for equality of variances		**t-test for equality of means**						
		F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% confidence interval of the difference	
									Lower	Upper
VDEL	**EVA**	**.013**	**.909**	**2.955**	**76**	**.004**	**.49867**	**.16873**	**.16262**	**.83472**
	EVNA			2.926	69.573	.005	.49867	.17042	.15873	.83861
VCRE	**EVA**	**.002**	**.966**	**1.460**	**76**	**.148**	**.29106**	**.19931**	**-.10590**	**.68803**
	EVNA			1.467	73.941	.147	.29106	.19844	-.10434	.68647
VCAP	**EVA**	**.030**	**.864**	**1.636**	**76**	**.106**	**.28538**	**.17441**	**-.06199**	**.63276**
	EVNA			1.608	66.717	.113	.28538	.17748	-.06890	.63966
BMI	**EVA**	**.343**	**.560**	**2.381**	**76**	**.020**	**.35837**	**.15053**	**.05856**	**.65818**
	EVNA			2.377	72.360	.020	.35837	.15077	.05784	.65891

Note: BMI: business model innovation, VDEL: value delivery, VCRE: value creation, VCAP: value capture, EVA: Equal variances assumed; EVNA: Equal variances not assumed

The third t-test analysed mean differences in BMI and its dimensions related to whether the firm had introduced process innovations or not (Table 106). As can be observed, less than the half of SMEs (43.59%) had introduced new or improved processes in the previous three years, while 56.41% had not. The companies that had introduced process innovations had higher mean values in BMI and in all its dimensions (VDEL, VCRE, VCAP).

Table 106 BMI and its dimensions' means regarding process innovation

		N	Mean	Std. Deviation	Std. Error Mean
VDEL	YES	34 (43,59%)	3.6691	.73526	.12610
	NO	44 (56,41%)	3.3125	.78156	.11782
VCRE	YES	34 (43,59%)	3.4191	.97063	.16646
	NO	44 (56,41%)	2.9592	.75854	.11435
VCAP	YES	34 (43,59%)	3.2647	.83244	.14276
	NO	44 (56,41%)	2.9091	.69694	.10507
BMI	YES	34 (43,59%)	3.4510	.70833	.12148
	NO	44 (56,41%)	3.0603	.61421	.09260

Note: BMI: Std: standard, business model innovation, VDEL: value delivery, VCRE: value creation, VCAP: value capture

The statistical significances of the mean differences are listed in Table 107. The differences between means were statistically significant [sig. (2-tailed) < 0.05] in all cases, suggesting that BMI differs between firms that have introduced process innovation and firms that have not.

Table 107 t-test applied to BMI and its dimensions in relation to process innovation

		Levene's test for equality of variances		t-test for equality of means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% confidence interval of the difference	
									Lower	Upper
VDEL	**EVA**	**.395**	**.532**	**2.050**	**76**	**.044**	**.35662**	**.17395**	**.01017**	**.70307**
	EVNA			2.066	73.047	.042	.35662	.17258	.01268	.70056
VCRE	**EVA**	**3.133**	**.081**	**2.350**	**76**	**.021**	**.45992**	**.19571**	**.07013**	**.84971**
	EVNA			2.277	61.060	.026	.45992	.20196	.05609	.86375
VCAP	**EVA**	**.071**	**.791**	**2.053**	**76**	**.044**	**.35561**	**.17325**	**.01055**	**.70068**
	EVNA			2.006	64.017	.049	.35561	.17726	.00150	.70973
BMI	**EVA**	**.036**	**.849**	**2.605**	**76**	**.011**	**.39072**	**.14996**	**.09205**	**.68939**
	EVNA			2.558	65.514	.013	.39072	.15274	.08571	.69572

Note: BMI: business model innovation, VDEL: value delivery, VCRE: value creation, VCAP: value capture, EVA: Equal variances assumed; EVNA: Equal variances not assumed

The fourth t-test analysed mean differences in BMI and its dimensions related to whether or not the firm had introduced marketing innovations related to promotion and communication channels (Table 108).

Table 108 BMI and its dimensions' means regarding marketing innovation (promotion and communication)

		N	Mean	Std. Deviation	Std. Error Mean
VDEL	YES	37 (47,44%)	3.5878	.81908	.13466
	NO	41 (52,56%)	3.3598	.73111	.11418
VCRE	YES	37 (47,44%)	3.3434	.94578	.15549
	NO	41 (52,56%)	2.9939	.79547	.12423
VCAP	YES	37 (47,44%)	3.3041	.85215	.14009
	NO	41 (52,56%)	2.8476	.63215	.09873
BMI	YES	37 (47,44%)	3.4118	.73159	.12027
	NO	41 (52,56%)	3.0671	.59431	.09282

Note: Std: standard, BMI: business model innovation, VDEL: value delivery, VCRE: value creation, VCAP: value capture

The results show that 52.56% of the study SMEs had not introduced new or improved promotion and communication channels, while 47.44% had. Means were higher for all SMEs that had engaged in this type of marketing innovation.

The statistical significances of the mean differences are listed in Table 109. Mean differences were statistically significant [sig. (2-tailed) < 0.05] in the cases of VCAP and BMI, whereas they were not significant [sig. (2-tailed) > 0.05] in the cases of VDEL and VCRE. The results suggest that VCAP and BMI differ significantly between SMEs that have introduced new promotion and communication channels and SMEs that have not.

Table 109 t-test applied to BMI and its dimensions in relation to marketing innovation (promotion and communication)

		Levene's test for equality of variances		t-test for equality of means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% confidence interval of the difference	
									Lower	Upper
VDEL	**EVA**	**.359**	**.551**	**1.300**	**76**	**.198**	**.22808**	**.17551**	**-.12148**	**.57765**
	EVNA			1.292	72.601	.200	.22808	.17655	-.12381	.57998
VCRE	**EVA**	**2.033**	**.158**	**1.772**	**76**	**.080**	**.34947**	**.19726**	**-.04340**	**.74234**
	EVNA			1.756	70.703	.083	.34947	.19902	-.04740	.74633
VCAP	**EVA**	**.625**	**.431**	**2.704**	**76**	**.008**	**.45649**	**.16882**	**.12026**	**.79273**
	EVNA			2.664	65.988	.010	.45649	.17139	.11431	.79868
BMI	**EVA**	**.498**	**.483**	**2.293**	**76**	**.025**	**.34468**	**.15031**	**.04531**	**.64406**
	EVNA			2.269	69.471	.026	.34468	.15192	.04164	.64772

Note: BMI: business model innovation, VDEL: value delivery, VCRE: value creation, VCAP: value capture, EVA: Equal variances assumed; EVNA: Equal variances not assumed

A fifth t-test analysed mean differences in BMI and its dimensions related to whether or not the firm had introduced new or improved sales and distribution channels (Table 110). The results show that only 28.21% of SMEs had implemented this marketing innovation. Among variables under study, all except for VDEL resulted in higher means.

Table 110 BMI and its dimensions' means regarding marketing innovation (sales and distribution)

		N	Mean	Std. Deviation	Std. Error Mean
VDEL	YES	22 (28.21%)	3.4318	.83517	.17806
	NO	56 (71.79%)	3.4821	.76107	.10170
VCRE	YES	22 (28.21%)	3.3636	.89552	.19092
	NO	56 (71.79%)	3.0795	.87149	.11646
VCAP	YES	22 (28.21%)	3.4659	.74120	.15802
	NO	56 (71.79%)	2.9063	.73479	.09819
BMI	YES	22 (28.21%)	3.4205	.75701	.16140
	NO	56 (71.79%)	3.1560	.64056	.08560

Note: Std: standard, BMI: business model innovation, VDEL: value delivery, VCRE: value creation, VCAP: value capture

The statistical significances of the mean differences are listed in Table 111. The results indicate that VCAP differs significantly (sig. [2-tailed] < 0.05) between firms that have developed innovations in sales and distribution and firms that have not. The mean differences for the remaining variables (VDEL, VCRE and BMI) were not statistically significant (sig. [2-tailed] > 0.05).

Table 111 t-test applied to BMI and its dimensions in relation to marketing innovation

		Levene's test for equality of variances		t-test for equality of means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% confidence interval of the difference Lower	Upper
VDEL	**EVA**	**.000**	**.990**	**-.256**	**76**	**.799**	**-.05032**	**.19683**	**-.44234**	**.34169**
	EVNA			-.245	35.494	.808	-.05032	.20506	-.46640	.36576
VCRE	**EVA**	**.004**	**.949**	**1.286**	**76**	**.202**	**.28409**	**.22097**	**-.15601**	**.72419**
	EVNA			1.270	37.549	.212	.28409	.22364	-.16883	.73700
VCAP	**EVA**	**.831**	**.365**	**3.020**	**76**	**.003**	**.55966**	**.18533**	**.19054**	**.92878**
	EVNA			3.008	38.173	.005	.55966	.18605	.18309	.93623
BMI	**EVA**	**.051**	**.822**	**1.558**	**76**	**.123**	**.26447**	**.16978**	**-.07367**	**.60262**
	EVNA			1.448	33.465	.157	.26447	.18269	-.10702	.63596

Note: BMI: business model innovation, VDEL: value delivery, VCRE: value creation, VCAP: value capture, EVA: Equal variances assumed; EVNA: Equal variances not assumed

The sixth t-test analysed mean differences in BMI and its dimensions related to whether or not the firm had introduced organisational innovations (Table 112). The results show that 73.08% of the SMEs had introduced organisational innovations, achieving higher mean values in BMI and two of its dimensions, VDEL and VCRE.

Table 112 BMI and its dimensions' means regarding organisational innovation

		N	Mean	Std. Deviation	Std. Error Mean
VDEL	YES	57	3.6623	.73267	.09705
	NO	21	2.9405	.65146	.14216
VCRE	YES	57	3.3632	.80920	.10718
	NO	21	2.6071	.84989	.18546
VCAP	YES	57	3.2412	.73643	.09754
	NO	21	2.5833	.67700	.14773
BMI	YES	57	3.4222	.61444	.08139
	NO	21	2.7103	.58251	.12711

Note: Std: standard, BMI: business model innovation, VDEL: value delivery, VCRE: value creation, VCAP: value capture

The statistical significances of the mean differences are listed in Table 113.

Table 113 *t*-test applied to BMI and its dimensions in relation to organisational innovation

		Levene's test for equality of variances		t-test for equality of means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% confidence interval of the difference Lower	Upper
VDEL	**EVA**	**.129**	**.721**	**3.970**	**76**	**.000**	**.72180**	**.18180**	**.35971**	**1.08390**
	EVNA			4.193	39.889	.000	.72180	.17213	.37389	1.06971
VCRE	**EVA**	**.043**	**.837**	**3.612**	**76**	**.001**	**.75610**	**.20935**	**.33915**	**1.17305**
	EVNA			3.530	34.227	.001	.75610	.21421	.32089	1.19131
VCAP	**EVA**	**.000**	**.999**	**3.573**	**76**	**.001**	**.65789**	**.18412**	**.29119**	**1.02460**
	EVNA			3.716	38.617	.001	.65789	.17703	.29970	1.01609
BMI	**EVA**	**.000**	**.984**	**4.601**	**76**	**.000**	**.71193**	**.15475**	**.40373**	**1.02014**
	EVNA			4.717	37.507	.000	.71193	.15094	.40625	1.01762

Note: BMI: business model innovation, VDEL: value delivery, VCRE: value creation, VCAP: value capture, EVA: Equal variances assumed; EVNA: Equal variances not assumed

They indicate that VDEL, VCRE, VCAP and BMI differ significantly (sig. [2-tailed] < 0.05) between SMEs that introduced organisational innovations and those that did not.

Finally, the last t-test analysed mean differences in BMI and its dimensions related to whether or not the firm had acquired advanced machinery, equipment or software (Table 114). The table shows that the percentage of SMEs that had acquired advanced machinery, equipment or software (66.67%) was higher than the percentage that had not (33.33%) and that the former's means are higher for BMI and all its dimensions.

Table 114 BMI and its dimensions' means regarding resource acquisition

		N	Mean	Std. Deviation	Std. Error Mean
VDEL	YES	52 (66,67%)	3.5721	.75786	.10510
	NO	26 (33,33%)	3.2596	.78893	.15472
VCRE	YES	52 (66,67%)	3.3116	.87604	.12148
	NO	26 (33,33%)	2.8558	.82817	.16242
VCAP	YES	52 (66,67%)	3.1971	.70596	.09790
	NO	26 (33,33%)	2.7981	.84858	.16642
BMI	YES	52 (66,67%)	3.3603	.68201	.09458
	NO	26 (33,33%)	2.9712	.61189	.12000

Note: Std: standard, BMI: business model innovation, VDEL: value delivery, VCRE: value creation, VCAP: value capture

The statistical significances of the mean differences are listed in Table 115. Mean differences were significant for VCRE, VCAP and BMI (sig. [2-tailed] < 0.05) but not for VDEL (sig. [2-tailed] < 0.05). Thus, no difference can be seen in the value delivery dimension between SMEs that invested in new resources and SMEs that did not, but such investment seems to make a difference with regard to value creation, value capture and the innovation of the whole business model.

Table 115 t-test applied to BMI and its dimensions in relation to resource acquisition

		Levene's test for equality of variances		t-test for equality of means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% confidence interval of the difference	
									Lower	Upper
VDEL	**EVA**	**.001**	**.981**	**1.694**	**76**	**.094**	**.31250**	**.18452**	**-.05500**	**.68000**
	EVNA			1.671	48.347	.101	.31250	.18704	-.06350	.68850
VCRE	**EVA**	**.048**	**.828**	**2.205**	**76**	**.030**	**.45586**	**.20671**	**.04417**	**.86755**
	EVNA			2.248	52.711	.029	.45586	.20283	.04899	.86273
VCAP	**EVA**	**2.390**	**.126**	**2.198**	**76**	**.031**	**.39904**	**.18155**	**.03745**	**.76063**
	EVNA			2.067	42.785	.045	.39904	.19308	.00960	.78848
BMI	**EVA**	**.039**	**.844**	**2.456**	**76**	**.016**	**.38913**	**.15847**	**.07351**	**.70475**
	EVNA			2.547	55.253	.014	.38913	.15279	.08296	.69530

Note: BMI: business model innovation, VDEL: value delivery, VCRE: value creation, VCAP: value capture, EVA: Equal variances assumed; EVNA: Equal variances not assumed

5.5.2. The influence of business units on business model innovation

In view of the above differences among business model innovation dimensions and business innovation, the differences between SMEs with a single business unit and SMEs with more than one business unit in relation to business innovation were further explored through t-test analysis to obtain a more detailed picture.

This analysis also had a second purpose, which was to analyse the assumption made when defining the analysis unit: that due to their size, SMEs operate mainly through one business unit and a single business model (Snihur y Tarzijan, 2018).

The first t-test for this second task analysed mean differences in BMI (business model innovation) and its dimensions in relation to the number of business units operated by the SME (Table 116). The results show that more than a half of the sample (69.23%) operated with a single business unit while the remaining 30.77% had more than one business unit. Mean comparison indicates that SMEs with multiple business units show higher scores in BMI and its three dimensions.

Table 116 BMI and its dimensions' means regarding the number of business units

	BU	N	Mean	Std. Deviation	Std. Error Mean
Value delivery (VDEL)	1	54 (69.23%)	3.2870	.75612	.10289
	2	24 (30.77%)	3.8750	.67566	.13792
Value creation (VCRE)	1	54 (69.23%)	3.0269	.89509	.12181
	2	24 (30.77%)	3.4583	.78942	.16114
Value capture(VCAP)	1	54 (69.23%)	2.9630	.81323	.11067
	2	24 (30.77%)	3.2917	.63702	.13003
Business Model Innovation (BMI)	1	54 (69.23%)	3.0923	.70327	.09570
	2	24 (30.77%)	3.5417	.51663	.10546

Note: BU: business unit

The statistical significances of the mean differences (Table 117), in turn, indicate that the mean equality assumption was rejected for all the variables except for VCAP. This result demonstrates a significant difference in the means of VDEL, VCRE and BMI between SMEs with a single business unit and SMEs with multiple business units, suggesting that the number of business units might affect the business model innovation approach of SMEs.

Table 117 *t*-test applied to BMI and its dimensions in relation to the number of business units

		Levene's test for equality of variances		t-test for equality of means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% confidence interval of the difference: Lower	95% confidence interval of the difference: Upper
VDEL	**EVA**	**.080**	**.778**	**-3.271**	**76**	**.002**	**-.58796**	**.17975**	**-.94597**	**-.22996**
	EVNA			-3.417	49.124	.001	-.58796	.17207	-.93373	-.24219
VCRE	**EVA**	**.142**	**.708**	**-2.034**	**76**	**.045**	**-.43139**	**.21208**	**-.85379**	**-.00900**
	EVNA			-2.136	49.745	.038	-.43139	.20200	-.83717	-.02562
VCAP	**EVA**	**2.311**	**.133**	**-1.753**	**76**	**.084**	**-.32870**	**.18748**	**-.70210**	**.04469**
	EVNA			-1.925	55.703	.059	-.32870	.17075	-.67080	.01339
BMI	**EVA**	**2.882**	**.094**	**-2.807**	**76**	**.006**	**-.44935**	**.16006**	**-.76814**	**-.13056**
	EVNA			-3.155	59.091	.003	-.44935	.14241	-.73430	-.16440

Note: BMI: business model innovation, VDEL: value delivery, VCRE: value creation, VCAP: value capture, EVA: Equal variances assumed; EVNA: Equal variances not assumed

5.5.3. The influence of business units on business innovation

A last statistical test was concluded with a comparison of the number of business units and traditional types of innovation. Since all the variables were dichotomous (i.e. yes/no and one/more than one), a Pearson's chi-square test was used (Druiven et al., 2019).

Table 118 illustrate the distribution of observations in relation to the number of business units and each of the innovation types. As can be seen, for SMEs operating with a single business unit, the number of firms that have not innovated in terms of product (INNOPROD), service (INNSERV), process (INNOPROC) and marketing innovations (INNMARPC and INMARSD) in both areas is greater than the number of firms that have. Additionally, the number of single-business-unit SMEs that have acquired new resources (INNOACQ) and introduced organisational innovations (INNORG) is greater than the number of such SMEs that have not.

Table 118 Cross Tabulations between business units and business innovation types

	INNPROD		INNSERV		INNPROC		INNOACQ		INNMARPC		INNMARSD		INNORG	
	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO
1 BU	25	29	17	37	21	33	33	21	22	32	12	42	36	18
2 BU	22	2	18	6	13	11	19	5	15	9	10	14	21	3
Total	47	31	35	43	34	44	52	26	37	41	22	56	57	21

Note: BU: business unit, INNOPROD: product innovation, INNOSERV: service innovation, INNOPROC: process innovation, INNOMARPC: marketing-related innovation activities in promotion and communication, INNOMARSD marketing-related innovation activities in sales and distribution, INNORG: organisational innovation, INNOADQ: resource acquisition (advanced machinery, equipment or software)

Among SMEs operating with more than one business unit, the results indicate that the number of such companies that introduced product, service, process, marketing (in promotion and communication), organisational innovations and that acquire new resources is greater than the number of such companies that did not. On the contrary, the companies with more than one business unit that did not introduce marketing innovations in sales and distribution were greater in number than the ones that did so.

The Pearson's chi-square test results for each of the innovation types are presented below. The influence of business units on product innovation is presented in Table 119. Before analysing the results, the requirements to use the chi-square test were checked (Cleff, 2019). For that purpose, it was confirm that the expected frequency in each cell was larger than five for at least 20% of the cells (see item a displayed at the bottom of Table 119). This requirement was met in Table 119 and also in the rest of the analyses presented in this subsection.

The Pearson’s chi-square row in Table 119 presents a significance level of 0.000 (<0.05), which indicates that there is a significant association between product innovation and business units. In other words, product innovation is dependent on the number of business units in the study SMEs.

Table 119 Influence of business units on product innovation

Chi-square tests	Value	df	Asymp. sig. (2-sided)	Exact sig. (2-sided)	Exact sig. (1-sided)
Pearson's chi-square	**14.282[a]**	**1**	**.000**		
Continuity correction[b]	12.450	1	.000		
Likelihood ratio	16.494	1	.000		
Fisher's exact test				.000	.000
Linear-by-linear association	14.099	1	.000		
No. of valid cases	78				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 9,54.
b. Computed only for a 2x2 table

In addition, the Phi and Cramer's V tests are performed, both tests of the strength of association between two categorical variables based on chi-square. Phi and Cramer's V coefficientes range between 0 and 1, with values higher than 0.25, 0.15, 0.10, 0.05 and 0 considered to represent very strong, strong, moderate, weak and very weak associations respectively (Akoglu, 2018).

As illustrated in Table 120, Phi and Cramer's V tests state that the strength of association between business unit and product innovation is very strong (0.428) and statistically significant (0.000).

