

## INNOVATION MANAGEMENT TECHNIQUES — A REVIEW FROM A STAKEHOLDER'S FOCUS PERSPECTIVE

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Received 25 November 2022

Revised 4 December 2024

Accepted 12 December 2024

Published 3 March 2025

This article analyses innovation management techniques (IMTs) or practices and their efficiency from a new perspective — stakeholder management — through three proxy models: environmental strategy, quality management, and corporate social responsibility. It also investigates the role of the Research and Development (R&D) function, particularly its critical position in adopting IMTs. It incorporates recent concepts such as co-innovation, design thinking, lean innovation, and artificial intelligence models. In this relationship, through a comprehensive literature review, this article develops a theoretical context to understand the evolution of the theory and practice of IMTs. This study draws on field research with data on 529 Spanish firms, their IMTs and stakeholders' management practices, and their innovation results. Through a partial least squares (PLS) analysis, this study illustrates a model delineating the role of stakeholders' focused management on the effect of IMTs on a firm's innovation performance. This research concludes on the

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relevance of IMT use to the incremental innovation output of companies. The stakeholders' management and R&D focus is supporting the innovation process. The main result is that incremental innovation is the path to radical innovation development. Thus, the findings conclude that a well-structured innovation system with precise stakeholder engagement underpins overall inventive activity inside firms. Various innovative approaches (IMTs) provide a systematic approach to invention, increasing the launch of successful ideas to the market.

*Keywords:* Innovation management techniques; innovation management practices; R&D management; stakeholders focus; corporate social responsibility; environmental strategy; quality management; innovation performance; radical innovation; incremental innovation.

## **Introduction and Objectives**

While the subject of “innovation management” has been extensively researched by the Academy, with Google Scholar yielding 1.150.000 results, the specific areas of “innovation management tools” and “practices” have a much narrower scope, with only 1.150 and 650 results, respectively. However, the demand for these topics in the practitioner’s area is significantly higher, with 15.700.000 results for “innovation management,” 152.000 results for “tools,” and 297.000 for the term “practices.” This disparity between academic research and practical demand underscores the crucial importance of our research and its direct relevance to managerial applicability. This question was suggested by [Van de Ven \(1986\)](#). Recent academic models such as open innovation, disruptive innovation, user innovation, innovation ecosystems, and design thinking have illustrated innovation management practices based on practical case studies. However, some authors ([Eveleens, 2010](#); [Tidd and Bessant, 2018](#)) have pointed out the critical need for connections between academic innovation literature and practice. Thus, this research subject is a matter of academic interest and crucial for practitioners to be sufficiently coherent and cumulative.

As mentioned, the management of innovation has received ample attention from scholars. Some early authors focused on organisational aspects ([Burns and Stalker, 1961](#)) and later managers’ focus and perceptions ([Storey, 2000](#)). However, the literature has advanced towards a more broad and systemic view of innovation, analysing processes, models, systems, strategy, change aspects, or entrepreneurial activity (e.g., [Tidd, 2001](#); [Tidd and Bessant, 2018](#)), and it is nevertheless a topic of debate in academic literature. Academy points out the need for a broader approach to managing innovation at firms and a holistic and contingent view of the available challenges and models ([Eveleens, 2010](#)).

Hence, from the practical side, there is a high demand among firms for pragmatic approaches to managing innovation, including recent challenges such as

globalisation, climate change, or societal projection. Therefore, several management models have been proposed to cope with innovation performance at a firm level. According to Drucker, a classic thinker, the critical challenges of innovation management are handling growing uncertainties and expanding global competition (Drucker, 2007, p. xix). Thus, numerous innovation management models and techniques or tools have been suggested to manage innovation more efficiently. This article, focusing on the latter, aims at providing a comprehensive and holistic view of innovation management practice.

We will aim to answer several research questions: How do new developments in innovation research affect management practice? Which tools and techniques are most widely used? Are there performance facts to be considered? How can these management practices be viewed broadly, such as the stakeholders' impact?

Regarding managing innovation, Van de Ven (1986) was a precursor in relating innovation to stakeholders. He (p. 591) emphasises that the central points of innovation management are based on four primary factors: "new ideas, people, transactions, and institutional context." Consequently, a firm's Research and Development (R&D) function pursues the points enabling those factors in the subsequent efficient assimilation and exploitation of knowledge (Liyanage *et al.*, 1999).

Recent academic literature has revised the role of stakeholders in the outcomes of firm innovation. Some streams focused on the involvement of stakeholders in co-innovation (Albors-Garrigos, *et al.*, 2018; Loureiro *et al.*, 2020; Markovic and Bagherzadeh, 2018). Others have revised their role in innovation management (Shams *et al.*, 2020; Veronica *et al.*, 2020). Alternatively, Silva *et al.* (2019) and Adner (2006) underscore how stakeholders' early involvement in the innovation process may reduce the risks involved in innovation exploitation. However, the subject has been dealt with loosely.

This study aims to contribute to this discussion and concentrate on how two factors, namely management focused on the public and the institutional context, which we could denominate as a "stakeholder-focused management approach" that prioritises the needs and interests of all stakeholders involved in the innovation process, moderate the impact of innovation management approaches and tools on a company's innovation performance. This study introduces a new perspective in the field of innovation management practice. Additionally, we seek to identify the impact of the R&D function in this process. The article will be based on an extensive literature study using this broad approach. It will consider recent innovation models and modes, such as disruptive innovation, innovation ecosystems, user co-innovation, and new tools, such as artificial intelligence (AI). The article will draw a conceptual map based on specialised software, providing a comprehensive view of the innovation management landscape and instilling

confidence in the thoroughness of our research. This article is organised as follows. The first section will discuss the theoretical context and develop the research hypotheses. Next, we will describe and justify the supporting research methodology. The statistical analysis will follow the study's discussion and results. Finally, we will discuss the research and its practical implications, providing actionable insights for innovation management in academic and practical settings.

## **Theoretical Context and Literature Analysis**

We employed a qualitative content analysis (Mayring, 2015) to ensure a comprehensive and systematic approach to the literature analysis that aligns with accepted literature review methodologies. Our goal was to conduct a thorough conceptual and relational analysis of the collected material (Krippendorff, 2018), instilling confidence in the reliability of our research.

AtlasTi9.0 software was used to organise, manage, and analyse the text in the selected web pages, identify relevant topics, and refine and classify the material. Documents that were not directly related to the search were eliminated through a team consensus. Consequently, a conceptual analysis was conducted on innovation management tools to identify relevant theories, methods, and gaps in the existing research (Mayring, 2015; Krippendorff, 2018; Hart, 2018).

The advanced AtlasTi9.0 software was instrumental in our research, allowing us to organise, manage, and analyse the text in the selected articles with unparalleled efficiency. Its sophisticated features enabled us to identify the relevant topics and refine and classify the results according to the frequency of codes encountered, as per Friese's (2019) methodology, showcasing the technological sophistication of our research.

In the case of the academic literature, our research was carried out during 2022–2024 as part of a broader project on innovation management practices. The databases selected were Google Scholar, Web of Science, and Scopus. Additionally, selective searches were carried out on the innovation management journals ranked by Scimago. Initially, general search terms such as innovation management, innovation management practice, tools, and techniques were used. Later, they were completed with terms related to the research, such as stakeholder management, corporate responsibility, and innovation or R&D management. More recent concepts and paradigms, such as co-innovation, lean innovation, design thinking, and AI, were considered since they are now part of the new trends in innovation practice.

The initial selection process yielded 250 journal articles, book chapters, conference papers, and other academic material. We then meticulously examined abstracts and articles and performed an additional search to ensure that the topics included innovation management practice. The final selection was based on the

Table 1. Classification of the selected articles.

Main subject addressed	Articles	Accum. citations	Ave. citations
IMTS	19	2.922	153,8
Innovation models/AI	19	9.433	524,1
Innovation management	12	15.698	1.308,2
Stakeholders and innovation	14	4257	304,1
Total quality management (TQM) and innovation	8	3.337	417,1
Corporate Social Responsibility (CSR) and innovation	8	4.823	602,9
R&D & innovation	9	2.158	239,8
Innovation management/radical innovation	8	2879	359,9
Sustainability and innovation	3	965	321,7
IMTs in detail			
Knowledge Management (KM)	11	6.490	590,0
Technology Management (TM)	13	3.202	246,3
Human resources management (HRM)	6	2.054	342,3
Audits	4	2.730	682,5
Innovation measurement	2	2.668	1.334,0
Lean management and innovation	3	3.592	1.197,3
New product development (NPD)	4	291	72,8
Proj. management	2	310	155,0
Creativity	1	77	77,0
Entrepreneurship	1	251	251,0
Financing	1	62	62,0
Business intelligence	2	320	160,0
Networking	1	2.698	2.698,0
	151	71.217	474,8

subject’s relevance and impact (cites) details, resulting in 151 journal articles, chapters, and conference papers. This thorough material selection process demonstrates the rigour of our research. Table 1 shows a taxonomy of these articles. Each article has been classified into one family, determining the main topic discussed. The accumulated and average citations per subject show that innovation management, innovation models, stakeholder management, and innovation management techniques (IMTs) have a high impact, considering the average citations per article. Corporate social responsibility, quality management (QM), and innovation also have a relatively high impact. In the IMTs section, knowledge management (KM) and technology management (TM) were successfully covered by academia. It is interesting to observe that a single article on networking (Pittaway *et al.*, 2004) draws 2.699 citations.

The support of Atlas Ti9.0 has been a vital tool in our research process. This software allowed us to comprehensively analyse and classify/code the contents

Table 2. Codes frequency.

Code	Frequency	Code	Frequency
Innovation Management	2,485	Project Manag.	177
Creativity Develop.	990	Innovation Market. Tools	151
Open Innovation	961	Best Practices	149
Competitiveness	954	Artificial Intelligence	167
Knowledge Manag. Tools	820	Business Intelligence	144
Product Innovation	784	Innovation Ecosystem	141
Innovation Perform.	700	Continuous Improv.	137
Collaborative Tools	687	Prod. Management Tools	134
Total Quality Manag.	623	Innovation Risks	131
Technology Manag.	606	Patent Management	124
Design Manag. Tools	535	Sustainable Innov.	110
Radical Innovation	461	Users' Innovation	102
Stakeholders Manag.	435	Concurrent Engin.	102
Entrepreneurship Manag.	427	Lean Management	99
Incremental Innovation	401	Quality Funct. Deploy.	97
Innov. Management Tools and Techniques	394	Teamwork	92
R&D Management	387	Value Analysis	82
Process Innovation	323	Innovation Manag. Models	76
Corporate Social Respons.	303	Disruptive Innovation	62
Design Thinking	284	Innovation Audits	48
Networking	239	Process Reengineering	38
Compet. Strategic Technology	233	Just in Time	26
Sustainable Management	232	Failure Mode Analysis	25
NPD Management	223	Innovation Measurement	23
Benchmarking	216	Co-innovation	19
Service Innovation	205	Innov. Financ. Tools	15
Change Manag.	201	Organisative Innov.	5
Human Res. Manag.	194	Innovation Efficiency	2

according to specific categories. According to [Mayring \(2015\)](#), this approach includes a concept classification and code frequency analysis of the selected material. This method allowed the authors to build a map with associations to construct the literature analysis discussion ([Krippendorff, 2018](#); [Mayring, 2015](#)).