Table 120 Symmetric measures of the size effect of business unit on product innovation

Symmetric measures		Value	Approx. sig.
Nominal by nominal	Phi	.428	.000
	Cramer's V	.428	.000
	No. of valid cases	78	78

The influence of business units on service innovation is outlined in Table 121. The Pearson's chi-square row (Table 121) illustrates a significance level of 0.000 (<0.05), which indicates that service innovation is dependent on the number of business units in the study SMEs.

Table 121 Influence of business units on service innovation

Chi-square tests	Value	df	Asymp. sig. (2-sided)	Exact sig. (2-sided)	Exact sig. (1-sided)
Pearson's chi-square	**12.721[a]**	**1**	**.000**		
Continuity correction[b]	11.022	1	.001		
Likelihood ratio	13.044	1	.000		
Fisher's exact test				.001	.000
Linear-by-linear association	12.558	1	.000		
No. of valid cases	78				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 10,77.
b. Computed only for a 2x2 table

The phi and Cramer's V tests (Table 122) indicates that the number of business units has a very strong effect on service innovation; this effect is statistically significant.

Table 122 Symmetric measures of the size effect of business unit on service innovation

Symmetric measures		Value	Approx. sig.
Nominal by nominal	Phi	.404	.000
	Cramer's V	.404	.000
	No. of valid cases	78	78

By contrast, the influence of the number of business units on process innovation (Table 123) regarding Pearson's chi-square is not statistically significant.

Table 123 Influence of business units on process innovation

Chi-square tests					
	Value	df	Asymp. sig. (2-sided)	Exact sig. (2-sided)	Exact sig. (1-sided)
Pearson's chi-square	**1.577[a]**	**1**	**.209**		
Continuity correction[b]	1.017	1	.313		
Likelihood ratio	1.570	1	.210		
Fisher's exact test				.227	.157
Linear-by-linear association	1.557	1	.212		
No. of valid cases	78				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 10,46.
b. Computed only for a 2x2 table

The effect size of business units on process innovation was also not significant (Table 124), and therefore, it was concluded that the existence of multiple business units in SMEs does not influence process innovation.

Table 124 Symmetric measures of the size effect of business unit on service innovation

Symmetric measures			
		Value	**Approx. sig.**
Nominal by nominal	Phi	.142	.209
	Cramer's V	.142	.209
	No. of valid cases	78	78

The influence of business units on marketing innovation related to promotion and communication (Table 125) does not result in a statistically significant difference in the Pearson's chi-square test.

Table 125 Influence of business units on marketing innovation (promotion and communication)

Chi-square tests					
	Value	df	Asymp. sig. (2-sided)	Exact sig. (2-sided)	Exact sig. (1-sided)
Pearson's chi-square	3.155[a]	1	.076		
Continuity correction[b]	2.343	1	.126		
Likelihood ratio	3.173	1	.075		
Fisher's exact test				.090	.063
Linear-by-linear association	3.115	1	.078		
No. of valid cases	78				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 11,38.
b. Computed only for a 2x2 table

The effect size was also not significant (Table 126), indicating that the introduction of innovations in promotion and communication did not depend on the number of business units in the SMEs under study.

Table 126 Symmetric measures of the size effect of business unit on marketing innovation (promotion and communication)

Symmetric measures			
		Value	**Approx. sig.**
Nominal by nominal	Phi	.201	.076
	Cramer's V	.201	.076
	No. of valid cases	78	78

The same results were obtained in the case of sales and distribution based marketing innovations, where the Pearson Chi-Square exceed the cut-off of 0.05 value for statistical significance (Table 127).

Table 127 Influence of business units on marketing innovation (sales and distribution)

Chi-Square Tests	Value	df	Asymp. sig. (2-sided)	Exact sig. (2-sided)	Exact sig. (1-sided)
Pearson's chi-square	3.102[a]	1	.078		
Continuity correction[b]	2.216	1	.137		
Likelihood ratio	2.992	1	.084		
Fisher's exact test				.103	.070
Linear-by-linear association	3.063	1	.080		
No. of valid cases	78				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 6,77.
b. Computed only for a 2x2 table

The phi and Cramer's V tests (Table 128) showed non-significant size effects. Thus, the introduction of innovations in sales and distribution was independent of the number of business units in the SMEs under study.

Table 128 Symmetric measures of the size effect of business unit on marketing innovation (sales and distribution)

Symmetric measures		Value	Approx. sig.
Nominal by nominal	Phi	.199	.078
	Cramer's V	.199	.078
	No. of valid cases	78	78

Regarding the influence of business units on organisational innovation (Table 129) the Pearson's chi-square value was not statistically significant.

Table 129 Influence of business units on organisational innovation

Chi-square tests	Value	df	Asymp. sig. (2-sided)	Exact sig. (2-sided)	Exact sig. (1-sided)
Pearson's chi-square	3.665[a]	1	.056		
Continuity correction[b]	2.683	1	.101		
Likelihood ratio	4.040	1	.044		
Fisher's exact test				.095	.047
Linear-by-linear association	3.618	1	.057		
No. of valid cases	78				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 6,46.
b. Computed only for a 2x2 table

The phi and Cramer's V coefficients were also not statistically significant (Table 130). Thus, the existence of multiple business units in SMEs does not influence organisational innovation.

Table 130 Symmetric measures of the size effect of business unit on organisational innovation

Symmetric measures		Value	Approx. sig.
Nominal by nominal	Phi	.217	.056
	Cramer's V	.217	.056
	No. of valid cases	78	78

Finally, the same results were achieved for resource acquisition. As seen in Table 131 Pearson's chi-square value was not statistically significant.

Table 131 Influence of business units on resource acquisition

Chi-square tests					
	Value	df	Asymp. sig. (2-sided)	Exact sig. (2-sided)	Exact sig. (1-sided)
Pearson's chi-square	2.438[a]	1	.118		
Continuity correction[b]	1.693	1	.193		
Likelihood ratio	2.562	1	.109		
Fisher's exact test				.192	.095
Linear-by-linear association	2.406	1	.121		
No. of valid cases	78				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 8,00.
b. Computed only for a 2x2 table

The effect size of business unit on resource acquisition was also not significant (Table 132). Thus, the results indicate that resource acquisition is not dependent on the number of business units in SMEs under study.

Table 132 Symmetric measures of the size effect of business unit on resource acquisition

Symmetric measures			
		Value	Approx. sig.
Nominal by nominal	Phi	.177	.118
	Cramer's V	.177	.118
	No. of valid cases	78	78

5.5.4. Statistical tests results interpretation

This subsection discusses and interprets the results obtained from the analysis of the various approaches SMEs can adopt to innovate, in response to the fourth objective established in section 3.3. Having explored the mean differences and their significance between distinct forms of innovation, we matched the relationships among the forms of innovation, graphically representing their interrelations (Figure 60).

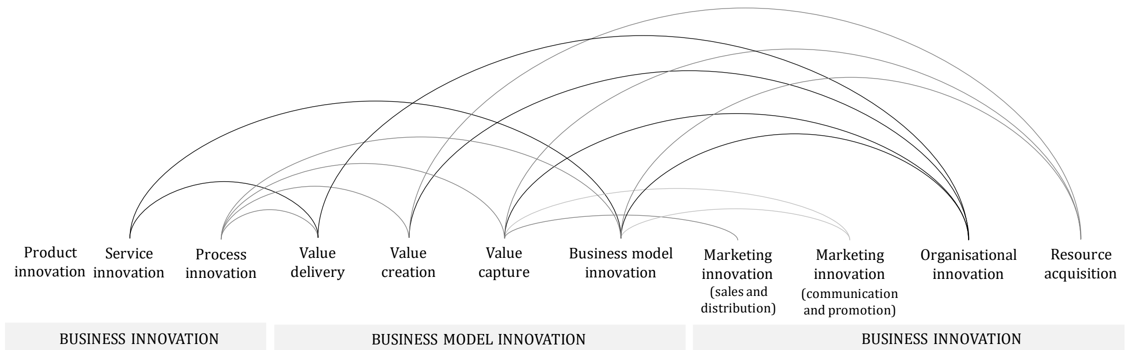

Figure 60 Relationships between business model innovation and business innovation

First, no significant difference in business model innovation or in any of its three dimensions was identified between SMEs that had introduced product innovations and those that had not. These results suggest that business model innovation and product innovation are not necessarily linked, and thus an SME can innovate its product portfolio without altering its business model, and it can reconfigure its business model without changing its core product. This outcome is contrary to that of Minarelli et al. (2015), who found in European SMEs in the food industry that product innovation implied the adoption of new business models. The outcomes does, though, support the view of Markides (2006), who stated that business model innovation is not about introducing new products or services but rather about redefining “what an existing product or service is and how it is provided to the customer” (p. 20).

Second, significant differences in business model innovation and the value delivery dimension were found between SMEs that had introduced service innovations and those that had not. Value creation and value capture dimensions presented higher mean values, however, the differences were non-significant. These findings suggest that SMEs that introduce service innovations also modify their value delivery logic, which in turn influences business model innovation. A possible explanation for this might be that service innovation allows the creation of new value propositions around new bundles of products and services. These findings could indicate an orientation towards servitization (changing from product to service provider). Further research is required to explore this aspect.

Third, the results confirm that business model innovation differs between SMEs that have introduced process innovation and SMEs that have not. This result might explain the cross-functional role that process innovation can play in business model innovation. Process innovation involves changes in production and service routines to streamline operations, often in relation to the company's production and technological competencies (Damanpour, 2010; Snihur y Wiklund, 2019). Since developing new ways of value delivery and value creation implies the modification or allocation of new resources and capabilities, it seems reasonable that process innovation complements changes in those dimensions of the business model. Moreover, process innovation is usually developed to save costs, and therefore it may influence value capture dimensions (Snihur y Wiklund, 2019).

Fourth, significant differences in the value capture dimension and business model innovation were found between SMEs that had introduced marketing innovations on promotion and communication channels and those that had not. In addition, those companies that had improved sales and distributions also improved the value capture dimension. Marketing innovation has a strong influence on price strategies, which may explain its relationship to the value capture dimension. In addition, gaining knowledge about customers’ needs and preferences and defining strategies to fit customer requirements might lead to the identification of new revenue streams. Following this logic, it may make sense that differences also exist in the value delivery dimension which were not identified.

Fifth, the results showed that business model innovation and its three dimensions differ between SMEs that have introduced organisational innovation and SMEs that have not. Business model innovation requires both managerial action and a systemic approach to purposively reconfigure the entire business logic of the company. Organisational innovation refers to new management practices, working methods and decision-making methods related to external partnerships. Thus, organisational innovation might be a transversal innovation required for business model innovation, since it may support the organisational transformation needed to address the new business logic.

Finally, the results confirm that business model innovation, value creation and value capture dimensions differ between SMEs that have acquired new resources and SMEs that have not. In this sense, the introduction of new machinery or software may be a balanced way to save costs, and even to find new ways of capturing value, therefore it may influence value capture dimensions (Snihur y Wiklund, 2019). The acquisition of advanced machinery, equipment or software could lead to improved forms of value creation, which may lead to cost reductions or the creation of new revenue streams, influencing business model innovation.

Based on this exploratory approach to the relationship between business model innovation and business innovation in SMEs, business model innovation is considered a distinct form of innovation which is different from and complementary to other types of business innovation. These findings are in line with prior research that suggests that innovations rarely occur in isolation but are often combined (Taran, Boer, et al., 2015). Additionally, this exploratory analysis underlines the need for more research on the causal relationships between the different types of innovation and possible innovation patterns in SMEs.

The impact of the number of business units on each type of innovation adopted by SMEs was also addressed. The statistical tests results indicate that there is a significant difference between SMEs with a single business unit and those with more than one business unit with respect to product and service innovation. Similarly, the value delivery dimension, value creation dimension and business model innovation have a statistically significantly higher mean in SMEs with more than one business unit when compared to SMEs with a single business unit. It is possible, therefore, that SMEs might have more than one business unit organised by market segmentation or product or service market but exploit the same business model across units (Snihur y Tarzijan, 2018). In this sense, they would be introducing product or service innovations to improve their value delivery dimension, which impacts the business model, without radically transforming the value creation and value capture dimensions. This might be because SMEs tend to specialise in niche markets, focusing on design and production quality, delivery speed and openness to new customer expectations (Cagliano et al., 2001; Child et al., 2017; Cosenz y

Bivona, 2020), which might lead them to particularly innovate their value delivery dimension.

However, other explanations could exist, and SMEs might be performing with multiple business models and supporting multiple business logics, depending on the product or service market combinations and market segmentation (Bouwman et al., 2015; Snihur y Tarzijan, 2018). Thus, further research should be developed to shed light on how the organisational structure and the main activity of an SME influence the number of business models it has and how this affects business model innovation.

Chapter 6

Conclusions, implications, limitations and further research

6. Conclusions, implications, limitations and further research

The present research has empirically explored the phenomenon of business model innovation in SMEs, which is the main contribution of this thesis. In this sense, the work addresses an emerging phenomenon still little understood and of great relevance for academics, practitioners, companies and regional policy makers. Additionally, it responds to a research gap in the academic literature, where several authors have emphasised the lack of integrative frameworks and the need for further empirical research. Particularly in the context of SMEs, which are considered the heart of a nation's wealth creation, employment generation and economic development, understanding the phenomenon of business model innovation becomes key for competitiveness and the development of the region.

Business model innovation allows firms to explore opportunities in new business areas (Casadesus-Masanell y Joan Enric Ricart, 2010; Pölzl, 2016), it facilitates the repositioning of a company in existing or new markets (Kranich A. et al., 2017; Schneider y Spieth, 2013), and it enables a company to provide more value for customers and to create a strategic defence against competitors (Bereznoy, 2019; H Chesbrough, 2007). Therefore, business model innovation is considered a source of competitive advantage that can lead to superior firm performance (Foss y Saebi, 2017; Schneider y Spieth, 2013).

Bearing in mind the potential benefits that business model innovation can bring to SMEs and the little research developed to date to empirically address the subject, the present thesis has adopted a holistic view of business model innovation, its antecedents and its performance implications. Due to the current state of development of the topic, this thesis adopted an exploratory approach that involves the development of an integrative framework and a mix of three analysis methods (PLS-SEM, fsQCA and statistical tests) to gain a broad view of the phenomenon. The researcher contacted a total of 267 SMEs from Gipuzkoa based on a purposive sampling technique; this outreach resulted in a final sample of 78 SMEs.

Linear causal relationships between antecedents and outcomes of business model innovation were analysed using four PLS-SEM analyses. Then, using fsQCA, we explored how these antecedents were configured to lead to business model innovation in SMEs. Additionally, we analysed the interrelations between business model innovation and other forms of innovation using various statistical tests (t-test and Pearson's chi-square test). From the discussion and interpretation of the PLS-SEM results, two main contributions are highlighted. The first is the relevance of business model innovation capabilities for business model innovation in SMEs, supported by managerial orientation, innovation culture and the use of busines model innovation tools. The second contribution stressed is the role of business model advantage as a key factor that partially mediates the effect of business model innovation on firm performance. Regarding the fsQCA analyses performed, the results reveal the importance of a configurational view of business model innovation which responds to different causation-effectuation logical paths. Finally, based on the results of statistical tests, we argue that business model innovation should be seen as a distinct form of innovation that is complementary to other types of business innovation (i.e. product, service, process, marketing and organisation).

Based on these findings, the following subsections address four main conclusions, their theoretical and research implications, and their practical implications for SME managers and policy makers. We then discuss the research's limitations and suggest future lines of research lines. The chapter ends with a presentation of the publications developed as part of this thesis.

6.1. Conclusions

In this section we reflect on the conclusions derived from the main findings of the three analyses conducted. We address these findings in four main blocks: (1) the relevance of business model innovation capabilities, (2) the causation-effectuation based antecedent configurations for business model innovation, (3) the mediating role of business model advantage between business model innovation and firm performance and (4) the relationship between business innovation and business model innovation.

The relevance of business model innovation capabilities for business model innovation in SMEs

The first conclusion of this thesis is that the deployment of business model innovation capabilities is relevant for business model innovation in SMEs. In particular, the need for three critical dynamic capabilities – namely, strategizing, sensing and experimentation – is highlighted, as through the PLS-SEM analyses they were found to positively and significantly affect business model innovation.

Thus, we conclude that SMEs need to develop strategizing capabilities to address business model innovation. Companies need to establish a sense of direction and move it into the organisation to create awareness of the need to continually rethink the established business model to align it with the company's strategic goals. The successful implementation of a business model innovation initiative can last years, and therefore establishing a strategy may help SMEs to reduce uncertainty around the challenge of reconfiguring the business model and to plan how to address it in the medium to long term. Such ability can help managers to more easily decide in a sustainable manner the type of innovation that best suits their strategic goals by guiding decisions on the use of capabilities and resources to meet business model innovation. Managers should support the development of strategizing abilities based on the use of prospective and strategic planning tools, which have also been found to positively influence business model innovation.

In addition, SMEs need to deploy sensing capabilities and therefore should make an effort to take time out of their daily routines to continuously monitor changes in their environment. This would enable them to move from operating reactively to proactively addressing and anticipating opportunities and threats. To do so, it is essential they identify their current and potential customers, as well as their key competitors and the current state of technological developments. This capability could be easily deployed by SMEs, given their proximity to their customers, which facilitates gathering customer feedback. In addition, the use of analysis and design tools can help companies to structure the exploration of their environment and to visualise new business opportunities.

SMEs also need to deploy experimentation capabilities to drive business model innovation. Experimentation capabilities imply investing time and resources, which in the case of SMEs could be a limitation. We suggest that SMEs start working on their experimental capabilities by using low-cost experiments that allow them to test new business model ideas rapidly in the market, and that they move iteratively towards more advanced experiments as they validate their hypotheses. The use of agile methodologies, such as lean-start up methods, can help SMEs to determine the way they experiment and to structure this iterative process.

This study, however, did not find that collaboration capabilities influence business model innovation, which was an unexpected result given prior research (Hock-Doepgen et al., 2020; Liao et al., 2019; Ricciardi et al., 2016; Van de Vrande et al., 2009; Yun y Jung, 2015). Although we have not been able to demonstrate this relationship, we suggest that collaboration can be key for SMEs, and therefore, research should be continued into the role of these capabilities in business model innovation in SMEs.

On the other hand, the PLS-SEM analyses did suggest that business model innovation capabilities are fostered through both innovation culture and a managerial orientation towards the long term, risk-taking and active investment. In the same way, the use of business model innovation tools was found to positively influence business model innovation.

Thus, managers should make an effort to focus on establishing long-term goals, to visualise the dynamic capabilities needed and facilitate business model innovation (DaSilva y Trkman, 2014). Moreover, managers should balance the need to respond to a short-term performance logic with investment in the deployment of resources to build strategizing, sensing and experimentation capabilities.

Additionally, SMEs should foster an innovation culture among their employees that encourages proactivity, alertness and experimentation with new ways of doing their work. Aligning employees with strategic goals, fostering creativity and encouraging collaboration among different functional areas within the organisation can help in deploying the required organisational routines for business model innovation.

The use of tools during business model innovation processes may also help with sharing a common language and thinking out of the box, while making tangible the required changes in the business model of the firm.

Our conclusions suggest, therefore, that all these drivers (business model innovation capabilities, managerial orientation, innovation culture and business model innovation tools) should be considered in an integrative way, aligning them towards business model innovation.

Finally, these findings provide the basis to further explore how SMEs can face existing challenges. The current pandemic crisis, the rapid digitalisation of the economy and the need for more sustainable forms of production and consumption are increasingly disrupting traditional ways of doing business. In a context where SMEs need to balance the sense of urgency with a lack of resources, being prepared to creatively rethink and rapidly reconfigure their business model becomes key for their competitiveness. The deployment of business model innovation capabilities is therefore essential for them. Moreover, innovation is increasingly influenced by social and normative values, where a greater orientation towards justice, security, equity, responsibility and sustainability is perceived. Thus, the fact that innovation cannot be understood, designed or managed without understanding the values of those involved in it is becoming increasingly relevant for business model innovation (Freeman y Auster, 2015).

Causation-effectuation-based antecedent configurations for business model innovation

Business model innovation capabilities, managerial orientation, innovation culture and business model innovation tools are found to be relevant antecedents of business model innovation in SMEs, and therefore, understanding how these elements are related and embedded in organisational routines related to business model innovation is key for SMEs.

In line with this, a second conclusion that emerges from the thesis findings is that SMEs can configure these elements in different ways to achieve business model innovation. Moreover, the results indicate that these configurations are based on two key processes: namely, effectuation and causation.

These configurations integrate the factors related to managerial orientation, innovation culture, strategizing capabilities, sensing capabilities and experimentation capabilities on the one hand, and the use of tools for business model innovation on the other hand. The configurational paths emphasise once again the importance of integrating the different dynamic capabilities for business model innovation (being sensing customer needs and technological options essential in all configurations) with a managerial orientation (focused on the long term, risk -taking and investment), the promotion of an innovation culture and the development of structured business model innovation processes supported by the use of business model innovation tools.

We conclude that there is no single effective way to achieve business model innovation in SMEs, but rather encourage combining the above-mentioned elements based on different recipes which follow two well-defined paths. The first path responds to a causation process, which involves defining the final goal in advance and the exploitation of pre-existing knowledge, focusing on business planning and competitive analyses to predict an uncertain future. The second path involves an effectuation process, which aims to identify opportunities based on short-term experiments, learning as one goes and exploiting environmental contingencies, while remaining flexible in this process (Berends et al., 2014; Chandler et al., 2011; Sarasvathy, 2001).

The existence of these two paths is further reinforced by the fact that both the analysis of the configurations related to the internal drivers associated with business model innovation (managerial orientation, innovation culture and business model innovation capabilities) and the practical approach to business model innovation (use of tools) confirm the existence of both effectuation and causation processes.

The causation path emphasises that SMEs need to design and plan a clear strategy towards business model innovation and continuously monitor the market (sensing capabilities) to identify opportunities in relation to the established strategy. This process should be supported by prospective and analysis tools (Table 28). This requires managers to adopt a long-term orientation that supports strategizing capabilities, while promoting an organisational culture of alertness and information sharing that facilitates establishing sensing routines within the organisation and among employees.

The effectuation path highlights that SMEs need to deploy sensing and experimentation capabilities supported by an underlying innovation culture to achieve business model innovation. SMEs should apply agile methodologies based on iteration, learning and experimentation (e.g. design thinking and lean start-up methods) and use related tools to support those capabilities and the movement towards business model innovation. This requires managers to promote and align organisational values to foster continuous business model innovation. Thus, SMEs through an iterative process of opportunity identification and experimentation can promote learning routines that will lead to business model innovation.

Based on the configurational paths, SMEs could adopt a causation approach or an effectuation approach that could be combined and mixed as needed. For instance, a firm could start experimenting to identify a new business idea, then follow up on sensing opportunities based on the results obtained, and as a result, define a strategy to address business model innovation. Or they in turn can start by defining a goal from the beginning and then experimenting to test the idea in the market.

The configurations we have identified serve as key recipes to which the organisation can always turn on its way to business model innovation. However, the decision as to which of the possible paths is best is not an immutable choice. In our opinion, an SME must be aware of the existing possibilities and then start on its own path, being conscious that along the way the path could require a change in approach. After all, as the results of this thesis show, business model innovation can improve both business model advantage and subsequent firm performance, so the effort to achieve it, however hard, is justified.

The mediating role of business model advantage between business model innovation and firm performance

A third conclusion derived from this thesis is that there is a facilitating (mediating) role for business model advantage in the improvement of firm performance through business model innovation. Even though this is a conclusion obtained from exploratory research that requires further study, we consider that it has a series of consequences, which we explain below.

From the perspective of the SME, the firm must be aware that the development of business model innovation must always be oriented towards achieving superior firm performance, but that these results may take time to manifest. The achievement associated with a business model advantage should be considered an intermediate result and a possible goal when pursuing business model innovation. Therefore, the results related to business model advantage could help SMEs make better decisions about business model innovation. In addition, evaluating these intermediate results against established objectives will help SMEs review the performance achievements derived from business model innovation.

Since the achievement of firm performance is not immediate and does not depend solely on business model innovation, having an intermediate milestone can help SMEs to become aware of their progress while defining partial objectives. In this vein, the company could establish indicators to measure the level at which changes made to their business model create greater value for customers. Benchmarking with competitors' business models could also help companies progress towards their goals. This would also allow them to measure the degree of competitiveness of their business model and identify the need to innovate it.

The above reflections suggest that the research models and frameworks used thus far to analyse the impact of business model innovation on firm performance, could use intermediate constructs (such as business model advantage) to understand the mechanisms of intermediation between business model innovation and firm performance. This approach would help generate more knowledge about the mechanisms that business model innovation triggers to generate superior performance, which is a major concern for both academics and practitioners (Anwar, 2018; Foss y Saebi, 2018).

Business model innovation as a distinct form of innovation that is complementary to other types of innovation

A final conclusion of this thesis refers to an issue that is of great relevance to companies, public administration, and academics. Much has been discussed about the legitimacy of business models and the meaning of business model innovation, the difference between it and other types of innovation being, thus far, blurred (Geissdoerfer, Vladimirova y Evans, 2018). In this sense, our exploratory work allows us to conclude that business model innovation is a phenomenon with its own nature which, although related to other well-known innovation types (i.e. product, service, process, marketing and organisational innovation), is distinct from them.

This conclusion implies, on the one hand, that companies must consider both business model innovation and business innovation (i.e. product, service, process, marketing and organisational innovation) in an integrative manner but at the same time with different approaches and implications. Companies must understand that the decision to innovate the business model may involve innovations in other dimensions of business innovation, and that business innovations can provoke business model innovations. Being aware of this relationship is key to the survival of the company, since this holistic view of innovation allows companies to abandon a sometimes sterile discussion on types of innovation and instead use this reflection to establish a more systemic perspective on how to improve their competitiveness through a broad approach to innovation.

Another implication related to this final conclusion is that business model innovation is an approach that requires process innovation, and new or improved organisational practices play a key role. This conclusion highlights the fact that talking about innovation means talking about the development of products, optimisation of processes, improvement of technologies, and more, but these discussions are not detached and dissociated. Instead, the different forms of innovation are interlinked and must be addressed as a whole in order to achieve more sustainable innovation that will finally lead to a greater competitive advantage. In other words, innovations rarely occur in isolation (Taran, Boer, et al., 2015).

6.2. Theoretical and research implications

This work contributes to the advancement of research and knowledge in business model innovation from six perspectives.

First, against the lack of solid theoretical underpinnings associated with business model innovation, this investigation explored the phenomenon through different theoretical lenses, which we encompassed in a theoretical membrane (Figure 24). Building on this membrane, the present research demonstrated the usefulness of merging ideas from innovation theory, configurational theory, effectuation theory, the resource-based view and the dynamic capabilities view. We argue that these theories complement each other rather than compete. Consequently, the theoretical membrane (Figure 24) is useful for understanding business model innovation and broadens the theoretical perspective on the phenomenon.

Second, this thesis contributes to business model innovation literature by expanding the focus to SMEs, responding to the calls of several authors (Arbussa et al., 2017; Clauss et al., 2020; Lopez-Nicolas et al., 2020; Pucihar et al., 2019). The phenomenon has been explored empirically from a holistic approach (linking business model innovation with different dynamic capabilities, the managerial orientation, the organisational culture, business model innovation tools, business model advantage and firm performance), which complements previous studies that addressed business model innovation from limited perspectives. Furthermore, prior research has been mainly developed through case studies, whereas the present investigation establishes the basis for further quantitative research allowing generalisation of the results. It should be noted, however, that the research framework (Figure 25) could be improved based on the results of the PLS-SEM analyses. Further research should be developed on the role of collaboration capabilities and business model innovation. Our results also show that innovation culture and managerial orientation do not influence business model innovation directly, suggesting that they may form a layer below business model innovation capabilities in our research framework (Figure 25). However, the mediation roles of managerial orientation and innovation culture should be further explored.

Third, the current investigation contributes to a better understanding of the effect of business model innovation on SME competitiveness, which has been little addressed in empirical research, probably due to the difficulty of linking business model innovation with firm performance (Anwar, 2018; Foss y Saebi, 2017). The present research sheds some light on the positive influence that business model innovation has on firm performance and on how achieving a business model advantage partially explains this effect. A new term, namely business model advantage, was defined and operationalised to measure the extent to which the business model offers more value to customers and differentiates a firm from competitors. Scholars and academics could apply this concept to further investigations into the role of business model innovation as a source of competitive advantage.

Fourth, as for the emergent area of business model literature – namely, business model tooling – the present research provides empirical evidence on the relevance of business model innovation tools. An extended review of existing tools was developed, analysing their utility and classifying them based on the steps of the business model innovation process (i.e. analysis, design and test). The operationalisation of the construct contributes to quantitative research on business model tooling, which to date has been mainly based on conceptual and case studies.

Fifth, regarding operationalisation of research variables, some scales have been self-developed or modified to adapt them to the context of the research. For example, a new scale was developed and validated to measure the use of business model innovation tools. In addition, due to the lack of multidimensional constructs to operationalise business model innovation as an outcome (measuring the changes made in the business model rather than the capability to innovate the business model), a Type II reflective-formative higher-order construct was developed based on previous scales that encompasses the three main dimensions of value delivery, value creation and value capture. Finally, business model advantage was operationalised, capturing the ability of a business model to provide customers with benefits superior to those provided by competitors, in terms of higher value, exclusiveness, access to new markets and inimitability. These scales are considered to contribute to quantitative research on business model innovation.

Finally, in terms of research methods, the current investigation highlights the relevance of configurational thinking and the use of related fsQCA techniques to produce knowledge that is more attuned to the complexities of the business model innovation phenomenon. In recent years, mixed approaches combining structural equation modelling and fsQCA have gained attention in business model innovation research. In this thesis, we contribute to this research stream by showing the potential of adopting a two-step mixed-method approach to gain a more fine-grained view of the business model innovation phenomenon.

6.3. Practical implications

The results and contributions of this investigation have relevant practical implications, since it identifies key areas on which SMEs can focus to improve their competitiveness through business model innovation. Thus, this thesis provides useful information for both SME managers and policy makers.

Implications for managers

First, this thesis stresses the fact that business model innovation generates a competitive advantage that can lead to the improvement of firm performance. Being aware of the importance of creating a business model advantage and setting objectives to address it can help SMEs to make more tangible the competitive achievements associated with business model innovation.

Second, to successfully achieve business model innovation, SMEs must develop a managerial orientation that allows them to balance short-term efficiency with long-term value creation, while promoting an innovation culture that fosters business model innovation capabilities, particularly strategizing, sensing and experimentation capabilities. To operationalise those behaviours and capabilities and create shared learning within the organisation, SMEs need also to promote the use of tools for business model innovation.

Third, SMEs must think about the best approach to business model innovation based on their context, path dependencies, capabilities and resources. Effectuation-causation-based paths can serve as guides for SMEs defining their approach to business model innovation. These paths are not fixed to a single effectuation or causation logic, so companies may reconsider the approach as they get results.

Finally, companies must understand and integrate into their strategic thinking a holistic view of innovation. Regardless of the causal relationships that exist, all innovation impacts or can influence every other type of innovation (i.e. product, service, process, marketing, organisational and business model). Thus, rethinking the business model requires an understanding of the systemic consequences and interrelationships between business innovation and business model innovation. The goal is to discuss not the ingredients (already known) but how to move towards the best recipe.

Implications for policy makers

Regarding the practical significance of our conclusions for public administration and other intermediary innovation agents fostering regional competitiveness, four main implications can be derived.

First, policy makers should support the development of key capabilities for the transformation and reactivation of SMEs' business models. This implication reinforces the need to complement technologically centred approaches (Industry 4.0, digital transformation of the industrial fabric, etc.) to innovation in SMEs with managerial practices and the deployment of dynamic capabilities for business model innovation.

Second, and in line with the first implication, policy makers should promote learning-by-doing programmes for SMEs to help them sense opportunities and experiment with new business model ideas while encouraging target-setting and strategic planning in the organisation for business model innovation.

Third, policy makers should encourage and support SMEs in the use of techniques and tools for business model innovation through, for example, training actions or action research initiatives, which will help firms to structure and establish learning processes in their organisations.

Finally, public administration should promote a culture of innovation in companies that supports a systemic view of innovation, moving away of the discussion on how best to innovate. The aim is for companies to develop sustainable approaches to innovation which will lead them to achieve greater competitive advantages through the integration and interrelation of different types of innovation.

6.4. Research limitations

Despite the theoretical and empirical contributions of the present research, it also presents three main limitations, which point to important avenues for future research.

The first limitation relates to the data collection instrument, which was based on a self-reported questionnaire. As noted in the literature review, self-administered questionnaires are widely used in business model innovation studies (Table 13), yet they are often said to be subject to methodological biases (Fuller et al., 2016). Although procedural and statistical remedies were applied to minimize biases in the data collection method, biases in the data may still occur, which influence further analyses (Podsakoff et al., 2003). Although SMEs' managers are seen as knowledgeable reporters of their company's characteristics and performance (Lubatkin et al., 2006), data collected from a single respondent is liable to that respondent's subjective opinion, which can limit the results (Kraus et al., 2012). Using multiple sources of data could help to address this limitation (Podsakoff et al., 2003). Additionally, given the difficulty in obtaining objective data on SME performance, which is rarely available (Kraus et al., 2012; Lubatkin et al., 2006), this thesis measured perceived firm performance. Several studies have proved the accuracy and reliability of perceived performance measures (Dess y Robinson, 1984; Geringer y Hebert, 1991; Govindarajan, 1988; Rauch et al., 2009; Sarkar et al., 2001; Wall et al., 2004). Nevertheless, an objective measure of firm performance could be more accurate. Furthermore, bearing in mind the results of this thesis, objective financial performance could provide a solid basis for better understanding the performance implications of business model innovation in SMEs.

The second limitation of this research was the sample size. The response rate (33.33%) is in line with the average response rates of similar studies (Cucculelli y Bettinelli, 2015) and therefore is considered representative of the selected population. However, it is still a relatively small sample for statistical purposes, and the results obtained from statistical analyses and PLS-SEM should be considered with some caution.

The third limitation refers to the criteria established to define the population of the study. Since the total number of SMEs involved in business model innovation was difficult to know, this investigation limited the population to SMEs in Gipuzkoa that had participated during the previous three years (2017–2019) in Regional

Government programmes fostering innovation. This procedure provided an adequate sample to explore the research objectives under study. However, additional options for identifying the study population should be considered.

6.5. Future research

Having presented the main conclusions, implications and limitations of this thesis, we present below some ideas and reflections for future research. Although this work has explored in a broad way the phenomenon of business model innovation in SMEs, it has also identified a number of questions that might lead to further research. Based on our findings, the limitations of the research and new research streams identified in the literature, new avenues in the study of business model innovation are suggested.

The role of dynamic capabilities in business model innovation

The present investigation highlights the role of certain dynamic capabilities for business model innovation, while identifying some key issues that should be further analysed regarding the antecedents of business model innovation. Due to sample size limitations, it has not been possible to test all the hypotheses in a single integrative research model. Further research should explore in deeper detail the connexions between the factors of the research framework and possible causal relationships among them, to better understand how SMEs could address business model innovation systematically.

Moreover, due to inconsistencies with prior research results regarding the influence of collaboration capabilities on business model innovation, future research should explore this relationship in more detail. In addition, it could be interesting to adopt an open innovation approach for this construct, as suggested by some authors (Foss y Saebi, 2017; Huang et al., 2013).

The effects of mediation on business model innovation

This thesis has hypothesised some mediation effects that should be further analysed using larger data samples. In addition, a review of empirical research on business model innovation revealed few studies that include mediation effects between variables. Due to the complexity of business model innovation phenomenon, further research should be developed using different research models to explore the interconnections between antecedents and outcomes.

The extension of research into business model innovation in SMEs

To move from exploratory to confirmatory research, larger samples are required to further validate the developed research framework, research models and operationalisation of variables suggested in this thesis. In addition, the research should be extended to other regions (e.g. within the Basque Region, Spain or

Europe) to achieve broader external validity of the results. This could also help us to determine whether our findings are industry- or geographically specific, or whether business model innovation results differ more fundamentally.

In addition, further research should consider SMEs' size, as micro, small and medium-sized firms may differ in terms of their managerial orientation, organisational culture and dynamic capabilities for business model innovation.

Another consideration for future research is how the business structure and main activity of SMEs can influence business model innovation. For this purpose, the relationships between business units, business models and business model innovation should be contemplated.

Finally, based on our experience, we consider that mixed approaches combining quantitative and qualitative data collection and analysis methods should be extended in future research. This methodological approach could provide meaningful insights when it comes to improving the understanding of business model innovation complexity.

The effect of business model innovation on firm performance

As for the effect of business model innovation on SMEs' performance, future research should deepen the exploration of this relationship. Since business model innovation can take years, longitudinal studies could investigate the same company repeatedly over a period of years to better understand how business model innovation links to firm performance. Additionally, further research should focus on identifying and studying the interactions between changes in the business model and the firm performance, addressing potential causal relationships.

Business innovation and business model innovation

Exploring the interrelatedness among product, service, process, marketing, organisational innovations and business model innovation, the question inevitably arises as to which came first: the chicken or the egg? Further research should be developed to address the causality dilemma between those innovations. In addition, further research into how the introduction of an innovation changes the business model of a company could be interesting. An approach for such research could be the adoption of a system dynamics view, such as the one suggested by Casadesus-Masanell and Ricart (2011), to explore the causal loops between innovation choices and consequences in the business model.

Sources for business model innovation

Regarding new areas of interest identified in the literature, future research could deepen our understanding of business model innovation capabilities and related management practices around digitalisation, sustainability and value-driven or crisis-driven approaches, to further reveal how companies can innovate their business models and adapt them to environmental challenges.

6.6. Research publications

In the course of this thesis, a number of articles have been produced, which are summarised in Table 133 with their current publication status

Table 133 List of articles produced in the course if this thesis

Nº	Articles
1	Ibarra, D., Bigdeli, A., Igartua, J.I., Ganzarain, J. (Forthcoming 2020). Business Model Innovation in established SMEs: A configurational approach. *Journal of Open Innovation: Technology, Market, and Complexity.*
2	Igartua, J. I. & Ibarra, D. (Forthcoming 2020). Ready for Industry 4.0 - A study of SMEs. In Spain Organisational Engineering in Industry 4.0. *Lecture Notes in Management and Industrial Engineering.* *h*ttps://www.springer.com/series/11786
3	Ibarra, D., Ganzarain, J., & Igartua, J. I. (2018). Business model innovation through Industry 4.0: A review. Procedia Manufacturing, 22, 4–10. https://doi.org/10.1016/j.promfg.2018.03.002
4	Ibarra, D., Igartua, J. I., & Ganzarain, J. (2018). Business Model Innovation from a Technology Perspective: A Review. In Lecture Notes in Management and Industrial Engineering (pp. 33–40). Springer International Publishing. https://doi.org/10.1007/978-3-319-96005-0_5
5	Ibarra, D., Ganzarain, J. & Igartua, J. I., (Forthcoming 2020). Empirical measurement instruments for business model innovation: a review. *Advances in Engineering Networks*
6	Moica, S., Ganzarain, J., Ibarra, D., & Ferencz, P. (2018). Change made in shop floor management to transform a conventional production system into an 'Industry 4.0': Case studies in SME automotive production manufacturing. 2018 7th International Conference on Industrial Technology and Management (ICITM). Presented at the 2018 7th International Conference on Industrial Technology and Management (ICITM). https://doi.org/10.1109/icitm.2018.8333919
7	Ibarra, D., Igartua, J. I., & Ganzarain, J. (2018, March). MEASURING THE BUSINESS MODEL: A CONCEPTUAL FRAMEWORK PROPOSAL APPLIED TO BOTH EDUCATIONAL FIELD AND UNIVERSITY-INDUSTRY COLLABORATION EXPERIENCES. INTED2018 Proceedings. 12th International Technology, Education and Development Conference. https://doi.org/10.21125/inted.2018.0821
8	Ibarra, D., Igartua, J. I., & Ganzarain, J. (2017, March). BUSINESS MODEL INNOVATION IN INDUSTRY 4.0: THE CASE OF A UNIVERSITY-INDUSTRY EXPERIENCE IN SMES. INTED2017 Proceedings. International Technology, Education and Development Conference. https://doi.org/10.21125/inted.2017.1374

Chapter 7

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7. References

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Chapter 8

Appendix

8. Appendix

APPENDIX A: Studies selected from the systematic literature review

	Reference	Title
1	Achtenhagen et al. (2013)	Dynamics of business models - strategizing, critical capabilities and activities for sustained value creation
2	Ammar and Chereau (2018)	Business model innovation from the strategic posture perspective: An exploration in manufacturing SMEs
3	Anwar (2018)	Business model innovation and SMEs performance-Does competitive advantage mediate?
4	Anwar et al. (2019)	Personality manager's and business model innovation
5	Arbussa et al. (2017)	Strategic agility-driven business model renewal: the case of an SME
6	Asemokha et al. (2019)	Business model innovation and entrepreneurial orientation relationships in SMEs: Implications for international performance
7	Bouwman et al. (2015)	Envision. Empowering SME business model innovation. D4.1 Description of methodology and questionnaire
8	Bouwman et al. (2018)	The impact of digitalization on business models
9	Bouwman et al. (2019)	Digitalization, business models, and SMEs: How do business model innovation practices improve performance of digitalizing SMEs?
10	Brettel et al. (2012)	Improving the performance of business models with relationship marketing efforts - An entrepreneurial perspective
11	Carayannis et al. (2017)	Re-visiting BMI as an Enabler of Strategic Intent and Organizational Resilience, Robustness, and Remunerativeness
12	Chereau and Meschi (2019)	The performance implications of the strategy-business model fit
13	Child et al. (2017)	SME international business models: The role of context and experience
14	Clauss et al. (2019)	Business model reconfiguration and innovation in smes: A mixed-method analysis from the electronics industry
15	Cucculelli and Bettinelli (2015)	Business models, intangibles and firm performance: evidence on corporate entrepreneurship from Italian manufacturing SMEs
16	Gatautis et al. (2019)	Impact of business model innovations on SME's innovativeness and performance
17	Guo et al. (2017)	Opportunity recognition and SME performance: the mediating effect of business model innovation
18	Heikkilä et al. (2016)	Business Model Innovation Paths and Tools
19	Heikkilä et al. (2018)	From strategic goals to business model innovation paths: an exploratory study
20	Hock-Doepgen et al. (2020)	Knowledge management capabilities and organizational risk-taking for business model innovation in SMEs
21	Huang et al. (2013)	Overcoming organizational inertia to strengthen business model innovation: An open innovation perspective
22	Lee et al. (2012)	The changing pattern of SME's innovativeness through business model globalization
23	Liao et al. (2019)	Direct and configurational paths of open innovation and organisational agility to business model innovation in SMEs
24	Loon and Chik (2019)	Efficiency-centered, innovation-enabling business models of high tech SMEs: Evidence from Hong Kong
25	Lopez-Nicolas et al. (2020)	Gender differences and business model experimentation in European SMEs

8. Appendix

	Reference	Title
26	Ma et al. (2018)	Green product innovation and firm performance: Assessing the moderating effect of novelty-centered and efficiency-centered business model design
27	Marolt et al. (2016)	Business model innovation: Insights from a multiple case study of Slovenian SMEs
28	Mueller et al. (2018)	Fortune favors the prepared: How SMEs approach business model innovations in Industry 4.0
29	Najmaei (2016)	Revisiting the modularity-performance nexus: business model innovation as a missing mechanism
30	Pati et al. (2018)	Business model design-performance relationship under external and internal contingencies: Evidence from SMEs in an emerging economy
31	Pedersen et al. (2018)	Exploring the Relationship Between Business Model Innovation, Corporate Sustainability, and Organisational Values within the Fashion Industry
32	Pucci et al. (2017)	Firm capabilities, business model design and performance of SMEs
33	Pucihar et al. (2019)	Drivers and outcomes of business model innovation-micro, small and medium-sized enterprises perspective
34	Rezazadeh (2017)	The contribution of business model innovation to collaborative entrepreneurship between SMEs: A review and avenues for further research
35	Ricciardi et al. (2016)	Organizational dynamism and adaptive business model innovation: The triple paradox configuration
36	Roaldsen (2014)	Dynamic capabilities as drivers of business model innovation-from the perspective of SMEs in mature industries
37	Rumble and Mangematin (2015)	Business model implementation: The antecedents of multi-sidedness
38	Torkkeli et al. (2015)	Do All Roads Lead to Rome? The Effect of the Decision-Making Logic on Business Model Change
39	Yun et al. (2015)	Knowledge strategy and business model conditions for sustainable growth of SMEs

APPENDIX B: Letter to participants and questionnaire

La Diputación Foral de Gipuzkoa junto con Mondragon Unibertsitatea, está desarrollando un estudio sobre la realidad y factores clave de las Pymes de Gipuzkoa en relación a la transformación y reactivación de sus Modelos de Negocio y Propuestas de Valor.