Using AtlasTiI.9.0, coding the journal articles and papers allowed us to identify 56 codes. These codes are gathered into eight families according to their co-occurrence. Table 2 indicates the frequency of the general codes and the families.

Observing Tables 1 and 2, we find some discrepancies and co-occurrences. Some concepts have few dedicated articles, while others are mentioned widely, such as R&D management, stakeholder management, corporate social responsibility, or

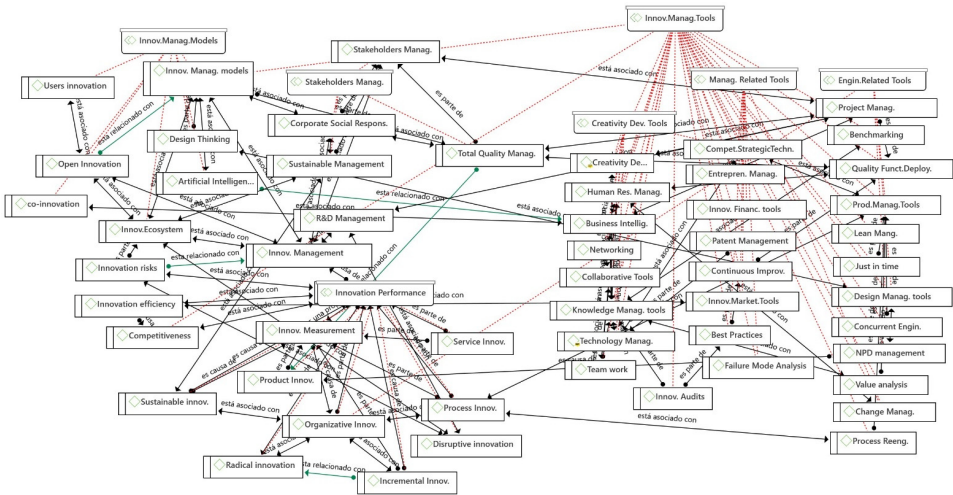


Fig. 1. Codes map according to Atlas Ti9.

sustainable management. Similarly, some IMTs (TM, creativity management tools, or HRM) have few dedicated articles but ample coding representation.

Our literature analysis will be guided by the family codes map drawn by Atlas Ti.9. The codes map, as shown in Fig. 1, depicts the families of IMTs, their relationships, and their taxonomy, a structure defined by previous authors (Albors *et al.*, 2018), on the right side. On the left side, it presents the contextual situation of IMTs, including innovation management, models, outcomes, and broader context stakeholder management. Notably, the codes map reveals the intense relationships between all codes, especially among IMTs.

### Innovation management and practice

An early researcher in innovation management (Van de Ven, 1986) introduced the idea of innovation management’s contingency on the firm’s environment and its stakeholders. This intent has been a subtle guide for many of the succeeding researchers. A relevant author on innovation management (Tidd, 2001, p. 173) pointed out that “research has failed to develop a comprehensive framework for innovation management practice for various reasons, including its lack of a contingent approach considering innovation, the environment, and its performance.”

The following authors have substantiated the approach by suggesting contingent tools for management practice. Oke and Goffin (2001) links innovation management practice to using tools in services such as performance measurement or industry property management. A follower (Eveleens, 2010) relates the six classical innovation models with several tools and practices that improve their

performance. In this line, Maital and Seshadri (2012) attempted to tackle innovation management by posing practices such as creativity development, organisational intelligence, innovation culture, and TM. Vaccaro *et al.* (2010) proposed leadership as a driver for innovation, while Carayannis *et al.* (2015) analyses innovation management practices from the view of KM, creativity, and entrepreneurship tools. Lawson and Samson (2001) posit that IMTs contribute to developing firm innovation capabilities.

Considering strategy, Chen *et al.* (2018) links open innovation with strategic collaboration, highlighting the importance of collaboration in the innovation process. Afuah (2003), following Eveleens (2010), published a manual that relates innovation strategy with the five classical innovation models. Furthermore, Ahmed *et al.* (2020) outlines that competitiveness can be developed through process, product innovation, and marketing tools. From the perspective of innovation outcomes, Nguyen (2021) conducted a literature review on innovation practices. Finally, Appio *et al.* (2021) analysed how digital transformation reshapes innovation ecosystems, emphasising the need for the audience to be aware of and adapt to these changes.

### **Innovation management models**

Innovation management practice has been related to innovation models. Hobday (2005) and Eveleens (2010) carried out a literature review on the six classical innovation models to identify contingent routines and management tools. Their results were not conclusive. However, recent literature has contemplated several innovation modes developed from case studies and with direct applications for practitioners. These models are related to the IMTs, which will be discussed below.

Goffin and Mitchell (2005) proposed the pentathlon model, identifying five crucial areas of the innovation process; however, it has not had a practical impact on followers. Following the previous scheme, Xu *et al.* (2007a, 2007b) suggested Haier as a case study of their proposed Total Innovation Management (TIM) model, with the culture of innovation as the spine of it. None of these had a further impact on followers. Aslam *et al.* (2020) tried to revive the model, describing it as Absolute Innovation (AI) by incorporating design thinking and innovation ecosystems. Similarly, Keeley *et al.* (2013) published a manual with 10 innovation models followed by leading innovative firms. This successful book, though with limited academic influence, had the potential to inspire practitioners to make a significant impact in the field.

Adner (2006), based on case studies, proposed a paradigm shift: the ecosystems of innovation. This paradigm effectively manages the risks associated with innovation by engaging with the innovation stakeholders, who play a crucial role in an

open innovation environment. The concept's significant impact on the field of innovation management is undeniable. [Granstrand and Holgersson \(2020\)](#) conducted a literature review. They defined an *innovation ecosystem* as “the evolving set of actors, activities, and artifacts, and the institutions and relations, including complementary and substitute relations, that are crucial for the innovative performance of an actor or a population of actors” (p. 2). This paradigm relates to the rest of the innovation models and is essential to understanding the role of IMTs.

[Piller and West \(2014\)](#) offered an engaging perspective within the Open Innovation framework of co-innovation, where firms leverage extensive knowledge, link it with users' innovation, and collaborate in search of their interests. In the same context of open innovation, [Saragih and Tan \(2018\)](#) published a literature review on co-innovation, defined as a shared work of generating innovative and exceptional design conducted by various actors from firms, customers, and collaborating partners. Furthermore, a successful case study of innovation in the retail sector has been discussed in this framework.

A new paradigm emerged at Stanford University in the 2010s, shaping the innovation ecosystem: Design Thinking ([Leifer et al., 2013](#)). With its five principles for innovation—empathise, define, ideate, prototype, and test, this approach has gained a significant grip among practitioners. [Nakata and Hwang's \(2020\)](#) survey of large firm managers highlighted its growing interest, particularly its contingent advantages in turbulent times. [Auernhammer and Roth \(2021\)](#) recently presented a literature review of the Design Thinking innovation model, offering a holistic perspective and fostering a creative culture within firms. [Verganti et al. \(2021\)](#) dedicated a particular issue in the *Journal of Product Innovation Management*, further emphasising the field's dynamic growth and the encouraging future of Design Thinking in innovation management.

Finally, recent literature has discussed a new paradigm or tool that leading firms adopt: AI. [Haefner et al. \(2021\)](#) pose that AI has a formative role where the usefulness of innovation management resources is overcome because of digitisation, and AI appears as the favoured option. The potential of AI resides in developing a more methodical approach by incorporating AI into organisations seeking innovation. [Füller et al. \(2022\)](#) surveyed 150 leading firm managers and concluded the crucial impact of AI in their innovation management, providing practical insights for firms considering AI adoption. These insights, drawn from recent studies, offer a wealth of knowledge for firms. Linked with the AI approach, [Muninger et al. \(2022\)](#) have accomplished a literature review on social media use for innovation management, offering practical guidance on integrating AI and social media strategies. Finally, [Grama and Magistretti \(2023\)](#) summarised the role of AI in influencing firms' innovation capabilities. They furnished a taxonomy of AI applications based on 62 empirical studies, offering a practical roadmap for

firms to leverage AI for innovation. They concluded with an AI taxonomy and identified two basic innovation capabilities triggered by AI adoption: enabling and enhancing innovation. Recently, [Roberts and Candi \(2024\)](#) surveyed a large sample of firms in the USA. They concluded that 50% of the surveyed firms used AI in their innovation projects, foreshadowing a promising future for this model.

## **Stakeholders' management and innovation**

A stream of recent literature links the stakeholder's paradigm with innovation. [Harrison et al. \(2010\)](#) state that firms developing trusting relationships with others share information regarding their utilities and allocate resources properly, promoting innovation, creating value, and contributing to creative processes. Similarly, [Kazadi et al. \(2016\)](#) conclude that stakeholders contribute to the development of KM and the firm's corporate capabilities.

[Igartua et al. \(2014b\)](#) considered four stakeholder systems followed by firms in their survey: quality, environmental, corporate social responsibility, and R&D. They found those firms presented a higher use of IMTs and innovation performance.

Various authors ([Pedrini and Ferri, 2019](#); [Leonidou et al., 2020](#); [Loureiro et al., 2020](#); [Shams et al., 2020](#)) carried out literature reviews on this subject and found links between stakeholder engagement with innovation management and subsequent entrepreneurship cocreation development. Similar conclusions were drawn from [Markovic and Bagherzadeh \(2018\)](#) regarding the mediating effect of KM.

[Silva et al. \(2019\)](#) developed a responsible (sustainable) innovation concept linked to adequate stakeholder engagement.

In a qualitative study, [Albats et al. \(2020\)](#) identify how open innovation requires the engagement of critical stakeholders. [Segarra-Oña et al. \(2020\)](#) arrive at the same outcome in the case of healthcare firms. [Veronica et al. \(2020\)](#) surveyed 80 high-tech small and medium-sized enterprises (SMEs) in Italy, and when combined with stakeholder engagement, sustainable innovation management becomes a crucial combination for their growth.