Este estudio se basa en un cuestionario, que toma como referencia elementos estratégicos y competitivos clave para su organización, e incide en las capacidades innovadoras y digitales con las que cuenta su empresa para impulsar la transformación de sus Propuestas de Valor y Modelos de Negocio, y la consecuente mejora de su competitividad.

Nos gustaría contar con su colaboración en esta investigación y así poder compartir con usted una reflexión que le ayudará a considerar los elementos clave a gestionar para ser más competitivo y eficiente en el mercado actual y futuro.

Para ello, le pedimos que cumplimente el cuestionario, tarea que le llevará 20 minutos, al que podrá acceder a través del siguiente link: https://es.surveymonkey.com/r/IMAGOGFA

Una vez concluido el proceso de recogida y tratamiento de datos y bajo su consentimiento, se le enviarán las conclusiones relativas a la situación de las Pymes de Gipuzkoa, así como las buenas prácticas que hayan podido ser identificadas.

A su vez, desde el departamento de Promoción Económica, Medio Rural y Equilibrio Territorial de Gipuzkoa, esta información será de gran utilidad para el desarrollo de iniciativas y políticas de apoyo al fortalecimiento competitivo de las Pymes de Gipuzkoa.

Gracias por su colaboración.

TRANSFORMACIÓN Y REACTIVACIÓN DE LOS MODELOS DE NEGOCIO Y PROPUESTAS DE VALOR DE LAS PYMES DE GIPUZKOA

A efectos estadísticos, le solicitamos los siguientes datos personales y de su organización, como paso previo al inicio del cuestionario.

DATOS RELATIVOS A USTED

Años en la empresa:

☐

Nivel en la estructura organizativa (siendo 1 la responsabilidad máxima en la organización):

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 o más

Formación:

◯ Economía y empresariales
◯ Ciencias, ingeniería y arquitectura
◯ Humanidades y ciencias sociales
◯ Otra formación

Experiencia previa:

☐ Experiencia previa en Pymes (incluye empresas familiares)
☐ Experiencia previa en grandes empresas
☐ Experiencia previa en organizaciones públicas o privadas de I+D (universidades, centros e instituciones de investigación, desarrollo)
☐ Sin experiencia previa

1

Departamento o función:

- ◯ Dirección/Consejo administración
- ◯ Calidad (Sistemas degestión)
- ◯ Investigación y Desarrollo (I+D)
- ◯ Ventas
- ◯ Innovación
- ◯ Desarrollo de productos/servicios
- ◯ Marketing
- ◯ Operaciones (compras, aprovisionamientos, producción, logística…)
- ◯ Sistemas de información
- ◯ Otro:

DATOS DE LA EMPRESA

CIF:

Código CNAE (4 dígitos) de la actividad principal:

Tipo de sociedad:

- ◯ S.A.
- ◯ S. A. L.
- ◯ S. Coop.
- ◯ S.L.
- ◯ S. L. L.
- ◯ Comunidad de Bienes
- ◯ Otro:

¿Es el control mayoritario de su empresa familiar?

(Un grupo familiar tiene más del 50% del capital)

◯ Sí ◯ No

¿La empresa forma parte de un grupo empresarial?

◯ Sí ◯ No

Antigüedad de la organización (años):

◯ < 5 ◯ 5-10 ◯ 11-20 ◯ > 20

Número de personas en plantilla:

◯ < 2 ◯ 3-5 ◯ 6-9 ◯ 10-14 ◯ 15-19 ◯ 20-49 ◯ 50-99 ◯ 100-249 ◯ > 250

2

Porcentaje de mujeres y hombres en plantilla:

Mujeres (%): ________

Hombres (%): ________

Volumen de Negocio (€):

◯ < 2 M€ ◯ 2-10 M€ ◯ 10-50M€ ◯ > 50 M€

Número de unidades de negocio (parte de la organización que cuenta con una estrategia, dirección y presupuesto propios que difieren de los del resto de unidades, pero se encuadran dentro de la estrategia global de la empresa):

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 o más

Mercados donde se desarrolla su principal actividad (en porcentaje):

Estatal (%): ________

U. Europea (%): ________

Resto Países (%): ________

Sectores de la clientela

De la siguiente lista, seleccione los sectores a los que pertenecen su principal clientela:

- ☐ Aeronáutico y espacial
- ☐ Alimentación
- ☐ Automoción
- ☐ Biociencias y salud
- ☐ Construcción
- ☐ Contenidos audiovisuales y digitales
- ☐ Energético
- ☐ Ferroviario
- ☐ Fundición
- ☐ Hábitat, madera, oficina y contract
- ☐ Marítimo
- ☐ Medioambiental
- ☐ Papel
- ☐ Siderúrgico
- ☐ Fabricación avanzada-Máquinas-herramienta
- ☐ Tecnologías Electrónicas y de la información
- ☐ Transporte, movilidad y logística
- ☐ Otro:

____

3

Gipuzkoako Foru Aldundia
Ekonomia Sustapeneko, Landa Inguruneko eta Lurralde Oreko Departamentua
Diputación Foral de Gipuzkoa
Departamento de Promoción Económica, Medio Rural y Equilibrio Territorial

IMAGO

Mondragon Unibertsitatea
Goi Eskola Politeknikoa
Escuela Politécnica Superior

TRANSFORMACIÓN Y REACTIVACIÓN DE LOS MODELOS DE NEGOCIO Y PROPUESTAS DE VALOR DE LAS PYMES DE GIPUZKOA

INSTRUCCIONES:

- Este cuestionario expresa su opinión como responsable de la empresa. Por favor, lea con atención los textos e intente contestar a todas las preguntas.
- Valore en una escala del 1 al 5 si está de acuerdo con las afirmaciones que se indican (siendo 1, totalmente en desacuerdo y 5 totalmente de acuerdo). En ciertas cuestiones deberá indicar sí/no.

¿CÓMO ES LA ORGANIZACIÓN?

Indique el grado de acuerdo con las siguientes afirmaciones:

Totalmente en desacuerdo	En desacuerdo	Ni de acuerdo ni en desacuerdo	De acuerdo	Totalmente de acuerdo
1	2	3	4	5

1. ENTORNO EMPRESARIAL: INCERTIDUMBRE PERCIBIDA

En los últimos 3 años...

	1	2	3	4	5
... los movimientos competitivos en nuestros mercados principales han cambiado rápidamente.	○	○	○	○	○
... las condiciones competitivas del mercado han sido impredecibles.	○	○	○	○	○
... la tecnología ha cambiado de manera rápida e impredecible en nuestra industria.	○	○	○	○	○
... la demanda de la clientela y sus preferencias han cambiado rápidamente.	○	○	○	○	○
... los cambios en las necesidades de la clientela han sido impredecibles.	○	○	○	○	○

2. ENTORNO EMPRESARIAL: HOSTILIDAD PERCIBIDA

En los últimos 3 años, nuestra organización ha operado en un entorno...

	1	2	3	4	5
... seguro y con pocas amenazas.	○	○	○	○	○
	○	○	○	○	○

4

... con grandes oportunidades de inversión y comercialización de nuevos productos/servicios.					
... con posibilidades de gestión, poca competencia y pocos obstáculos.	○	○	○	○	○

3. ESTILO DE DIRECCIÓN

En los últimos 3 años, mis prioridades estratégicas en la gestión…

	1	2	3	4	5
… se han visto influenciadas por la necesidad de gestionar la empresa en una situación de crisis.	○	○	○	○	○
… se han orientado a la reducción de costes en lugar de a la inversión (en la I+D, de capital, etc.)	○	○	○	○	○
… se han orientado al corto plazo en lugar de al largo plazo.	○	○	○	○	○
… se han orientado a proyectos de bajo riesgo en lugar de proyectos con mayor potencial pero que conllevaban un mayor riesgo.	○	○	○	○	○

4. CULTURA ORGANIZACIONAL

En nuestra organización...

	1	2	3	4	5
…se fomenta la creatividad y la innovación.	○	○	○	○	○
… se anima a las personas a experimentar con nuevas formas de hacer su trabajo.	○	○	○	○	○
… se aprovecha el conocimiento y las iniciativas de las personas (p. ej. recogiendo sugerencias, animándolas a proponer ideas, o creando equipos para el desarrollo de innovaciones).	○	○	○	○	○
… se fomenta la comunicación abierta y el intercambio de información entre diferentes agentes y funciones/departamentos.	○	○	○	○	○
… se fomenta el trabajo en equipo y la cooperación entre funciones/departamentos.	○	○	○	○	○

5. AGILIDAD Y FLEXIBILIDAD EMPRESARIAL

En nuestra organización...

	1	2	3	4	5
... las personas son altamente polivalentes, pudiendo adecuarse rápidamente a nuevas tareas y funciones.	○	○	○	○	○
... somos capaces de reasignar y utilizar nuestros recursos financieros de manera fluida.	○	○	○	○	○
... la estructura organizacional permite una redistribución flexible de nuestros activos físicos (maquinaría, equipos, infraestructura ...) y respuesta ágil.	○	○	○	○	○

5

6. ESTRATEGIA DE INNOVACIÓN

En nuestra organización...

	1	2	3	4	5
… tenemos una estrategia de innovación bien definida.	○	○	○	○	○
…la estrategia de innovación está alineada con la estrategia de nuestra empresa.	○	○	○	○	○
…la estrategia de innovación está claramente articulada como un medio para transformar nuestra empresa.	○	○	○	○	○
…disponemos de un plan de acción bien definido para ejecutar e implementar nuestra estrategia de innovación.	○	○	○	○	○

7. COMPETITIVIDAD

Si tuviera que destacar un elemento competitivo frente a otro, ¿Cuál considera que ha sido el elemento clave de su organización frente a su competencia en los últimos tres años?

- ☐ La diferenciación (innovación, I+D, marketing, etc.)
- ☐ La eficiencia (productividad, calidad, rapidez, costos, etc.)

TRANSFORMACIÓN Y REACTIVACIÓN DE LOS MODELOS DE NEGOCIO Y PROPUESTAS DE VALOR DE LAS PYMES DE GIPUZKOA

¿CÓMO SE REACTIVA Y TRANSFORMA SU ORGANIZACIÓN?

Indique el grado de acuerdo con las siguientes afirmaciones:

Totalmente en desacuerdo	En desacuerdo	Ni de acuerdo ni en desacuerdo	De acuerdo	Totalmente de acuerdo
1	2	3	4	5

8. DETECCIÓN DE NECESIDADES DE LA CLIENTELA

En nuestra organización...

	1	2	3	4	5
… observamos y evaluamos sistemáticamente las necesidades de nuestra clientela.	○	○	○	○	○

6

	1	2	3	4	5
… analizamos el uso de nuestros productos/servicios en contextos reales.	○	○	○	○	○
… se nos da bien distinguir diferentes grupos de personas usuarias y segmentos de mercado.	○	○	○	○	○

9. IDENTIFICACIÓN DE OPORTUNIDADES TECNOLÓGICAS

En nuestra organización...

	1	2	3	4	5
… nos mantenemos al día en relación con los nuevos productos/servicios y las tecnologías prometedoras.	○	○	○	○	○
… utilizamos diferentes fuentes de información para identificar oportunidades en torno a nuevos productos/servicios y tecnologías.	○	○	○	○	○
… realizamos un seguimiento de las tecnologías utilizadas por nuestra competencia.	○	○	○	○	○

10. CONCEPTUALIZACIÓN Y EXPERIMENTACIÓN

En nuestra organización...

	1	2	3	4	5
… ideamos frecuentemente nuevos conceptos de productos/servicios, Propuestas de Valor o Modelos de Negocio.	○	○	○	○	○
… somos capaces de traducir ideas y conceptos en productos, servicios, Propuestas de Valor o Modelos de Negocio detallados.	○	○	○	○	○
…los nuevos conceptos se prueban mediante prototipos y/o pruebas piloto antes de su desarrollo final.	○	○	○	○	○
…experimentamos con nuevas formas de crear y entregar valor a nuestra clientela así como de capturar el valor de nuestras innovaciones de manera regular.	○	○	○	○	○
… combinamos los conocimientos relativos al mercado, las nuevas tecnologías y los Modelos de Negocio en los procesos de generación de ideas y/o experimentación.	○	○	○	○	○
…a la hora de idear nuevos conceptos analizamos cada uno de los elementos de nuestro Modelo de Negocio (Propuesta de Valor, clientela objetivo, relaciones y canales, actividades y recursos, estructura de costes e ingresos y alianzas clave).	○	○	○	○	○

11. COLABORACIÓN E INNOVACIÓN ABIERTA

En nuestra organización...

	1	2	3	4	5
… involucramos a la clientela en nuestros procesos de innovación (p. ej. mediante investigaciones de mercado activas o desarrollando productos/servicios basados en sus especificaciones).	○	○	○	○	○
… intercambiamos conocimiento con agentes externos (p. ej. empresas proveedoras, universidades, centros de investigación, clúster, organizaciones públicas, otras organizaciones).	○	○	○	○	○
… colaboramos con agentes externos en el desarrollo de nuestras innovaciones, Propuestas de Valor y Modelos de Negocio.	○	○	○	○	○

12. INTEGRACIÓN DE LA CADENA Y RED DE VALOR

En nuestra organización...

	1	2	3	4	5
… utilizamos diversos software empresariales: ERP, CRM, PLM, PDM, CAD, SCM.					
… los software empresariales que utilizamos están interconectados con el sistema principal de la organización, intercambiando información y utilizando la información intercambiada.					
… la información generada por los software empresariales de nuestra organización se utiliza en tiempo real.					
… disponemos de sistemas que permiten la integración digital con nuestra clientela, empresas proveedoras y distribuidas.					
… los datos generados por nuestros sistemas de información son compartidos y utilizados por diferentes agentes de nuestra red/ecosistema/cadena de valor.					
… nuestros procesos funcionales se pueden conectar a través de soluciones en la nube con los de diversos agentes de nuestro ecosistema (empresas proveedoras, clientela, entidades financieras, clúster, universidades o centros de investigación).					
… disponemos de sistemas que nos permiten estar conectados e intercambiar datos con terceras partes de nuestra red/ecosistema/cadena de valor.					

13. PROCESOS EMPRESARIALES

En nuestra organización...

	1	2	3	4	5
… los procesos (compras, logística, producción, ventas, etc.) son flexibles y eficientes gracias a que se encuentran digitalizados.					
… contamos con sistemas de información que generan datos en tiempo real a lo largo de toda la cadena de valor (información proveniente de los medios de producción o de los procesos).					
… el grado de trazabilidad de la información durante el proceso productivo es alto.					
… el nivel de calidad de la información que generan los sistemas de información es alto.					
… los procesos productivos están automatizados permitiendo manejar tiempos de producción y tamaños de serie más cortos, así como la personalización masiva de productos/servicios.					
… hacemos uso de soluciones digitales y otras tecnologías facilitadoras a lo largo de la cadena de valor.					

14. PROCESO DE INNOVACIÓN

En los proyectos orientados a la transformación, reactivación y mejora de nuestro(s) Modelo(s) de Negocio y Propuesta(s) de Valor...

	1	2	3	4	5
…seguimos un proceso formal, con una secuencia de pasos que definen las etapas por las que pasa un nuevo producto, servicio o idea de negocio en su camino hasta el lanzamiento al mercado.					

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	1	2	3	4	5
…seguimos un proceso simple, estructurado y flexible.	◯	◯	◯	◯	◯
... seguimos un proceso gestionado de manera integral (las decisiones y las actividades se planifican para responder a los objetivos generales de la empresa).	◯	◯	◯	◯	◯
…seguimos un proceso deliberadamente iterativo (prueba-error) que busca desarrollar y testear múltiples posibles soluciones antes de seleccionar la solución óptima.	◯	◯	◯	◯	◯
…aplicamos metodologías ágiles basadas en la iteración, el aprendizaje y la experimentación para el desarrollo y validación de nuevas Propuestas de Valor y Modelos de Negocio (p. ej. Design Thinking, Lean Start-up, Scrum, Kanban, Agile, etc.)	◯	◯	◯	◯	◯

15. TÉCNICAS Y HERRAMIENTAS

En los proyectos orientados a la transformación, reactivación y mejora de nuestro(s) Modelo(s) de Negocio y Propuesta(s) de Valor... utilizamos de manera regular técnicas para …

	1	2	3	4	5
... la exploración prospectiva de oportunidades. Por ejemplo: Vigilancia tecnológica, Trendwatching, Escenarios, Roadmapping, etc.	◯	◯	◯	◯	◯
... la identificación de mejoras y ayuda en la toma de decisiones estratégicas. Por ejemplo: Análisis DAFO (Debilidades, amenazas, fortalezas y oportunidades), modelo de 5 fuerzas de Porter, análisis de la cadena de valor, mapa de actores, etc.	◯	◯	◯	◯	◯
... la identificación, comprensión y segmentación de la clientela así como sus necesidades, expectativas y problemáticas. Por ejemplo: entrevistas, Focus Group, Mapa de empatía, Personas, mapa de Stakeholders, etc.	◯	◯	◯	◯	◯
...el análisis de la Propuesta de Valor así como su alineación con las necesidades, expectativas y problemáticas de la clientela. Por ejemplo: Canvas de la Propuesta de Valor, mapa de valor, portfolio de productos/servicios, etc.	◯	◯	◯	◯	◯
... la evaluación sistémica e integral de nuestra Propuesta de Valor y Modelo de Negocio actuales. Por ejemplo: Canvas del Modelo de Negocio, Canvas de la Propuesta de Valor u otros modelos similares, Plan de Negocio, metodologías basadas en la simulación, patrones de Modelo de Negocio, etc.	◯	◯	◯	◯	◯
... la generación creativa de nuevas ideas de productos, servicios, Propuestas de Valor o Modelo de Negocio. Por ejemplo: Brainstorming, mapas mentales, pensamiento lateral, etc.	◯	◯	◯	◯	◯
... el diseño de nuevas Propuestas de Valor y Modelos de Negocio. Por ejemplo: Canvas del Modelo de Negocio, Canvas de la Propuesta de Valor u otros modelos similares, Plan de Negocio, metodologías basadas en la simulación, patrones de modelo de negocio, etc.	◯	◯	◯	◯	◯
... el testeo y validación de hipótesis o ideas relacionadas con la Propuesta de Valor o Modelo de Negocio. Por ejemplo: benchmarking, prototipado rápido, pruebas de usabilidad, experimentación, simulaciones, Mínimo Producto Viable, uso de indicadores, etc.	◯	◯	◯	◯	◯

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TRANSFORMACIÓN Y REACTIVACIÓN DE LOS MODELOS DE NEGOCIO Y PROPUESTAS DE VALOR DE LAS PYMES DE GIPUZKOA

¿CÓMO ES EL MODELO DE NEGOCIO?