Following [Pedrini and Ferri \(2019\)](#) and [Godfrey et al. \(2009\)](#), we will consider three accepted management proxy concepts with a published background that support the management stakeholder approach: corporate social responsibility, QM, and sustainable management.

## **Corporate Social Responsibility (CSR) and Innovation**

### **CSR and innovation**

There are various articles claiming a relationship between CSR and innovation. [Gallego-Álvarez et al. \(2011\)](#) analysed a sample of prominent Dow Jones firms

with sustained R&D investments, demonstrating a positive relationship between corporate social responsibility practices and innovation, which varied according to the industry sector. In a different context of firm size (SMEs), [Ferauge \(2012\)](#), after a conceptual approach, points out the complementarity between CSR and innovation. Following this approach, [Kim et al. \(2014\)](#), with a large sample of French firms (800), concluded with the CSR catalyst role for innovation by fostering creativity. [Broadstock et al. \(2020\)](#) arrived at a similar conclusion in Japan with a large sample of the impact of CSR practices on value creation and innovation. [Altenburger \(2018\)](#) developed an interesting conceptual relationship between open innovation, CSR, and user innovation.

[Szutowski and Ratajczak \(2016\)](#) posed a similar model, suggesting that the impact of innovation on CSR practices depends on the type of innovation and degree of novelty. External factors, such as industry, company characteristics, performance, and R&D, also moderated the relationship.

Finally, [Zhou et al. \(2020\)](#) conducted a large sample and found that CSR positively affected service and product innovation in service and manufacturing firms. This was positively mediated by employee involvement and supplier collaboration.

### **Quality management and innovation**

QM has evolved towards the development of TQM, which considers all stakeholders in the product value chain, from suppliers to customers. Moreover, the third generation of QM has emerged as a stakeholder model with a holistic, relational focus ([Foster and Jonker, 2003](#)). Subsequent authors ([Bessant and Caffyn, 1997](#); [Bhuiyan and Baghel, 2005](#)) define continuous improvement (CI), a crucial QM program, as a tool for continuous innovation. Furthermore, [Prajogo and Sohal \(2003\)](#) and ([Hoang et al., 2006](#)) discuss two case studies and consider QM a tool for developing innovation. Finally, ([Zeng et al., 2015](#)), in a study of manufacturing firms, discovered that using “hard” QM tools has significantly impacted innovation performance.

A recent stream of literature studied the link of QM with ITMs. ([Yusr et al., 2017](#)) suggested the influence of QM on KM tools and the subsequent impact on innovation performance. [Perdomo-Ortiz et al. \(2009\)](#) suggested a correlation between QM and HRM and its positive impact on innovation outcomes. However, other authors have posed doubtful conclusions on the impact of QM tools on innovation outcomes ([Zammar et al., 2024](#); [Perdomo-Ortiz et al., 2009](#); [Lopes et al., 2022](#)).

### **Sustainable management and innovation**

Limited material has been published in this area. However, in an extensive study of Chinese firms, [Liao et al. \(2019\)](#) and [Yang et al. \(2019\)](#) have pointed out how

these firms have proactively developed their sustainable strategy and innovation skills in response to institutional and social pressures. Similarly, *Cillo et al. (2019)* have analysed the links between sustainable development and sustainable innovation, further highlighting the dynamic nature of the business environment.

*Liao and Tsai (2019)* surveyed 126 manufacturing firms in China, concluding that customer demand and environmental regulations significantly influence the effects of innovation intensity and creativity enhancement on eco-innovation strategies. This underscores the powerful influence of market forces on these firms' strategies.

### **The role of R&D management**

A few scholars have discussed the role of the R&D function in firms' innovation activities. Several have posed that R&D is not an essential function and procedure to guarantee the firm's innovation and success in innovation activities. After field studies, *Barge-Gil et al. (2011)*, *Hervas-Oliver et al. (2011)*, *Tsuji et al. (2018)*, and *Hameed et al. (2018)* concluded that innovation activity was possible in non-R&D firms that followed alternative procedures and tools.

On the other side, other authors have underscored the pivotal role of the R&D function. *Mikkola (2001)* outlines how R&D portfolio management techniques can lead to a significant increase in performance. In a Taiwan survey, *Huang and Lin (2006)* found that adequate R&D staff significantly contributes to better innovation performance, which should reassure and convince us of the importance of R&D. Similarly, *Love and Mansury (2007)* link R&D and external linkages to increasing innovation performance. *Rammer et al. (2009)* further underline that R&D is a crucial driver for innovation performance in SMEs with collaborating external R&D.

### **Incremental vs. radical innovation as an outcome**

The classical outcome of innovation is the consideration of incremental or radical innovation. Various authors have explored the transition from incremental to radical innovation, each offering unique perspectives. *McDermott and O'Connor (2002)* emphasise the role of market, firm staff resources, and Van Lacker *et al. (2016)* competencies and innovation capabilities. *Bessant et al. (2014)* underscore the crucial role of R&D and formal procedures in navigating the uncertain environment of radical innovation. *Ringberg et al. (2019)* advocate for a shift in managerial mindset, while *Coccia (2017)* suggests that problem-driven R&D can lead to radical innovation solutions. *Van Lancker et al. (2016)* highlight the potential of Open Innovation in fostering radical innovation outcomes.

A growing school of thought recognises innovation management tools' role in fostering radical innovation. [Gui et al. \(2022\)](#) highlight the transformative power of KM tools in the journey towards radical innovation. In a field study, [Rampa and Agogué \(2021\)](#) demonstrate how creativity tools can stimulate the development of radical innovation capabilities. [Oke \(2007\)](#), in a study on service firms' innovation, attributes radical innovation outcomes to the use of formal tools. Following this school, [Igartua et al. \(2014a,b\)](#) attribute success to various IMTs, including the crucial role of networking, financing innovation, creativity, patent policies, and business intelligence tools. Nevertheless, a recent survey led by [Ardito et al. \(2020\)](#) concluded, based on a sample of 6,000 firms in Italy, that sourcing knowledge from suppliers, customers, and competitors influenced balancing the outcome of incremental vs. radical innovation.

### **Innovation Management Tools (IMTs)**

The literature selection resulted in 19 articles centred on IMTs. We will analyse its findings. Innovation Management Tools (IMTs) have been defined as a “range of tools, techniques, and methodologies that help companies adapt to circumstances and systematically meet market challenges” ([Hidalgo and Albers, 2008](#), p. 117). In this respect, [Aas et al. \(2015\)](#) posit the need for a contingent view of innovation management practices within the innovation context.

This contingent approach is outlined by many researchers regarding the adoption of IMTs: [Libutti \(2000\)](#) described the promotion effort of introducing IMTs in Italian industries, mainly the marketing of innovation, Technology Watch and Search, property rights management, and QM. The adoption of the project outcome was relative, concluding that the significant impact was the development of an innovative culture. [Ulusoy \(2003\)](#) conducted an extensive survey in Turkey, concluding the need for improvement in various areas of the supply chain and innovation management. [Mol and Birkinshaw \(2009\)](#) studied the introduction of the new management of innovation practices without arriving at clear conclusions. [Bakouros and Samara \(2010\)](#) studied IMT adoption in Greece with similar results, as SMEs valued its effectiveness but thought they were not ready to use it. [Sánchez et al. \(2011\)](#) surveyed 200 firms in the electronic industry, finding that the best-performing firms had a higher utilisation of IMTs. [Skalkos and Bakouros \(2011\)](#) also reported promoting IMTs based on KM on very small firms and the difficulties associated with human resources competencies.

The European Commission (EC) has been a driving force in promoting IMTs to address the contingency problem. Their classification of IMTs into three groups in 1999 — inner-focused, outward-focused, and onward-focused ([European Commission, 1999](#)) — was a significant contribution. A later publication ([European](#)

Commission, 2004) proposed 10 typologies, with Project management, Business planning, Networking, and benchmarking emerging as the most widespread. This classification, a cornerstone in understanding and utilising IMTs, has been instrumental. Building on the EC's experience, Hidalgo and Albers (2008) proposed a typology of 42 IMTs, classifying them into 10 groups according to their immediate goals and outlining the role of KM. Skalkos's (2012) literature review proposed a directory of 36 IMTs in 10 categories. Further on, Zammar *et al.* (2024) conducted another review and concluded an evident gap in the IMTs literature.

Services is a sector receiving some attention from researchers. In a literature review on services, Cavalcante *et al.* (2020) identified 87 IMTs outlining the following: New Service Development (NSD), Service Engineering (SE), and Service Design (SD) regarding the main stages of the service innovation process. Furthermore, in services, D'Alvano and Hidalgo (2012) conducted a field study of IMTs, concluding that the most used IMTs were Brainstorming, Strategic alignment value analysis, Networking, and Best practices.

In a survey of 300 firms, Tidd and Thuriaux-Alemán (2016) assessed eight functional groups of IMTs and found a high use variation across industry sectors. However, they identified a positive relationship with innovation outcomes, with technology and product portfolio management being universally positive. Similarly, Albers-Garrigos *et al.* (2018) conducted a literature study on IMTs and their innovation impact, analysing 52 articles. Of these, 15 covered the effect of IMTs on firm innovation performance. Most were based on case studies, and only six were based on actual surveys. Eight (four of which through surveys) reported a positive impact on innovation in general. In addition, three articles (one survey-based) stated a positive effect on incremental innovation, and finally, only a case-study article reported a positive impact on radical innovation.

In a survey of 140 firms, Kalay and Gary (2015) concluded that tools linked to innovation strategy, organisational structure, and innovation culture were the main factors in improving firm innovation outcomes. They also found that while customer and supplier relationships could be identified as impacting firm innovation performance, technological capability had no substantial effects.

Pertuz and Pérez (2021) found 116 practices based on the innovation management process in their literature survey. The most popular tools were project management, product development and process improvements, idea generation, and practices related to HRM. However, they did not provide an analysis of the efficiency of these tools. Similarly, Hafkesbrink and Schaff (2024) surveyed 350 firms on various strategic, agile, and creative tools but did not find a clear impact on innovation performance.

## Analyses of IMTs in detail

Our review, which encompasses 53 carefully selected articles, delves into analysing specific tools. Among the most investigated are those about KM and TM.