Indique el grado de acuerdo con las siguientes afirmaciones:

Totalmente en desacuerdo	En desacuerdo	Ni de acuerdo ni en desacuerdo	De acuerdo	Totalmente de acuerdo
1	2	3	4	5

16. TIPO DE MODELO DE NEGOCIO

	1	2	3	4	5
Nuestra base de clientela está claramente identificada y bien segmentada; conocemos sus necesidades, frustraciones y expectativas futuras.	○	○	○	○	○
Nuestra Propuesta de Valor está claramente articulada y alineada con las necesidades de nuestros segmentos de clientela.	○	○	○	○	○
Nuestros canales de distribución y comunicación responden a las necesidades de cada uno de nuestros segmentos de clientela, son accesibles, eficientes y/o se encuentran integrados.	○	○	○	○	○
Mantenemos una relación de calidad con nuestra clientela que se adecua a sus necesidades y expectativas en todo momento.	○	○	○	○	○
Disponemos de los recursos, capacidades y competencias clave para desarrollar nuestras propuestas de valor.	○	○	○	○	○
Disponemos de las actividades clave para desarrollar nuestras propuestas de valor y satisfacer las necesidades de nuestra clientela.	○	○	○	○	○
Conocemos nuestra red de valor o ecosistema, gozando de buenas relaciones y colaborando/creando alianzas clave siempre que lo necesitamos.	○	○	○	○	○
Nuestros mecanismos de ingresos están bien definidos, estructurados y alineados con las necesidades del mercado.	○	○	○	○	○
Nuestra estructura de costes es eficiente y se adapta a los precios del mercado.	○	○	○	○	○

17. TIPO DE OFERTA: PRODUCTO

Seleccione la opción que mejor responda a la oferta de productos principal de su organización.

○ Disponemos de producto propio y lo comercializamos directamente.

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◯ Desarrollamos producto propio pero no lo comercializamos directamente.

◯ No disponemos de producto propio o se fabrica bajo plano, para incorporarlo a otros sistemas.

◯ No vendemos ningún tipo de producto.

18. TIPO DE OFERTA: SERVICIO

Seleccione la opción que mejor responda a la oferta de servicios principal de su organización.

◯ Ofrecemos servicios asociados a la venta del producto como el mantenimiento, suministro de fungibles, repuestos o asesoría.

◯ Prestamos servicios de alquiler/arrendamiento de bienes y activos.

◯ Somos una empresa de servicios y procesos industriales.

◯ No ofrecemos ningún tipo de servicio.

Gipuzkoako Foru Aldundia
Ekonomia Sustapeneko, Landa Inguruneko eta Lurralde Orekako Departamentua
Diputación Foral de Gipuzkoa
Departamento de Promoción Económica, Medio Rural y Equilibrio Territorial

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Escuela Politécnica Superior

TRANSFORMACIÓN Y REACTIVACIÓN DE LOS MODELOS DE NEGOCIO Y PROPUESTAS DE VALOR DE LAS PYMES DE GIPUZKOA

¿QUÉ SE HA TRANSFORMADO EN SU ORGANIZACIÓN EN LOS ÚLTIMOS TRES AÑOS?

Indique el grado de acuerdo con las siguientes afirmaciones:

Totalmente en desacuerdo	En desacuerdo	Ni de acuerdo ni en desacuerdo	De acuerdo	Totalmente de acuerdo
1	2	3	4	5

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19. INNOVACIÓN EN LA PROPUESTA DEVALOR

En los últimos 3 años, en nuestra organización…

	1	2	3	4	5
… hemos dado respuesta a nuevas necesidades de la clientela previamente no satisfechas por el mercado.	◯	◯	◯	◯	◯
… hemos dado solución a problemas de la clientela, no resueltos por nuestros competidores.	◯	◯	◯	◯	◯
… hemos introducido nuevas formas de valor para la clientela.	◯	◯	◯	◯	◯
… hemos introducido nuevas formas de valor para terceras partes como empresas proveedoras o distribuidoras.	◯	◯	◯	◯	◯
... hemos diversificado en nuevos mercados, dirigiéndonos a tipos de clientela completamente nuevas o nuevos entornos geográficos.	◯	◯	◯	◯	◯
... hemos ampliado nuestra actividad a nuevos segmentos de clientela.	◯	◯	◯	◯	◯

20. INNOVACIÓN EN LA CADENA DE VALOR

En los últimos 3 años, en nuestra organización…

	1	2	3	4	5
... hemos modificado significativamente el conjunto de actividades clave de nuestro negocio mediante la adquisición o eliminación de ciertas actividades o su reorganización interna y/o externa permitiéndonos ser más eficientes y dar una mejor respuesta.	◯	◯	◯	◯	◯
... hemos establecido nuevas colaboraciones con terceras partes que nos han permitido optimizar y mejorar nuestras Propuestas de Valor y/o Modelo de Negocio.	◯	◯	◯	◯	◯
... hemos integrado a terceras partes (clientela, empresas proveedoras y distribuidores u otras) de formas novedosas en relación a la entrega de productos y servicios.	◯	◯	◯	◯	◯
... hemos re-configurado nuestra cadena de valor permitiéndonos ser más eficientes y dar una mejor respuesta a todas las partes interesadas.	◯	◯	◯	◯	◯

21. INNOVACIÓN EN EL MODELO DE INGRESOS Y/O ESTRUCTURA DE COSTES

En los últimos 3 años, en nuestra organización…

	1	2	3	4	5
... hemos introducido nuevas formas de reducir los costes.	◯	◯	◯	◯	◯
... hemos introducido nuevos mecanismos de fijación de precios.	◯	◯	◯	◯	◯
... hemos introducido nuevas formas de ser más rentables.	◯	◯	◯	◯	◯
... hemos introducido nuevas fuentes o mecanismos de ingresos.	◯	◯	◯	◯	◯

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22. INNOVACIÓN EN EL MODELO DE NEGOCIO A TRAVÉS DE LA SERVITIZACIÓN

En los últimos 3 años, en nuestra organización…

	1	2	3	4	5
...hemos desarrollado productos que conectados permiten ser gestionados a lo largo de todo su ciclo de vida.					
...hemos desarrollado productos que la clientela puede personalizar de acuerdo a sus preferencias antes y después de su producción.					
...hemos desarrollado productos que están conectados y se comunican con otros productos/plataformas, maquinaria o sistemas externos gracias a la integración de sensores (de memoria, monitorización, localización, etc.)					
...hemos desarrollado productos que recopilan datos del entorno y otros sistemas gracias a la integración de sensores.					
… hemos ofrecido servicios basados en datos (como servicios de mantenimiento predictivo, logística avanzada, relaciones post-venta, etc.) gracias a los datos recogidos por nuestros productos en su fase de uso.					
… hemos ofrecido paquetes de producto-servicio, por los que la clientela paga por el uso o rendimiento del producto en lugar de por el producto en sí.					
…hemos establecido nuevas relaciones con la clientela en base a servicios que alargan el ciclo de vida de nuestro producto.					
… hemos ofrecido paquetes de producto-servicio, basados en relaciones contractuales a largo plazo.					
… hemos priorizado la oferta de servicios frente a la venta tradicional de productos.					
… hemos obtenido ingresos basados en la oferta de nuevos servicios avanzados.					

23. INNOVACIÓN EN EL MODELO DE NEGOCIO: CAMBIO EN LA LÓGICA DEL NEGOCIO

En los últimos 3 años, ¿ha cambiado la lógica de su negocio al...

	SÍ	NO
...modificar o asumir nuevas posiciones en su cadena de valor y/o red de valor? Por ejemplo: deslocalización-relocalización, externalización-internalización, reestructuración-reorganización, nuevas colaboraciones, integración de terceras partes como clientela o empresas proveedoras en la cadena de valor.	◯	◯
... introducir nuevas Propuestas de Valor previamente no ofertadas por su organización? Por ejemplo: ofrecer nuevos productos, servicios o combinaciones de ambos, ofrecer nuevas experiencias, mayor nivel de personalización o exclusividad, nuevas maneras de interactuar con la clientela (alquiler en lugar de venta, pago por uso o rendimiento, etc.)	◯	◯
... introducir nuevos productos inteligentes y/o servicios avanzados basados en nuevas tecnologías digitales? Por ejemplo: recogida de datos de la clientela y su explotación para la venta o desarrollo de nuevos servicios basados en datos, migración de producto a servicios avanzados, etc.)	◯	◯
... generar por primera vez nuevos ingresos a través de internet? Por ejemplo: comercio electrónico, uso de la nube para colaborar con terceras partes, venta de servicio en base a una plataforma en la nube, etc.	◯	◯
... generar por primera vez nuevos ingresos al desarrollar y gestionar plataformas (u otros mecanismos) que habilitan las transacciones de compra-venta o intercambio de información entre terceras partes por las que reciben una comisión?	◯	◯
... generar nuevos mecanismos de ingresos en base a nuevas estrategias de precios que van más allá de las adaptaciones regulares? Por ejemplo: pago por uso/rendimiento en lugar de producto, precios desagregados, premium, low-cost, precios dinámicos, precios asociados a una estrategia de ventas recurrentes, etc.)	◯	◯
...dirigirse a un mercado totalmente nuevo o novedoso para su organización, con una lógica de negocio hasta ahora no aplicada y completamente diferente? Por ejemplo: dirigiéndose a un nuevo segmento de clientela o introduciéndose en un mercado opuesto al anterior y al de su competencia (estrategias de océano azul, innovación en la base de la pirámide, innovación inversa, etc.)	◯	◯
... reinventarse como empresa? Por ejemplo: pasando de ser fabricantes a distribuidores o intermediarios, pasando de empresa de servicios a fabricantes o viceversa, etc.	◯	◯

24. Como gerente de la organización, ¿en qué nivel considera que sus decisiones han influido en la transformación del Modelo de Negocio?

Muy bajo	Bajo	Ni bajo ni alto	Alto	Muy alto	N/C
◯	◯	◯	◯	◯	◯

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25. INTRODUCCIÓN DE OTRO TIPO DE INNOVACIONES

En los últimos 3 años, ...

	SÍ	NO
¿ha introducido su organización algún producto nuevo o sensiblemente mejorado en el mercado? Excluya la simple reventa de productos comprados a otras empresas y los cambios de naturaleza exclusivamente estética.	○	○
¿ha introducido su organización algún servicio nuevo o sensiblemente mejorado en el mercado?	○	○
¿ha introducido su organización algún proceso o actividad de soporte nueva o sensiblemente mejorada para la producción o suministro de bienes y servicios?	○	○
¿ha adquirido su organización maquinaria, equipos o software avanzados para producir productos y procesos nuevos o significativamente mejorados?	○	○
¿ha introducido su organización algún canal de comunicación y promoción nuevo o sensiblemente mejorado a nivel de marketing?	○	○
¿ha introducido su organización algún canal de venta y distribución nuevo o sensiblemente mejorado?	○	○
¿ha introducido su organización nuevas prácticas de gestión, métodos de organización del trabajo y toma de decisiones o métodos para la organización de relaciones externas con otras empresas/instituciones?	○	○

Gipuzkoako Foru Aldundia
Ekonomia Sustapeneko, Landa Ingurunoko eta Lurralde Orekako Departamentua
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¿QUÉ RESULTADOS SE HAN OBTENIDO?

26. VENTAJA COMPETITIVA DEL MODELO DE NEGOCIO

Indique el grado de acuerdo con las siguientes afirmaciones:

Totalmente en desacuerdo	En desacuerdo	Ni de acuerdo ni en desacuerdo	De acuerdo	Totalmente de acuerdo
1	2	3	4	5

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Nuestro Modelo de Negocio…

	1	2	3	4	5
… resulta difícil de copiar para la competencia.	◯	◯	◯	◯	◯
… ofrece beneficios únicos para la clientela no disponibles en otros lugares.	◯	◯	◯	◯	◯
… tiene ventajas significativas con respecto al Modelo de Negocio de nuestra competencia.	◯	◯	◯	◯	◯
…a ojos de la clientela, es de mayor calidad/valor que el de nuestra competencia.	◯	◯	◯	◯	◯
…se caracteriza por tener una marca fuerte y distintiva.	◯	◯	◯	◯	◯
… es más competitivo en la actualidad que hace tres años.	◯	◯	◯	◯	◯

27. RENDIMIENTO DE LA ORGANIZACIÓN

Evalúe el nivel de resultados alcanzados por su organización en relación con los obtenidos por su competencia con respecto a las siguientes medidas.

Muy por debajo de la competencia	Por debajo	Ni por debajo ni por encima	Por encima	Muy por encima de la competencia
1	2	3	4	5

	1	2	3	4	5
Crecimiento de los beneficios.	◯	◯	◯	◯	◯
Crecimiento de la rentabilidad.	◯	◯	◯	◯	◯
Crecimiento de las ventas.	◯	◯	◯	◯	◯
Crecimiento de la cuota de mercado.	◯	◯	◯	◯	◯
Nivel de satisfacción de la clientela.	◯	◯	◯	◯	◯
Grado de lealtad de la clientela.	◯	◯	◯	◯	◯
Captación de nueva clientela.	◯	◯	◯	◯	◯
Entrega de valor a la clientela.	◯	◯	◯	◯	◯

28. DIFICULTADES PARA LA TRANSFORMACIÓN EMPRESARIAL

Indique el nivel de importancia que han tenido las siguientes dificultades para su organización durante los últimos 3 años:

	Muy bajo	Bajo	Ni bajo ni alto	Alto	Muy alto
Falta de financiación para el desarrollo de nuevas propuestas de valor y Modelos de Negocio.					
Falta de recursos (medios físicos, técnicos o de conocimiento).					
Falta de talento y capacitación cualificada dentro de la organización.					
Falta de alianzas clave y dificultad para colaborar.					
Falta de madurez en el mercado y disposición de la clientela para aceptar nuevas propuestas de valor y Modelos de Negocio.					
Falta de legitimidad ante la clientela ("no nos perciben").					
Dificultad para segmentar la clientela e identificar sus necesidades.					
Dificultad para explotar nuevas oportunidades tecnológicas.					
Dificultad para generar nuevos modelos de ingresos sostenibles.					
Dificultad para generar un valor diferencial en un entorno muy competitivo.					
Incompatibilidad entre las nuevas ideas de Modelo de Negocio y la configuración del Modelo de Negocio actual.					
Dificultad para gestionar el cambio de paradigma en la organización.					

29. ESTRATEGIA FUTURA

Indique el nivel de importancia de los siguientes aspectos en relación a su estrategia futura (próximos 3 años).

	Muy bajo	Bajo	Ni bajo ni alto	Alto	Muy alto
Expansión a nuevos mercados y segmentos de clientela.					
Internacionalización.					
Diversficación (nuevas ofertas, nuevas unidades de negocio).					
Transformación digital del negocio (lograr un alto nivel de digitalización y automatización).					
Servitización (migrar de producto a servicio).					
Sostenibilidad y Modelo de Negocio de economía circular.					
Redes de colaboración, alianzas estratégicas y tecnológicas.					
Gestión de personas, captación de talento, relevo generacional, etc.					
Mayor eficiencia en procesos y operaciones.					
Transformación de la Propuesta de Valor.					
Transformación del Modelo de Negocio.					

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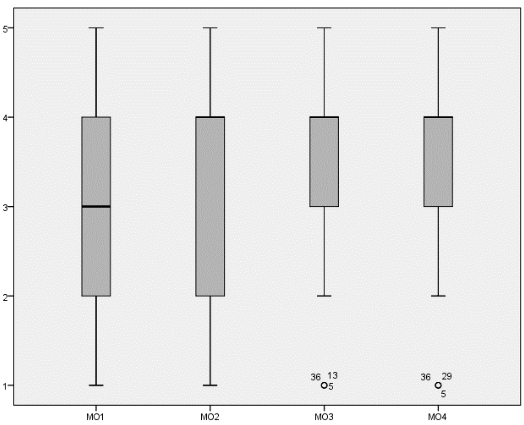
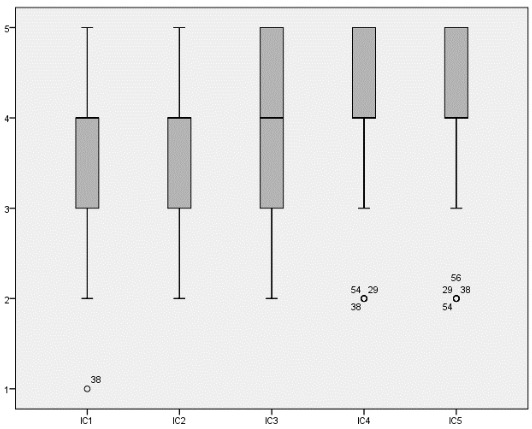
APPENDIX C: Outliers analysis

The following bloxplots present the distribution of the variables under study. The observations identified as possible outliers in each diagram present no asterisk, which suggest that none of the observations are extreme outliers.