Several scholars have explored the positive impact of KM practice on innovation dynamics or product development (Hull *et al.*, 2000; Du Plessis, 2007; Vaccaro *et al.*, 2010; Gloet and Samson, 2022). Some have even suggested associations with other tools, such as HRM, for efficiency (Gloet and Terziovski, 2004). However, the most robust associations are with open innovation and collaborative approaches (Abbate *et al.*, 2019; Wang and Hu, 2020). A few scholars, through field studies, have outlined a direct relationship with innovation performance (Cantner *et al.*, 2011; Mardani *et al.*, 2018). Others (Valentim *et al.*, 2016) propose that these tools contribute to increasing absorptive capacity, and Daroch and McNaughton (2002) link the knowledge acquisition forms with incremental or radical innovation. Authors frequently mention the contingent aspects of KM with firm size and sector (Valentim *et al.*, 2016).

The academic literature has broadly covered TM tools. Early authors provided descriptions of tools and models associated with them (Brady *et al.*, 1997; Butler, 1999; Drejer, 1997; Phaal *et al.*, 2000, 2004, 2006). Cetindamar *et al.* (2006) studied their use in Turkey's industry, finding that 70% of the surveyed firms utilised them and found them helpful for idea generation, problem-solving, improving efficiency, and gaining flexibility. Cetindamar *et al.* (2009) later published a conceptual article linking TM with firm dynamic capabilities. Farrukh *et al.* (1999, 2000) have also extensively studied TM tools, providing dimensions and characteristics of a catalogue of TM. They later analysed technology road mapping, portfolio matrices, linked analysis, grids, and technology road mapping (Farrukh *et al.*, 1999, 2006). Similarly, Zabala-Iturriagoitia (2014) has analysed the usefulness and difficulties of Technology Watch by SMEs, emphasising the crucial need for expert guidance in these smaller enterprises.

Very few researchers report the performance outcome of TM tools. In a field study, Oerlemans *et al.* (2013) found how using TM tools moderated the relationship between alliance portfolio diversity and a firm's innovation outcomes. With some case studies, Vishnevskiy *et al.* (2015) suggested that road mapping was conducive to organisational innovation and innovation activity. In a single case study, Igartua *et al.* (2010) concluded that portfolio management, technology watch, and road mapping were crucial for successful innovation in an Open innovation environment.

While few articles have dealt with HRM practices, several authors (James, 2002; Bal *et al.*, 2013) suggest that HRM practices promote the innovation dynamics of firms or their innovation capability (Le and Le, 2023; Maier *et al.*,

2014). These studies are significant as they provide insights into how HRM can be leveraged to enhance innovation within firms. Others are more specific, such as Jackson and Dunn-Jensen (2021), posing that HRM improves firms' innovation and ambidexterity. More explicitly, Laursen and Foss (2003) conducted an extensive study on Denmark with 2,000 firms, demonstrating that the application of HRM packages positively impacted firms' innovation performance.

NPD has evolved into a distinct discipline supported by various academic journals. In this context, we will analyse several articles related to IMTs.

Kahn (2002) studied how NPD tools have been used to forecast the success of industrial vs. consumer products with high accuracy (60%). De Waal and Knott (2013) outlined the NPD contingency and its need for local adaptation, particularly for SMEs. Later research (De Waal and Knott, 2019) demonstrated the performance impact of thoroughly applying NPD tools in SMEs. Leber *et al.* (2014) conducted a field study with Slovene firms and identified training difficulties when applying NPD tools.

Researchers have shown little interest in innovation auditing. The majority employ a descriptive or normative approach. Frishammar *et al.* (2019) propose an innovative auditing framework, and Ananda *et al.* (2023) recently conducted a literature study on Auditing and Innovation. No conclusions are reported on performance or success factors. From a practical point of view, Cormican and O'Sullivan (2004) and Björkdahl and Holmén (2016) suggest proposals and best practices following various case studies.

Wang and Wang (2008) highlight the interest in a knowledge-sharing system for data based on a case study and suggest its practicality as a business intelligence tool. This research underscores the importance of data in the context of business intelligence. Vriens and Sjøilen (2014) also contribute to this field by proposing a business intelligence tool called disruptive intelligence, which they claim is particularly useful in disruptive innovation environments. It must be emphasised that according to previous paragraphs, AI as an innovation management model bears a promising future.

We have selected two articles discussing Project Management tools. Blindenbach-Driessen *et al.* (2010) discussed the performance approach of these tools and their difficulties. Blindenbach-Driessen and Van Den Ende (2010), when studying 180 firms, argued that project management tools are also contingent and firm dependent.

Some publications have analysed other IMTs. For instance, Fontana and Musa (2017) studied 200 firms and outlined how entrepreneurial management tools influenced process innovation but could not positively impact innovation performance. Stefani *et al.* (2020) reviewed financing tools, signalling them as promising. Bollinger (2020), in an extensive survey of creativity tools,

concluded its contingent character but could not confirm its favourable outcome, pointing out the contingent aspects. Pittaway *et al.* (2004) studied networking. They found that the main advantages of networking were risk sharing, obtaining access to new markets and technologies, speeding products to market, and finding complementary skills.

Lean innovation management has been proposed as a holistic innovation management model rather than a tool. Blank and Eckhardt (2023) defines it as increasing efficiency by capturing customer feedback early and often and minimising waste in the product development cycle. This view is supported by Solaimani *et al.* (2019) in a literature review, suggesting that lean innovation management must combine both “soft” (e.g., learning culture, collaborative attitude) and “hard” (e.g., learning routines, collaborative organisational structures) aspects focused on learning. In a survey of 240 multinational firms, Abdallah *et al.* (2018) found that innovation orientation and lean approach are complementary and that lean tools are more related to incremental innovation.