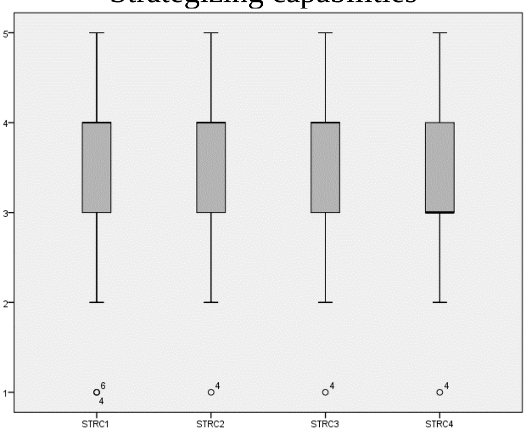
Managerial orientation



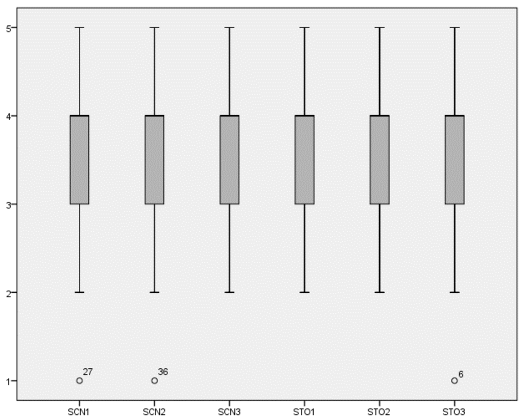
Innovation culture



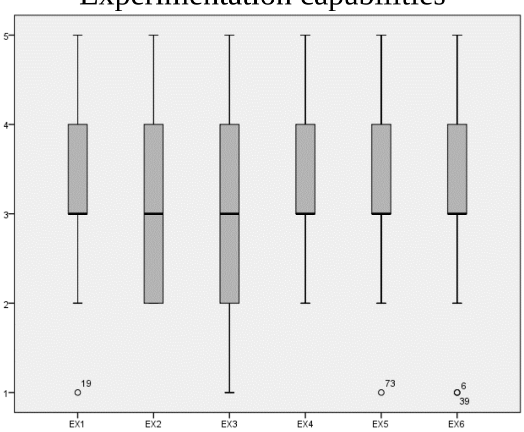
Strategizing capabilities



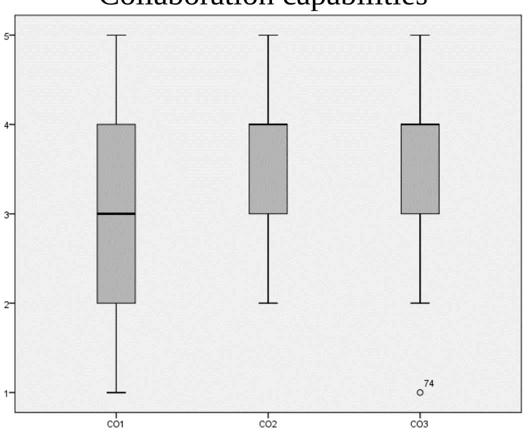
Sensing capabilities



Experimentation capabilities

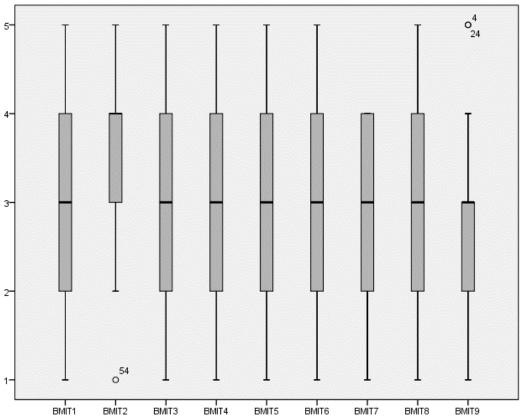


Collaboration capabilities

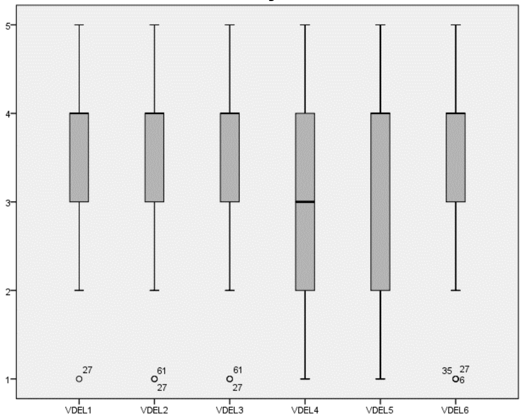


8. Appendix

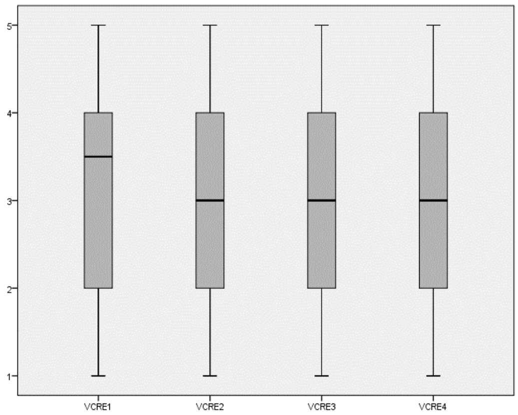
Business model innovation tools



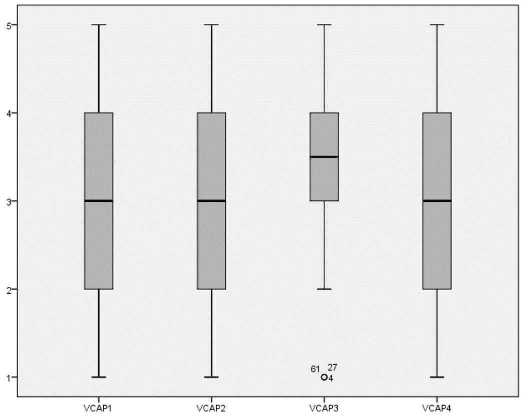
Value delivery dimension



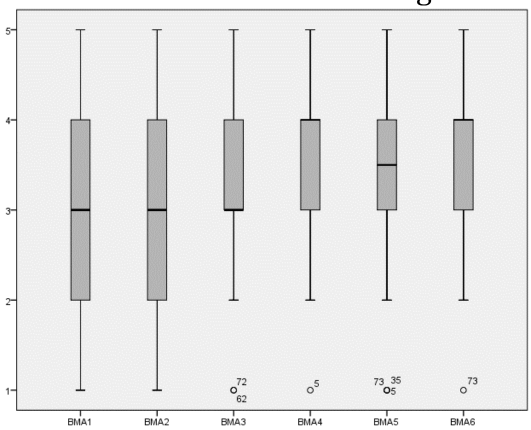
Value creation dimension



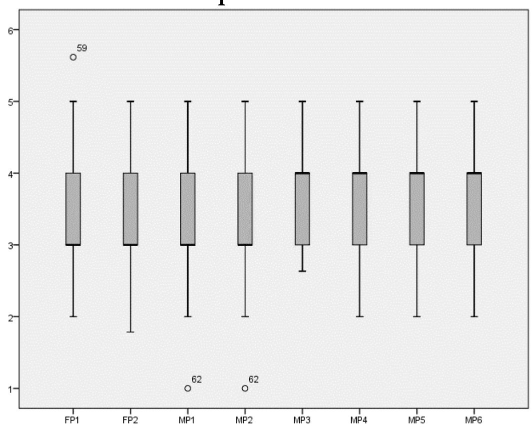
Value capture dimension



Business model advantage



Firm performance



APPENDIX D: fsQCA code in R

```
> library(QCA)
> mydata <- read.csv("DataEM.csv", header = TRUE, sep = ";", dec = ",")
>
> # Data calibration using Totally fuzzy and relative (TFR) method
>
> TFR1<- calibrate(mydata$MO1, method = "TFR")
> TFR2<- calibrate(mydata$MO2, method = "TFR")
> TFR3<- calibrate(mydata$MO3, method = "TFR")
> TFR4<- calibrate(mydata$MO4, method = "TFR")
> TFR5<- calibrate(mydata$IC1, method = "TFR")
> TFR6<- calibrate(mydata$IC2, method = "TFR")
> TFR7<- calibrate(mydata$IC3, method = "TFR")
> TFR8<- calibrate(mydata$IC4, method = "TFR")
> TFR9<- calibrate(mydata$IC5, method = "TFR")
> TFR10<- calibrate(mydata$STRC1, method = "TFR")
> TFR11<- calibrate(mydata$STRC2, method = "TFR")
> TFR12<- calibrate(mydata$STRC3, method = "TFR")
> TFR13<- calibrate(mydata$STRC4, method = "TFR")
> TFR14<- calibrate(mydata$SCN1, method = "TFR")
> TFR15<- calibrate(mydata$SCN2, method = "TFR")
> TFR16<- calibrate(mydata$STO1, method = "TFR")
> TFR17<- calibrate(mydata$STO2, method = "TFR")
> TFR18<- calibrate(mydata$EX1, method = "TFR")
> TFR19<- calibrate(mydata$EX2, method = "TFR")
> TFR20<- calibrate(mydata$EX3, method = "TFR")
> TFR21<- calibrate(mydata$EX4, method = "TFR")
> TFR22<- calibrate(mydata$EX5, method = "TFR")
> TFR23<- calibrate(mydata$EX6, method = "TFR")
> TFR24<- calibrate(mydata$BMIT1, method = "TFR")
> TFR25<- calibrate(mydata$BMIT2, method = "TFR")
> TFR26<- calibrate(mydata$BMIT3, method = "TFR")
> TFR27<- calibrate(mydata$BMIT4, method = "TFR")
> TFR28<- calibrate(mydata$BMIT5, method = "TFR")
> TFR29<- calibrate(mydata$BMIT6, method = "TFR")
> TFR30<- calibrate(mydata$BMIT7, method = "TFR")
> TFR31<- calibrate(mydata$BMIT8, method = "TFR")
> TFR32<- calibrate(mydata$BMIT9, method = "TFR")
> TFR33<- calibrate(mydata$VDEL1, method = "TFR")
> TFR34<- calibrate(mydata$VDEL2, method = "TFR")
> TFR35<- calibrate(mydata$VDEL3, method = "TFR")
> TFR36<- calibrate(mydata$VDEL6, method = "TFR")
> TFR37<- calibrate(mydata$VCRE1, method = "TFR")
> TFR38<- calibrate(mydata$VCRE2, method = "TFR")
> TFR39<- calibrate(mydata$VCRE3, method = "TFR")
> TFR40<- calibrate(mydata$VCRE4, method = "TFR")
> TFR41<- calibrate(mydata$VCAP1, method = "TFR")
> TFR42<- calibrate(mydata$VCAP2, method = "TFR")
> TFR43<- calibrate(mydata$VCAP3, method = "TFR")
> TFR44<- calibrate(mydata$VCAP4, method = "TFR")
>
>
> TFRdata=data.frame(MO1=TFR1,
+         MO2=TFR2,
+         MO3=TFR3,
+         MO4=TFR4,
+         IC1=TFR5,
+         IC2=TFR6,
+         IC3=TFR7,
+         IC4=TFR8,
+         IC5=TFR9,
+         STRC1=TFR10,
+         STRC2=TFR11,
+         STRC3=TFR12,
+         STRC4=TFR13,
+         SCN1=TFR14,
+         SCN2=TFR15,
+         STO1=TFR16,
+         STO2=TFR17,
+         EX1=TFR18,
+         EX2=TFR19,
+         EX3=TFR20,
+         EX4=TFR21,
+         EX5=TFR22,
+         EX6=TFR23,
+         BMIT1=TFR24,
```

```
+           BMIT2=TFR25,
+           BMIT3=TFR26,
+           BMIT4=TFR27,
+           BMIT5=TFR28,
+           BMIT6=TFR29,
+           BMIT7=TFR30,
+           BMIT8=TFR31,
+           BMIT9=TFR32,
+           VDEL1=TFR33,
+           VDEL2=TFR34,
+           VDEL3=TFR35,
+           VDEL6=TFR36,
+           VCRE1=TFR37,
+           VCRE2=TFR38,
+           VCRE3=TFR39,
+           VCRE4=TFR40,
+           VCAP1=TFR41,
+           VCAP2=TFR42,
+           VCAP3=TFR43,
+           VCAP4=TFR44
+ )
>
>
> # Calibrated data after calculating variables' means
> mydata <- read.csv("CALIBRATED.csv", header = TRUE, sep = ";", dec = ",")
> View(mydata)

> # necessary conditions
superSubset(mydata[,c(1,2,3,4,5,13)], outcome = "BMI", incl.cut = 0.41, cov.cut = 0.6, ron.cut =
+  0.6)

               inclN  RoN   covN
----------------------------------------
 1  mo              0.509  0.911  0.842
 2  MO              0.819  0.788  0.834
 3  ic              0.419  0.922  0.821
 4  IC              0.873  0.715  0.811
 5  strc            0.417  0.895  0.772
 6  STRC            0.880  0.764  0.841
 7  SC              0.913  0.670  0.804
 8  ec              0.455  0.911  0.819
 9  EC              0.885  0.792  0.858
10  mo*IC           0.458  0.972  0.935
11  MO*IC           0.770  0.875  0.883
12  mo*STRC         0.458  0.985  0.965
13  MO*STRC         0.741  0.891  0.889
14  mo*SENC         0.478  0.957  0.909
15  MO*SENC         0.776  0.889  0.896
16  mo*EC           0.476  0.977  0.950
17  MO*EC           0.762  0.907  0.909
18  IC*STRC         0.779  0.872  0.883
19  IC*SENC         0.829  0.835  0.869
20  IC*ec           0.415  0.956  0.889
21  IC*EC           0.806  0.911  0.920
22  STRC*SENC       0.826  0.867  0.891
23  STRC*EC         0.801  0.914  0.923
24  SENC*ec         0.412  0.951  0.877
25  SENC*EC         0.837  0.887  0.908
26  mo*IC*STRC      0.417  0.990  0.972
27  MO*IC*STRC      0.703  0.927  0.916
28  mo*IC*SENC      0.441  0.979  0.949
29  MO*IC*SENC      0.739  0.918  0.914
30  mo*IC*EC        0.442  0.989  0.972
31  MO*IC*EC        0.718  0.945  0.938
32  mo*STRC*SENC    0.438  0.986  0.965
33  MO*STRC*SENC    0.717  0.935  0.927
34  mo*STRC*EC      0.439  0.991  0.977
35  MO*STRC*EC      0.702  0.951  0.942
36  mo*SENC*EC      0.456  0.985  0.964
37  MO*SENC*EC      0.736  0.946  0.941
38  IC*STRC*SENC    0.752  0.919  0.917
39  IC*STRC*EC      0.738  0.955  0.951
40  IC*SENC*EC      0.781  0.945  0.947
41  STRC*SENC*EC    0.765  0.949  0.948
42  MO*IC*STRC*SENC 0.685  0.950  0.938
43  mo*IC*STRC*EC   0.411  0.993  0.981
44  MO*IC*STRC*EC   0.667  0.969  0.959
```

```
45  mo*IC*SENC*EC     0.429  0.993  0.981
46  MO*IC*SENC*EC     0.703  0.965  0.957
47  mo*STRC*SENC*EC    0.422  0.992  0.978
48  MO*STRC*SENC*EC    0.684  0.972  0.964
49  IC*STRC*SENC*EC    0.718  0.971  0.966
50  MO*IC*STRC*SENC*EC  0.656  0.980  0.972
--------------------------------------

> # Truth table development
> ttA=truthTable(mydata[,c(1,2,3,4,5,13)], outcome = "BMI", complete = TRUE, sort.by = "incl, n+")
> ttA

  OUT: output value
    n: number of cases in configuration
 incl: sufficiency inclusion score
  PRI: proportional reduction in inconsistency

    MO IC STRC SENC EC   OUT    n   incl  PRI
16   0  1  1  1  1    0    6  0.982 0.938
30   1  1  1  0  1    0    1  0.982 0.875
24   1  0  1  1  1    0    2  0.978 0.902
32   1  1  1  1  1    0    30  0.972 0.937
22   1  0  1  0  1    0    1  0.971 0.779
12   0  1  0  1  1    0    4  0.970 0.765
 8   0  0  1  1  1    0    2  0.968 0.844
15   0  1  1  1  0    0    1  0.968 0.793
10   0  1  0  0  1    0    1  0.963 0.458
20   1  0  0  1  1    0    1  0.962 0.586
29   1  1  1  0  0    0    1  0.958 0.631
18   1  0  0  0  1    0    2  0.957 0.538
28   1  1  0  1  1    0    5  0.957 0.742
 7   0  0  1  1  0    0    1  0.953 0.761
31   1  1  1  1  0    0    3  0.950 0.756
 2   0  0  0  0  1    0    1  0.942 0.313
25   1  1  0  0  0    0    4  0.940 0.497
27   1  1  0  1  0    0    2  0.936 0.450
 4   0  0  0  1  1    0    1  0.936 0.389
11   0  1  0  1  0    0    4  0.911 0.342
 3   0  0  0  1  0    0    1  0.888 0.181
 1   0  0  0  0  0    0    4  0.870 0.188
 5   0  0  1  0  0    ?    0    -    -
 6   0  0  1  0  1    ?    0    -    -
 9   0  1  0  0  0    ?    0    -    -
13   0  1  1  0  0    ?    0    -    -
14   0  1  1  0  1    ?    0    -    -
17   1  0  0  0  0    ?    0    -    -
19   1  0  0  1  0    ?    0    -    -
21   1  0  1  0  0    ?    0    -    -
23   1  0  1  1  0    ?    0    -    -
26   1  1  0  0  1    ?    0    -    -

> # Truth table_ Establishment of frequency and consistency thresholds
> ttA=truthTable(mydata[,c(1,2,3,4,5,13)], outcome = "BMI", complete = TRUE, n.cut = 2, incl.cut = 0.93, sort.by = "incl, n+")
> ttA

  OUT: output value
    n: number of cases in configuration
 incl: sufficiency inclusion score
  PRI: proportional reduction in inconsistency

    MO IC STRC SENC EC   OUT    n   incl  PRI
16   0  1  1  1  1    1    6  0.982 0.938
24   1  0  1  1  1    1    2  0.978 0.902
32   1  1  1  1  1    1    30  0.972 0.937
12   0  1  0  1  1    1    4  0.970 0.765
 8   0  0  1  1  1    1    2  0.968 0.844
18   1  0  0  0  1    1    2  0.957 0.538
28   1  1  0  1  1    1    5  0.957 0.742
31   1  1  1  1  0    1    3  0.950 0.756
25   1  1  0  0  0    1    4  0.940 0.497
27   1  1  0  1  0    1    2  0.936 0.450
11   0  1  0  1  0    0    4  0.911 0.342
 1   0  0  0  0  0    0    4  0.870 0.188
30   1  1  1  0  1    ?    1  0.982 0.875
22   1  0  1  0  1    ?    1  0.971 0.779
15   0  1  1  1  0    ?    1  0.968 0.793
10   0  1  0  0  1    ?    1  0.963 0.458
```

```
20   1  0  0  1  1    ?    1   0.962 0.586
29   1  1  1  0  0    ?    1   0.958 0.631
 7   0  0  1  1  0    ?    1   0.953 0.761
 2   0  0  0  0  1    ?    1   0.942 0.313
 4   0  0  0  1  1    ?    1   0.936 0.389
 3   0  0  0  1  0    ?    1   0.888 0.181
 5   0  0  1  0  0    ?    0    -    -
 6   0  0  1  0  1    ?    0    -    -
 9   0  1  0  0  0    ?    0    -    -
13   0  1  1  0  0    ?    0    -    -
14   0  1  1  0  1    ?    0    -    -
17   1  0  0  0  0    ?    0    -    -
19   1  0  0  1  0    ?    0    -    -
21   1  0  1  0  0    ?    0    -    -
23   1  0  1  1  0    ?    0    -    -
26   1  1  0  0  1    ?    0    -    -

> # Complex solution
> SOLC=minimize(ttA, details = TRUE)
> SOLC

n OUT = 1/0/C: 60/8/0
  Total      : 68

M1: MO*IC*SENC + IC*SENC*EC + STRC*SENC*EC + MO*IC*is*ec + MO*ic*is*sc*EC => BMI

                    inclS   PRI   covS   covU
---------------------------------------------
1  MO*IC*SENC         0.914  0.826  0.739  0.022
2  IC*SENC*EC         0.947  0.895  0.781  0.016
3  STRC*SENC*EC       0.948  0.898  0.765  0.036
4  MO*IC*strc*ec      0.922  0.489  0.260  0.012
5  MO*ic*strc*sc*EC   0.957  0.538  0.208  0.009
---------------------------------------------
   M1                 0.892  0.803  0.888

> # parsimonious solution
> SOLP=minimize(ttA, include = "?", details = TRUE)
> SOLP

n OUT = 1/0/C: 60/8/0
  Total      : 68

M1: MO + EC => BMI

       inclS   PRI   covS   covU
---------------------------------
1  MO  0.834  0.699  0.819  0.057
2  EC  0.858  0.750  0.885  0.123
---------------------------------
   M1  0.802  0.672  0.942

> # Inspection of simplifying assumptions (SA)
> SOLP$SA
$M1
   MO IC STRC SENC EC
2   0  0  0  0  1
4   0  0  0  1  1
6   0  0  1  0  1
10  0  1  0  0  1
14  0  1  1  0  1
17  1  0  0  0  0
19  1  0  0  1  0
20  1  0  0  1  1
21  1  0  1  0  0
22  1  0  1  0  1
23  1  0  1  1  0
26  1  1  0  0  1
29  1  1  1  0  0
30  1  1  1  0  1

> # Intermediate solution
> # Specification of directional expectations assuming that it is the presence of the causal conditions that lead to BMI
> SOLI <- minimize(ttA, include = "?", dir.exp = "1,1,1,1,1")
> SOLI

From C1P1:
```

```
M1:    MO*IC + MO*EC + IC*SENC*EC + STRC*SENC*EC => BMI

> print(SOLI, details = TRUE)

  OUT: output value
    n: number of cases in configuration
 incl: sufficiency inclusion score
  PRI: proportional reduction in inconsistency

    MO IC STRC SENC EC   OUT    n   incl  PRI
16   0  1  1  1  1    1    6   0.982 0.938
24   1  0  1  1  1    1    2   0.978 0.902
32   1  1  1  1  1    1    30  0.972 0.937
12   0  1  0  1  1    1    4   0.970 0.765
 8   0  0  1  1  1    1    2   0.968 0.844
18   1  0  0  0  1    1    2   0.957 0.538
28   1  1  0  1  1    1    5   0.957 0.742
31   1  1  1  1  0    1    3   0.950 0.756
25   1  1  0  0  0    1    4   0.940 0.497
27   1  1  0  1  0    1    2   0.936 0.450
11   0  1  0  1  0    0    4   0.911 0.342
 1   0  0  0  0  0    0    4   0.870 0.188
30   1  1  1  0  1    ?    1   0.982 0.875
22   1  0  1  0  1    ?    1   0.971 0.779
15   0  1  1  1  0    ?    1   0.968 0.793
10   0  1  0  0  1    ?    1   0.963 0.458
20   1  0  0  1  1    ?    1   0.962 0.586
29   1  1  1  0  0    ?    1   0.958 0.631
 7   0  0  1  1  0    ?    1   0.953 0.761
 2   0  0  0  0  1    ?    1   0.942 0.313
 4   0  0  0  1  1    ?    1   0.936 0.389
 3   0  0  0  1  0    ?    1   0.888 0.181
 5   0  0  1  0  0    ?    0    -    -
 6   0  0  1  0  1    ?    0    -    -
 9   0  1  0  0  0    ?    0    -    -
13   0  1  1  0  0    ?    0    -    -
14   0  1  1  0  1    ?    0    -    -
17   1  0  0  0  0    ?    0    -    -
19   1  0  0  1  0    ?    0    -    -
21   1  0  1  0  0    ?    0    -    -
23   1  0  1  1  0    ?    0    -    -
26   1  1  0  0  1    ?    0    -    -

n OUT = 1/0/C: 60/8/0
  Total      : 68

From C1P1:

M1:    MO*IC + MO*EC + IC*SENC*EC + STRC*SENC*EC => BMI

                 inclS   PRI   covS   covU
---------------------------------------
1  MO*IC        0.883  0.772  0.770  0.052
2  MO*EC        0.909  0.816  0.762  0.016
3  IC*SENC*EC   0.947  0.895  0.781  0.016
4  STRC*SENC*EC 0.948  0.898  0.765  0.018
---------------------------------------
   M1           0.856  0.749  0.911

> # Exploration of easy and difficult conterfactuals
> names(SOLI$i.sol)
[1] "C1P1"
> names(SOLI$i.sol$C1P1)
 [1] "EC"        "DC"        "NSEC"      "PIchart"   "c.sol"     "p.sol"     "solution"
 [8] "essential" "primes"    "IC"        "pims"
> SOLI$i.sol$C1P1$EC
   MO IC STRC SENC EC
20  1  0  0  1  1
22  1  0  1  0  1
26  1  1  0  0  1
29  1  1  1  0  0
30  1  1  1  0  1
> SOLI$i.sol$C1P1$DC
   MO IC STRC SENC EC
2   0  0  0  0  1
4   0  0  0  1  1
```

```
6  0 0 1 0 1
10 0 1 0 0 1
14 0 1 1 0 1
17 1 0 0 0 0
19 1 0 0 1 0
21 1 0 1 0 0
23 1 0 1 1 0
> # Enhanced Standard Analysis
> # Exclusion of incoherent conterfactuals from the most parsimonious solution
> INC <- findRows("~SENC", obj = ttA, type =1 )
> INC
 [1]  2  5  6  9 10 13 14 17 21 22 26 29 30
> # Exclusion of simultaneous subset relations from the most parsimonious solution
> SSR <- findRows(obj = ttA, type = 3)
> SSR
[1] 18 25 27
> # Exclusion of contradictory simplifying assumptions from the most parsimonious solution
> CSA <- findRows(obj = ttA, type = 2)
> CSA
 [1]  2  4  6 10 14 17 19 20 21 22 26 29 30
> # Exclusion of all untenable assumptions
> ALL <- findRows("~SENC", obj = ttA, type = 0)
> ALL
 [1]  2  4  5  6  9 10 13 14 17 18 19 20 21 22 25 26 27 29 30
> # Enhanced parsimonious solution
> EPS=minimize(ttA, include = "?", exclude = ALL)
> print(EPS, details = TRUE)

  OUT: output value
    n: number of cases in configuration
 incl: sufficiency inclusion score
  PRI: proportional reduction in inconsistency

    MO IC STRC SENC EC   OUT    n   incl  PRI
16   0  1  1  1  1    1    6   0.982 0.938
24   1  0  1  1  1    1    2   0.978 0.902
32   1  1  1  1  1    1    30  0.972 0.937
12   0  1  0  1  1    1    4   0.970 0.765
 8   0  0  1  1  1    1    2   0.968 0.844
18   1  0  0  0  1    1    2   0.957 0.538
28   1  1  0  1  1    1    5   0.957 0.742
31   1  1  1  1  0    1    3   0.950 0.756
25   1  1  0  0  0    1    4   0.940 0.497
27   1  1  0  1  0    1    2   0.936 0.450
11   0  1  0  1  0    0    4   0.911 0.342
 1   0  0  0  0  0    0    4   0.870 0.188
30   1  1  1  0  1    ?    1   0.982 0.875
22   1  0  1  0  1    ?    1   0.971 0.779
15   0  1  1  1  0    ?    1   0.968 0.793
10   0  1  0  0  1    ?    1   0.963 0.458
20   1  0  0  1  1    ?    1   0.962 0.586
29   1  1  1  0  0    ?    1   0.958 0.631
 7   0  0  1  1  0    ?    1   0.953 0.761
 2   0  0  0  0  1    ?    1   0.942 0.313
 4   0  0  0  1  1    ?    1   0.936 0.389
 3   0  0  0  1  0    ?    1   0.888 0.181
 5   0  0  1  0  0    ?    0    -    -
 6   0  0  1  0  1    ?    0    -    -
 9   0  1  0  0  0    ?    0    -    -
13   0  1  1  0  0    ?    0    -    -
14   0  1  1  0  1    ?    0    -    -
17   1  0  0  0  0    ?    0    -    -
19   1  0  0  1  0    ?    0    -    -
21   1  0  1  0  0    ?    0    -    -
23   1  0  1  1  0    ?    0    -    -
26   1  1  0  0  1    ?    0    -    -

n OUT = 1/0/C: 60/8/0
  Total      : 68

M1: STRC*SENC + IC*SENC*EC => BMI

          inclS   PRI   covS   covU
---------------------------------------
1  STRC*SENC     0.891  0.806  0.826  0.108
2  IC*SENC*EC  0.947  0.895  0.781  0.063
---------------------------------------
```

```
  M1       0.881  0.792  0.889

> # Enhanced intermediate solution
> EPI <- minimize(ttA, include = "?", exclude = ALL, dir.exp = "1,1,1,1,1")
> print(EPI, details = TRUE)

 OUT: output value
   n: number of cases in configuration
 incl: sufficiency inclusion score
 PRI: proportional reduction in inconsistency

    MO IC STRC SENC EC   OUT    n   incl  PRI
16   0  1  1  1  1    1    6   0.982 0.938
24   1  0  1  1  1    1    2   0.978 0.902
32   1  1  1  1  1    1    30  0.972 0.937
12   0  1  0  1  1    1    4   0.970 0.765
 8   0  0  1  1  1    1    2   0.968 0.844
18   1  0  0  0  1    1    2   0.957 0.538
28   1  1  0  1  1    1    5   0.957 0.742
31   1  1  1  1  0    1    3   0.950 0.756
25   1  1  0  0  0    1    4   0.940 0.497
27   1  1  0  1  0    1    2   0.936 0.450
11   0  1  0  1  0    0    4   0.911 0.342
 1   0  0  0  0  0    0    4   0.870 0.188
30   1  1  1  0  1    ?    1   0.982 0.875
22   1  0  1  0  1    ?    1   0.971 0.779
15   0  1  1  1  0    ?    1   0.968 0.793
10   0  1  0  0  1    ?    1   0.963 0.458
20   1  0  0  1  1    ?    1   0.962 0.586
29   1  1  1  0  0    ?    1   0.958 0.631
 7   0  0  1  1  0    ?    1   0.953 0.761
 2   0  0  0  0  1    ?    1   0.942 0.313
 4   0  0  0  1  1    ?    1   0.936 0.389
 3   0  0  0  1  0    ?    1   0.888 0.181
 5   0  0  1  0  0    ?    0    -    -
 6   0  0  1  0  1    ?    0    -    -
 9   0  1  0  0  0    ?    0    -    -
13   0  1  1  0  0    ?    0    -    -
14   0  1  1  0  1    ?    0    -    -
17   1  0  0  0  0    ?    0    -    -
19   1  0  0  1  0    ?    0    -    -
21   1  0  1  0  0    ?    0    -    -
23   1  0  1  1  0    ?    0    -    -
26   1  1  0  0  1    ?    0    -    -

n OUT = 1/0/C: 60/8/0
 Total     : 68

From C1P1:

M1:    IC*SENC*EC + STRC*SENC*EC + MO*IC*STRC*SENC => BMI

           inclS   PRI   covS   covU
------------------------------------------
1  IC*SENC*EC    0.947  0.895  0.781  0.063
2  STRC*SENC*EC    0.948  0.898  0.765  0.047
3  MO*IC*STRC*SENC  0.938  0.868  0.685  0.030
------------------------------------------
  M1         0.908  0.830  0.858

  > # fsQCA B: Analysis of tools configurations for BMI
  >
  > # necessary conditions
  > superSubset(mydata[,c(6,7,8,9,10)], outcome = "VDEL", incl.cut = 0.4,cov.cut = 0.6, ron.cut = 0.6)

                      inclN   RoN   covN
  --------------------------------------------------
   1  toola1                0.436  0.910  0.812
   2  TOOLA1                  0.830  0.744  0.818
   3  toola2                0.527  0.861  0.787
   4  TOOLA2                  0.748  0.833  0.848
   5  toold                 0.497  0.870  0.784
   6  TOOLD                   0.773  0.815  0.843
   7  toolt                 0.495  0.876  0.791
   8  TOOLT                   0.780  0.810  0.842
   9  TOOLA1*toola2           0.441  0.961  0.911
  10  TOOLA1*TOOLA2            0.693  0.898  0.888
```

```
11  TOOLA1*toold            0.413  0.953  0.886
12  TOOLA1*TOOLD            0.713  0.891  0.886
13  TOOLA1*toolt            0.422  0.949  0.879
14  TOOLA1*TOOLT            0.712  0.890  0.885
15  toola2*toold            0.438  0.896  0.791
16  TOOLA2*TOOLD            0.699  0.881  0.873
17  toola2*toolt            0.411  0.919  0.817
18  TOOLA2*TOOLT            0.668  0.897  0.880
19  toold*toolt             0.411  0.911  0.802
20  TOOLD*TOOLT             0.706  0.884  0.878
21  TOOLA1*TOOLA2*TOOLD     0.655  0.924  0.906
22  TOOLA1*TOOLA2*TOOLT     0.634  0.928  0.905
23  TOOLA1*TOOLD*TOOLT      0.661  0.921  0.904
24  TOOLA2*TOOLD*TOOLT      0.647  0.909  0.887
25  TOOLA1*TOOLA2*TOOLD*TOOLT  0.613  0.937  0.912
--------------------------------------------------

> superSubset(mydata[,c(6,7,8,9,11)], outcome = "VCRE", incl.cut = 0.4, cov.cut = 0.6, ron.cut = 0.6)

                     inclN   RoN   covN
--------------------------------------------------
 1  toola1              0.423  0.887  0.760
 2  TOOLA1              0.847  0.731  0.805
 3  toola2              0.511  0.833  0.736
 4  TOOLA2              0.783  0.840  0.856
 5  toold               0.484  0.846  0.736
 6  TOOLD               0.808  0.820  0.849
 7  toolt               0.490  0.858  0.755
 8  TOOLT               0.800  0.802  0.833
 9  TOOLA1*toola2       0.450  0.955  0.895
10  TOOLA1*TOOLA2       0.723  0.903  0.894
11  TOOLA1*toold        0.421  0.947  0.870
12  TOOLA1*TOOLD        0.742  0.893  0.889
13  TOOLA1*toolt        0.437  0.949  0.879
14  TOOLA1*TOOLT        0.732  0.884  0.878
15  toola2*toold        0.423  0.873  0.738
16  toola2*TOOLD        0.403  0.979  0.942
17  TOOLA2*TOOLD        0.742  0.898  0.893
18  toola2*toolt        0.411  0.907  0.787
19  toola2*TOOLT        0.410  0.962  0.899
20  TOOLA2*TOOLT        0.703  0.906  0.892
21  toold*toolt         0.408  0.898  0.768
22  TOOLD*TOOLT         0.736  0.888  0.883
23  TOOLA1*TOOLA2*TOOLD     0.690  0.935  0.920
24  TOOLA1*TOOLA2*TOOLT     0.662  0.932  0.912
25  TOOLA1*TOOLD*TOOLT      0.687  0.922  0.905
26  TOOLA2*TOOLD*TOOLT      0.687  0.924  0.908
27  TOOLA1*TOOLA2*TOOLD*TOOLT  0.647  0.947  0.927
--------------------------------------------------

> superSubset(mydata[,c(6,7,8,9,12)], outcome = "VCAP", incl.cut = 0.4,cov.cut = 0.6,  ron.cut = 0.6)

                     inclN   RoN   covN
--------------------------------------------------
 1  toola1              0.439  0.901  0.793
 2  TOOLA1              0.839  0.727  0.801
 3  toola2              0.524  0.845  0.758
 4  TOOLA2              0.761  0.823  0.836
 5  toold               0.492  0.854  0.752
 6  TOOLD               0.795  0.812  0.840
 7  toolt               0.505  0.872  0.783
 8  TOOLT               0.778  0.784  0.814
 9  TOOLA1*toola2       0.452  0.959  0.905
10  TOOLA1*TOOLA2       0.703  0.886  0.873
11  TOOLA1*toold        0.423  0.951  0.879
12  TOOLA1*TOOLD        0.730  0.885  0.879
13  TOOLA1*toolt        0.434  0.948  0.876
14  TOOLA1*TOOLT        0.723  0.878  0.871
15  toola2*toold        0.428  0.879  0.751
16  toola2*TOOLD        0.408  0.986  0.960
17  TOOLA2*TOOLD        0.719  0.878  0.870
18  toola2*toolt        0.418  0.914  0.804
19  toola2*TOOLT        0.406  0.961  0.897
20  TOOLA2*TOOLT        0.685  0.892  0.874
21  toold*toolt         0.413  0.903  0.783
22  TOOLD*TOOLT         0.719  0.875  0.867
23  TOOLA1*TOOLA2*TOOLD     0.668  0.916  0.896
```

```
24  TOOLA1*TOOLA2*TOOLT       0.650  0.923  0.899
25  TOOLA1*TOOLD*TOOLT        0.676  0.914  0.895
26  TOOLA2*TOOLD*TOOLT        0.663  0.904  0.881
27  TOOLA1*TOOLA2*TOOLD*TOOLT  0.628  0.933  0.905
--------------------------------------------------

> superSubset(mydata[,c(6,7,8,9,13)], outcome = "BMI", incl.cut = 0.4, cov.cut = 0.6, ron.cut = 0.6)

                     inclN   RoN   covN
--------------------------------------------------
 1  toola1                 0.444  0.908  0.808
 2  TOOLA1                 0.858  0.753  0.827
 3  toola2                 0.531  0.854  0.775
 4  TOOLA2                 0.775  0.843  0.859
 5  toold                  0.501  0.864  0.773
 6  TOOLD                  0.804  0.828  0.857
 7  toolt                  0.504  0.875  0.788
 8  TOOLT                  0.800  0.813  0.845
 9  TOOLA1*toola2          0.458  0.967  0.924
10  TOOLA1*TOOLA2          0.724  0.914  0.907
11  TOOLA1*toold           0.427  0.957  0.895
12  TOOLA1*TOOLD           0.749  0.912  0.911
13  TOOLA1*toolt           0.437  0.953  0.891
14  TOOLA1*TOOLT           0.743  0.906  0.904
15  toola2*toold           0.440  0.890  0.778
16  toola2*TOOLD           0.407  0.988  0.967
17  TOOLA2*TOOLD           0.733  0.899  0.895
18  toola2*toolt           0.423  0.921  0.822
19  toola2*TOOLT           0.411  0.967  0.914
20  TOOLA2*TOOLT           0.698  0.911  0.898
21  toold*toolt            0.420  0.911  0.803
22  TOOLD*TOOLT            0.736  0.899  0.895
23  TOOLA1*TOOLA2*TOOLD       0.690  0.945  0.933
24  TOOLA1*TOOLA2*TOOLT       0.667  0.947  0.932
25  TOOLA1*TOOLD*TOOLT        0.697  0.942  0.931
26  TOOLA2*TOOLD*TOOLT        0.680  0.926  0.911
27  TOOLA1*TOOLA2*TOOLD*TOOLT  0.650  0.959  0.944
--------------------------------------------------

>
>
> # Truth table development for VDEL
> ttB=truthTable(mydata[,c(6,7,8,9,10)], outcome = "VDEL", complete = TRUE, sort.by = "incl, n+")
> ttB=truthTable(mydata[,c(6,7,8,9,10)], outcome = "VDEL", complete = TRUE,n.cut = 2, incl.cut = c(0.89), sort.by = "incl, n+")
>
> # Find simultaneous subset relations from the most parsimonious solution
> SSR <- findRows(obj = ttB, type = 3)
> SSR
numeric(0)
> # Find contradictory simplifying assumptions from the most parsimonious solution
> CSA <- findRows(obj = ttB, type = 2)

Error: None of the values in OUT is explained. Please check the truth table.

>
> # Standard Analysis
> PS=minimize(ttB, include = "?")
> PS

M1: TOOLA1 + TOOLT => VDEL

> print(PS, details = TRUE)

  OUT: output value
    n: number of cases in configuration
 incl: sufficiency inclusion score
  PRI: proportional reduction in inconsistency

    TOOLA1 TOOLA2 TOOLD TOOLT   OUT    n   incl  PRI
15    1      1      1     0      1     2   0.955 0.821
12    1      0      1     1      1     4   0.950 0.827
14    1      1      0     1      1     5   0.942 0.793
13    1      1      0     0      1     3   0.938 0.743
10    1      0      0     1      1     4   0.932 0.742
 8    0      1      1     1      1     7   0.931 0.765
 9    1      0      0     0      1     6   0.912 0.671
16    1      1      1     1      1    30   0.912 0.835
```

```
 2   0   0   0   1   1   3  0.898 0.605
 1   0   0   0   0   0   13  0.814 0.501
 7   0   1   1   0   ?   1  0.949 0.753
 3   0   0   1   0   ?   0   -   -
 4   0   0   1   1   ?   0   -   -
 5   0   1   0   0   ?   0   -   -
 6   0   1   0   1   ?   0   -   -
11   1   0   1   0   ?   0   -   -

n OUT = 1/0/C: 64/13/0
  Total    : 77

M1: TOOLA1 + TOOLT => VDEL

        inclS   PRI   covS   covU
-------------------------------------
1  TOOLA1  0.818  0.709  0.830  0.118
2  TOOLT   0.842  0.745  0.780  0.067
-------------------------------------
   M1     0.790  0.679  0.897

> PI=minimize(ttB, include = "?", dir.exp = "1,1,1,1")
> PI

From C1P1:

M1:    TOOLA1 + TOOLT => VDEL

> print(PI, details = TRUE)

  OUT: output value
    n: number of cases in configuration
 incl: sufficiency inclusion score
  PRI: proportional reduction in inconsistency

    TOOLA1 TOOLA2 TOOLD TOOLT   OUT    n   incl  PRI
15   1    1    1    0    1   2  0.955 0.821
12   1    0    1    1    1   4  0.950 0.827
14   1    1    0    1    1   5  0.942 0.793
13   1    1    0    0    1   3  0.938 0.743
10   1    0    0    1    1   4  0.932 0.742
 8   0    1    1    1    1   7  0.931 0.765
 9   1    0    0    0    1   6  0.912 0.671
16   1    1    1    1    1   30  0.912 0.835
 2   0    0    0    1    1   3  0.898 0.605
 1   0    0    0    0    0   13  0.814 0.501
 7   0    1    1    0    ?   1  0.949 0.753
 3   0    0    1    0    ?   0   -   -
 4   0    0    1    1    ?   0   -   -
 5   0    1    0    0    ?   0   -   -
 6   0    1    0    1    ?   0   -   -
11   1    0    1    0    ?   0   -   -

n OUT = 1/0/C: 64/13/0
  Total    : 77

From C1P1:

M1:    TOOLA1 + TOOLT => VDEL

        inclS   PRI   covS   covU
-------------------------------------
1  TOOLA1  0.818  0.709  0.830  0.118
2  TOOLT   0.842  0.745  0.780  0.067
-------------------------------------
   M1     0.790  0.679  0.897

> PC=minimize(ttB)
> PC

M1: TOOLA1*TOOLA2 + TOOLA1*toold + TOOLA1*TOOLT + toola2*toold*TOOLT + TOOLA2*TOOLD*TOOLT => VDEL

> print(PC, details = TRUE)

  OUT: output value
    n: number of cases in configuration
 incl: sufficiency inclusion score
```

```
  PRI: proportional reduction in inconsistency

    TOOLA1 TOOLA2 TOOLD TOOLT   OUT    n   incl  PRI
15    1     1     1     0     1    2   0.955 0.821
12    1     0     1     1     1    4   0.950 0.827
14    1     1     0     1     1    5   0.942 0.793
13    1     1     0     0     1    3   0.938 0.743
10    1     0     0     1     1    4   0.932 0.742
 8    0     1     1     1     1    7   0.931 0.765
 9    1     0     0     0     1    6   0.912 0.671
16    1     1     1     1     1    30  0.912 0.835
 2    0     0     0     1     1    3   0.898 0.605
 1    0     0     0     0     0    13  0.814 0.501
 7    0     1     1     0     ?    1   0.949 0.753
 3    0     0     1     0     ?    0   -   -
 4    0     0     1     1     ?    0   -   -
 5    0     1     0     0     ?    0   -   -
 6    0     1     0     1     ?    0   -   -
11    1     0     1     0     ?    0   -   -

n OUT = 1/0/C: 64/13/0
  Total     : 77

M1: TOOLA1*TOOLA2 + TOOLA1*toold + TOOLA1*TOOLT + toola2*toold*TOOLT + TOOLA2*TOOLD*TOOLT => VDEL

                 inclS   PRI   covS   covU
-------------------------------------------------
1  TOOLA1*TOOLA2       0.888  0.800  0.693  0.020
2  TOOLA1*toold        0.886  0.700  0.413  0.036
3  TOOLA1*TOOLT        0.885  0.801  0.712  0.038
4  toola2*toold*TOOLT  0.903  0.691  0.318  0.021
5  TOOLA2*TOOLD*TOOLT  0.887  0.800  0.647  0.030
-------------------------------------------------
   M1              0.839  0.739  0.862

>
>
> # Truth table development for VCRE
> ttB=truthTable(mydata[,c(6,7,8,9,11)], outcome = "VCRE", complete = TRUE, n.cut = 2, incl.cut = c(0.89), sort.by = "incl, n+")
> ttB

  OUT: output value
    n: number of cases in configuration
 incl: sufficiency inclusion score
  PRI: proportional reduction in inconsistency

    TOOLA1 TOOLA2 TOOLD TOOLT   OUT    n   incl  PRI
15    1     1     1     0     1    2   0.961 0.850
12    1     0     1     1     1    4   0.951 0.816
14    1     1     0     1     1    5   0.944 0.782
13    1     1     0     0     1    3   0.940 0.747
 8    0     1     1     1     1    7   0.940 0.812
10    1     0     0     1     1    4   0.932 0.730
16    1     1     1     1     1    30  0.927 0.864
 9    1     0     0     0     1    6   0.907 0.636
 2    0     0     0     1     1    3   0.895 0.567
 1    0     0     0     0     0    13  0.772 0.383
 7    0     1     1     0     ?    1   0.941 0.737
 3    0     0     1     0     ?    0   -   -
 4    0     0     1     1     ?    0   -   -
 5    0     1     0     0     ?    0   -   -
 6    0     1     0     1     ?    0   -   -
11    1     0     1     0     ?    0   -   -

>
> # Find simultaneous subset relations from the most parsimonious solution
> SSR <- findRows(obj = ttB, type = 3)
> SSR
numeric(0)
> # Find contradictory simplifying assumptions from the most parsimonious solution
> CSA <- findRows(obj = ttB, type = 2)

Error: None of the values in OUT is explained. Please check the truth table.

>
> # Standard Analysis
> PS=minimize(ttB, include = "?")
```

```
> PS

M1: TOOLA1 + TOOLT => VCRE

> print(PS, details = TRUE)

  OUT: output value
    n: number of cases in configuration
 incl: sufficiency inclusion score
  PRI: proportional reduction in inconsistency

    TOOLA1 TOOLA2 TOOLD TOOLT   OUT    n   incl  PRI
15    1     1     1    0     1    2   0.961 0.850
12    1     0     1    1     1    4   0.951 0.816
14    1     1     0    1     1    5   0.944 0.782
13    1     1     0    0     1    3   0.940 0.747
 8    0     1     1    1     1    7   0.940 0.812
10    1     0     0    1     1    4   0.932 0.730
16    1     1     1    1     1    30  0.927 0.864
 9    1     0     0    0     1    6   0.907 0.636
 2    0     0     0    1     1    3   0.895 0.567
 1    0     0     0    0     0    13  0.772 0.383
 7    0     1     1    0     ?    1   0.941 0.737
 3    0     0     1    0     ?    0    -    -
 4    0     0     1    1     ?    0    -    -
 5    0     1     0    0     ?    0    -    -
 6    0     1     0    1     ?    0    -    -
11    1     0     1    0     ?    0    -    -

n OUT = 1/0/C: 64/13/0
  Total      : 77

M1: TOOLA1 + TOOLT => VCRE

          inclS   PRI   covS   covU
-------------------------------------
1  TOOLA1  0.805  0.684  0.847  0.115
2  TOOLT   0.833  0.725  0.800  0.068
-------------------------------------
   M1      0.776  0.652  0.915

> PI=minimize(ttB, include = "?", dir.exp = "1,1,1,1")
> PI

From C1P1:

M1:    TOOLA1 + TOOLT => VCRE

> print(PI, details = TRUE)

  OUT: output value
    n: number of cases in configuration
 incl: sufficiency inclusion score
  PRI: proportional reduction in inconsistency

    TOOLA1 TOOLA2 TOOLD TOOLT   OUT    n   incl  PRI
15    1     1     1    0     1    2   0.961 0.850
12    1     0     1    1     1    4   0.951 0.816
14    1     1     0    1     1    5   0.944 0.782
13    1     1     0    0     1    3   0.940 0.747
 8    0     1     1    1     1    7   0.940 0.812
10    1     0     0    1     1    4   0.932 0.730
16    1     1     1    1     1    30  0.927 0.864
 9    1     0     0    0     1    6   0.907 0.636
 2    0     0     0    1     1    3   0.895 0.567
 1    0     0     0    0     0    13  0.772 0.383
 7    0     1     1    0     ?    1   0.941 0.737
 3    0     0     1    0     ?    0    -    -
 4    0     0     1    1     ?    0    -    -
 5    0     1     0    0     ?    0    -    -
 6    0     1     0    1     ?    0    -    -
11    1     0     1    0     ?    0    -    -

n OUT = 1/0/C: 64/13/0
  Total      : 77

From C1P1:
```

```
M1:    TOOLA1 + TOOLT => VCRE

         inclS   PRI   covS   covU
-------------------------------------
1  TOOLA1  0.805  0.684  0.847  0.115
2  TOOLT   0.833  0.725  0.800  0.068
-------------------------------------
   M1     0.776  0.652  0.915

> PC=minimize(ttB)
> PC

M1: TOOLA1*TOOLA2 + TOOLA1*toold + TOOLA1*TOOLT + toola2*toold*TOOLT + TOOLA2*TOOLD*TOOLT => VCRE

> print(PC, details = TRUE)

  OUT: output value
    n: number of cases in configuration
 incl: sufficiency inclusion score
  PRI: proportional reduction in inconsistency

     TOOLA1 TOOLA2 TOOLD TOOLT   OUT    n   incl  PRI
15    1     1     1     0     1    2   0.961 0.850
12    1     0     1     1     1    4   0.951 0.816
14    1     1     0     1     1    5   0.944 0.782
13    1     1     0     0     1    3   0.940 0.747
 8    0     1     1     1     1    7   0.940 0.812
10    1     0     0     1     1    4   0.932 0.730
16    1     1     1     1     1    30  0.927 0.864
 9    1     0     0     0     1    6   0.907 0.636
 2    0     0     0     1     1    3   0.895 0.567
 1    0     0     0     0     0    13  0.772 0.383
 7    0     1     1     0     ?    1   0.941 0.737
 3    0     0     1     0     ?    0    -    -
 4    0     0     1     1     ?    0    -    -
 5    0     1     0     0     ?    0    -    -
 6    0     1     0     1     ?    0    -    -
11    1     0     1     0     ?    0    -    -

n OUT = 1/0/C: 64/13/0
  Total     : 77

M1: TOOLA1*TOOLA2 + TOOLA1*toold + TOOLA1*TOOLT + toola2*toold*TOOLT + TOOLA2*TOOLD*TOOLT => VCRE

                  inclS   PRI   covS   covU
-------------------------------------------------
1  TOOLA1*TOOLA2       0.894  0.809  0.723  0.021
2  TOOLA1*toold       0.870  0.632  0.421  0.031
3  TOOLA1*TOOLT       0.878  0.785  0.732  0.030
4  toola2*toold*TOOLT  0.901  0.653  0.329  0.020
5  TOOLA2*TOOLD*TOOLT  0.908  0.837  0.687  0.035
-------------------------------------------------
   M1              0.829  0.718  0.884

>
> # Truth table development for VCAP
> ttB=truthTable(mydata[,c(6,7,8,9,12)], outcome = "VCAP", complete = TRUE,
  n.cut = 2, incl.cut = c(0.88), sort.by = "incl, n+")
> ttB

  OUT: output value
    n: number of cases in configuration
 incl: sufficiency inclusion score
  PRI: proportional reduction in inconsistency

     TOOLA1 TOOLA2 TOOLD TOOLT   OUT    n   incl  PRI
12    1     0     1     1     1    4   0.965 0.866
14    1     1     0     1     1    5   0.960 0.836
15    1     1     1     0     1    2   0.956 0.840
10    1     0     0     1     1    4   0.936 0.724
 8    0     1     1     1     1    7   0.924 0.752
13    1     1     0     0     1    3   0.920 0.696
16    1     1     1     1     1    30  0.905 0.821
 9    1     0     0     0     1    6   0.903 0.644
 2    0     0     0     1     1    3   0.889 0.519
 1    0     0     0     0     0    13  0.827 0.504
```

```
 7   0    1    1    0    ?   1  0.961 0.830
 3   0    0    1    0    ?   0   -   -
 4   0    0    1    1    ?   0   -   -
 5   0    1    0    0    ?   0   -   -
 6   0    1    0    1    ?   0   -   -
11    1    0    1    0    ?   0   -   -

> # Find simultaneous subset relations from the most parsimonious solution
> SSR <- findRows(obj = ttB, type = 3)
> SSR
numeric(0)
> # Find contradictory simplifying assumptions from the most parsimonious solution
> CSA <- findRows(obj = ttB, type = 2)

Error: None of the values in OUT is explained. Please check the truth table.

> # Standard Analysis
> PS=minimize(ttB, include = "?")
> PS

M1: TOOLA1 + TOOLT => VCAP

> print(PS, details = TRUE)

  OUT: output value
    n: number of cases in configuration
 incl: sufficiency inclusion score
  PRI: proportional reduction in inconsistency

    TOOLA1 TOOLA2 TOOLD TOOLT   OUT    n   incl  PRI
12    1     0     1     1     1    4  0.965 0.866
14    1     1     0     1     1    5  0.960 0.836
15    1     1     1     0     1    2  0.956 0.840
10    1     0     0     1     1    4  0.936 0.724
 8   0    1     1     1     1    7  0.924 0.752
13    1     1     0     0     1    3  0.920 0.696
16    1     1     1     1     1    30  0.905 0.821
 9   1     0     0     0     1    6  0.903 0.644
 2   0     0     0     1     1    3  0.889 0.519
 1   0     0     0     0     0    13  0.827 0.504
 7   0    1     1     0     ?    1  0.961 0.830
 3   0     0     1     0     ?    0   -   -
 4   0     0     1     1     ?    0   -   -
 5   0     1     0     0     ?    0   -   -
 6   0     1     0     1     ?    0   -   -
11    1     0     1     0     ?    0   -   -

n OUT = 1/0/C: 64/13/0
  Total      : 77

M1: TOOLA1 + TOOLT => VCAP

          inclS   PRI   covS   covU
-------------------------------------
1  TOOLA1  0.801  0.682  0.839  0.116
2  TOOLT   0.814  0.695  0.778  0.055
-------------------------------------
   M1      0.763  0.636  0.894

> PI=minimize(ttB, include = "?", dir.exp = "1,1,1,1")
> PI

From C1P1:

M1:    TOOLA1 + TOOLT => VCAP

> print(PI, details = TRUE)

  OUT: output value
    n: number of cases in configuration
 incl: sufficiency inclusion score
  PRI: proportional reduction in inconsistency

    TOOLA1 TOOLA2 TOOLD TOOLT   OUT    n   incl  PRI
12    1     0     1     1     1    4  0.965 0.866
14    1     1     0     1     1    5  0.960 0.836
15    1     1     1     0     1    2  0.956 0.840
```

```
10   1    0    0   1    1    4   0.936 0.724
 8   0    1    1   1    1    7   0.924 0.752
13   1    1    0   0    1    3   0.920 0.696
16   1    1    1   1    1    30  0.905 0.821
 9   1    0    0   0    1    6   0.903 0.644
 2   0    0    0   1    1    3   0.889 0.519
 1   0    0    0   0    0    13  0.827 0.504
 7   0    1    1   0    ?    1   0.961 0.830
 3   0    0    1   0    ?    0    -    -
 4   0    0    1   1    ?    0    -    -
 5   0    1    0   0    ?    0    -    -
 6   0    1    0   1    ?    0    -    -
11   1    0    1   0    ?    0    -    -

n OUT = 1/0/C: 64/13/0
  Total     : 77

From C1P1:

M1:    TOOLA1 + TOOLT => VCAP

         inclS   PRI   covS   covU
-------------------------------------
1  TOOLA1  0.801  0.682  0.839  0.116
2  TOOLT   0.814  0.695  0.778  0.055
-------------------------------------
   M1      0.763  0.636  0.894

> PC=minimize(ttB)
> PC

M1: TOOLA1*TOOLA2 + TOOLA1*toold + TOOLA1*TOOLT + toola2*toold*TOOLT + TOOLA2*TOOLD*TOOLT
    => VCAP

> print(PC, details = TRUE)

  OUT: output value
    n: number of cases in configuration
 incl: sufficiency inclusion score
  PRI: proportional reduction in inconsistency

   TOOLA1 TOOLA2 TOOLD TOOLT   OUT    n   incl  PRI
12   1    0    1   1    1    4   0.965 0.866
14   1    1    0   1    1    5   0.960 0.836
15   1    1    1   0    1    2   0.956 0.840
10   1    0    0   1    1    4   0.936 0.724
 8   0    1    1   1    1    7   0.924 0.752
13   1    1    0   0    1    3   0.920 0.696
16   1    1    1   1    1    30  0.905 0.821
 9   1    0    0   0    1    6   0.903 0.644
 2   0    0    0   1    1    3   0.889 0.519
 1   0    0    0   0    0    13  0.827 0.504
 7   0    1    1   0    ?    1   0.961 0.830
 3   0    0    1   0    ?    0    -    -
 4   0    0    1   1    ?    0    -    -
 5   0    1    0   0    ?    0    -    -
 6   0    1    0   1    ?    0    -    -
11   1    0    1   0    ?    0    -    -

n OUT = 1/0/C: 64/13/0
  Total     : 77

M1: TOOLA1*TOOLA2 + TOOLA1*toold + TOOLA1*TOOLT + toola2*toold*TOOLT + TOOLA2*TOOLD*TOOLT
    => VCAP

                 inclS   PRI   covS   covU
-------------------------------------------------
1  TOOLA1*TOOLA2       0.873  0.777  0.703  0.020
2  TOOLA1*toold        0.879  0.666  0.423  0.036
3  TOOLA1*TOOLT        0.871  0.773  0.723  0.033
4  toola2*toold*TOOLT  0.889  0.595  0.323  0.015
5  TOOLA2*TOOLD*TOOLT  0.881  0.787  0.663  0.030
-------------------------------------------------
   M1                  0.813  0.696  0.862


>
```

```
> # Truth table development for BMI
> ttB=truthTable(mydata[,c(6,7,8,9,13)], outcome = "BMI", complete = TRUE,  n.cut = 2, incl.cut = c(0.9), sort.by = "incl, n+")
> ttB

  OUT: output value
    n: number of cases in configuration
 incl: sufficiency inclusion score
  PRI: proportional reduction in inconsistency

    TOOLA1 TOOLA2 TOOLD TOOLT   OUT    n   incl  PRI
12    1     0     1     1     1    4   0.968 0.861
15    1     1     1     0     1    2   0.967 0.842
14    1     1     0     1     1    5   0.961 0.820
 8    0     1     1     1     1    7   0.954 0.801
10    1     0     0     1     1    4   0.945 0.738
16    1     1     1     1     1    30  0.944 0.887
13    1     1     0     0     1    3   0.942 0.716
 9    1     0     0     0     1    6   0.928 0.661
 2    0     0     0     1     1    3   0.904 0.496
 1    0     0     0     0     0    13  0.827 0.410
 7    0     1     1     0     ?    1   0.962 0.773
 3    0     0     1     0     ?    0    -    -
 4    0     0     1     1     ?    0    -    -
 5    0     1     0     0     ?    0    -    -
 6    0     1     0     1     ?    0    -    -
11    1     0     1     0     ?    0    -    -

>
> # Find simultaneous subset relations from the most parsimonious solution
> SSR <- findRows(obj = ttB, type = 3)
> SSR
numeric(0)
> # Find contradictory simplifying assumptions from the most parsimonious solution
> CSA <- findRows(obj = ttB, type = 2)

Error: None of the values in OUT is explained. Please check the truth table.

>
> # Standard Analysis
> PS=minimize(ttB, include = "?")
> PS

M1: TOOLA1 + TOOLT => BMI

> print(PS, details = TRUE)

  OUT: output value
    n: number of cases in configuration
 incl: sufficiency inclusion score
  PRI: proportional reduction in inconsistency

    TOOLA1 TOOLA2 TOOLD TOOLT   OUT    n   incl  PRI
12    1     0     1     1     1    4   0.968 0.861
15    1     1     1     0     1    2   0.967 0.842
14    1     1     0     1     1    5   0.961 0.820
 8    0     1     1     1     1    7   0.954 0.801
10    1     0     0     1     1    4   0.945 0.738
16    1     1     1     1     1    30  0.944 0.887
13    1     1     0     0     1    3   0.942 0.716
 9    1     0     0     0     1    6   0.928 0.661
 2    0     0     0     1     1    3   0.904 0.496
 1    0     0     0     0     0    13  0.827 0.410
 7    0     1     1     0     ?    1   0.962 0.773
 3    0     0     1     0     ?    0    -    -
 4    0     0     1     1     ?    0    -    -
 5    0     1     0     0     ?    0    -    -
 6    0     1     0     1     ?    0    -    -
11    1     0     1     0     ?    0    -    -

n OUT = 1/0/C: 64/13/0
  Total      : 77

M1: TOOLA1 + TOOLT => BMI

          inclS   PRI   covS   covU
-------------------------------------
1  TOOLA1  0.827  0.705  0.858  0.114
```

```
2  TOOLT   0.845  0.730  0.800  0.057
-------------------------------------
   M1      0.787  0.653  0.915

> PI=minimize(ttB, include = "?", dir.exp = "1,1,1,1")
> PI

From C1P1:

M1:    TOOLA1 + TOOLT => BMI

> print(PI, details = TRUE)

  OUT: output value
    n: number of cases in configuration
 incl: sufficiency inclusion score
  PRI: proportional reduction in inconsistency

     TOOLA1 TOOLA2 TOOLD TOOLT   OUT    n   incl  PRI
12    1     0     1     1     1    4   0.968 0.861
15    1     1     1     0     1    2   0.967 0.842
14    1     1     0     1     1    5   0.961 0.820
 8    0     1     1     1     1    7   0.954 0.801
10    1     0     0     1     1    4   0.945 0.738
16    1     1     1     1     1    30  0.944 0.887
13    1     1     0     0     1    3   0.942 0.716
 9    1     0     0     0     1    6   0.928 0.661
 2    0     0     0     1     1    3   0.904 0.496
 1    0     0     0     0     0    13  0.827 0.410
 7    0     1     1     0     ?    1   0.962 0.773
 3    0     0     1     0     ?    0    -    -
 4    0     0     1     1     ?    0    -    -
 5    0     1     0     0     ?    0    -    -
 6    0     1     0     1     ?    0    -    -
11    1     0     1     0     ?    0    -    -

n OUT = 1/0/C: 64/13/0
  Total      : 77

From C1P1:

M1:    TOOLA1 + TOOLT => BMI

           inclS   PRI   covS   covU
-------------------------------------
1  TOOLA1  0.827  0.705  0.858  0.114
2  TOOLT   0.845  0.730  0.800  0.057
-------------------------------------
   M1      0.787  0.653  0.915

> PC=minimize(ttB)
> PC

M1: TOOLA1*TOOLA2 + TOOLA1*toold + TOOLA1*TOOLT + toola2*toold*TOOLT + TOOLA2*TOOLD*TOOLT => BMI

> print(PC, details = TRUE)

  OUT: output value
    n: number of cases in configuration
 incl: sufficiency inclusion score
  PRI: proportional reduction in inconsistency

     TOOLA1 TOOLA2 TOOLD TOOLT   OUT    n   incl  PRI
12    1     0     1     1     1    4   0.968 0.861
15    1     1     1     0     1    2   0.967 0.842
14    1     1     0     1     1    5   0.961 0.820
 8    0     1     1     1     1    7   0.954 0.801
10    1     0     0     1     1    4   0.945 0.738
16    1     1     1     1     1    30  0.944 0.887
13    1     1     0     0     1    3   0.942 0.716
 9    1     0     0     0     1    6   0.928 0.661
 2    0     0     0     1     1    3   0.904 0.496
 1    0     0     0     0     0    13  0.827 0.410
 7    0     1     1     0     ?    1   0.962 0.773
 3    0     0     1     0     ?    0    -    -
 4    0     0     1     1     ?    0    -    -
 5    0     1     0     0     ?    0    -    -
```

```
 6   0   1   0   1   ?   0   -   -
11   1   0   1   0   ?   0   -   -

n OUT = 1/0/C: 64/13/0
  Total     : 77

M1: TOOLA1*TOOLA2 + TOOLA1*toold + TOOLA1*TOOLT + toola2*toold*TOOLT + TOOLA2*TOOLD*TOOLT => BMI

                  inclS   PRI   covS   covU
--------------------------------------------------
1  TOOLA1*TOOLA2       0.907  0.822  0.724  0.019
2  TOOLA1*toold        0.895  0.673  0.427  0.038
3  TOOLA1*TOOLT        0.904  0.820  0.743  0.034
4  toola2*toold*TOOLT  0.910  0.630  0.328  0.020
5  TOOLA2*TOOLD*TOOLT  0.911  0.829  0.680  0.025
--------------------------------------------------
   M1                  0.844  0.728  0.887


>
```