Finally, we discuss the question of innovation measurement. Here, the picture is also blurred. Adams *et al.* (2006) and Melendez *et al.* (2019) carried out a literature review on this theme. Both pointed out the lack of an accepted framework and thus signalled the subject as a crucial research gap.

In conclusion, we have observed how academics considered innovation management practice and IMTs from a contingent approach to the firm innovation environment. Thus, IMTs can be related to innovation management models and the firm stakeholder’s context.

However, though academic research has tried to provide a framework and taxonomy for IMTs, no clear results were found providing a definite taxonomy or comparing the utilisation and efficiency of the various IMTs or their impacts on the different modes of innovation. Still, Igartua *et al.* (2014a,b) and Albors-Garrigos *et al.* (2018) reported the frequency of specific tools such as entrepreneurial management, KM, TM and prospective, business intelligence, project management, and special tools for human resource management. Moreover, it uncovered that the use of IMTs could be a predictive tool for incremental innovation.

## **Proposed Model and Hypotheses**

### **Initial model**

Based on the previous theoretical context, we propose the following model and hypotheses deduced from the research gaps.

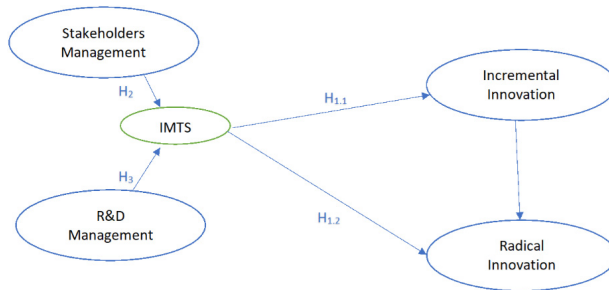


Fig. 2. Proposed model.

Our model aims to measure the impact that the use of IMTs by firms has on their innovation performance, whether radical or incremental. Additionally, we wish to assess the mediation factor of firm stakeholder engagement, represented by the three proxies of CRS, QM, and ES, and the effect that the R&D function has on this innovation performance.

These relationships are depicted in Fig. 2.

### Hypotheses

We propose various hypotheses based on the previous literature analysis to address the research questions and gaps already discussed. Table 3 describes the hypotheses and points out the academic references, already discussed in the previous paragraphs, for its proposition.

Table 3. Research hypotheses.

	Hypotheses	References
H1	The utilisation by the firm of IMTs has a positive impact on its innovation performance in general	Blindenbach-Driessen <i>et al.</i> (2010), Cormican and O’Sullivan (2004), Laursen and Foss (2003), Tidd and Thuriaux-Alemán (2016), Björkdahl and Holmén (2016), Abdallah <i>et al.</i> (2018), Yusr <i>et al.</i> (2017), Mardani <i>et al.</i> (2018), Wang and Hu (2020), Albats <i>et al.</i> (2020), Loureiro <i>et al.</i> (2020), Grama-Vigouroux <i>et al.</i> (2020)
H1.1	The utilisation of IMTs has a positive impact on its incremental innovation outcome	Albors-Garrigos <i>et al.</i> (2018), Tao <i>et al.</i> (2010), Ardito <i>et al.</i> (2020)

Table 3. (Continued)

	Hypotheses	References
H.1.2	The utilisation of IMTs has a positive impact on its radical innovation outcome	Igartua (2014), <i>Ardito et al. (2020)</i>
H2	Stakeholders' management positively affects the impact of IMT utilisation on the firm's innovation performance	<i>Albats et al. (2020), Secundo et al. (2020), Grama-Vigouroux et al. (2020), Ardito et al. (2020), Broadstock et al. (2020), Cillo et al. (2019), Kazadi et al. (2016), Zeng et al. (2015), Tsuji et al. (2018)</i>
H3	The activity of R&D management positively affects the impact of IMTs on innovation performance	<i>Love and Mansury (2007), Huang and Lin (2006), Hameed et al. (2018)</i>

## Methods

### Data and questionnaire

The survey was developed using some questions related to innovation performance and practice from the EC's Community Innovation Survey (CIS). In addition, we included questions related to management practices and IMT use (*Mairesse and Mohnen, 2010*); the questions in the study were measured following a 1–5-point Likert scale, whether they were totally in accordance or disagreed with the cited responses. IMTs were graded according to their utilisation frequency: 5 — very often and 1 — never. About QM or Sustainable management, the level of achievement of standards, (UNE 9001) or EFQM, or its strategic intent. R&D management is measured through its historical experience, standards (UNE 16602) or strategic priority (1–5). Additionally, performance was rated through two radical and incremental innovation variables categorised into five groups representing the total percentage of sales from products or services incorporating incremental and radical innovations in the last three years.

The survey was directed at general managers among industry firms in the North of Spain. Among the 5.194 firms (staff > 24), we followed a stratified sampling procedure, surveying 566 firms. Some questionnaires were rejected due to the need for more available data on the variables of interest. The final sample comprised 529 companies (4.05% sampling error for a 95% confidence level). Interviews were carried out previously among 30 respondents to test the questionnaire's adequacy. Table 4 shows the IMTs whose use was assessed in the survey.

Table 4. Innovation Management Tools (IMTs) analysed in the survey.

Abbrev.	Name	IMTs group	Techniques
TCon	KM tools	Creativity and teamwork tools $\alpha = 0.901$ (Survey data based on reliability analysis)	Knowledge auditing, Knowledge mapping, Document management
TCrea	Creativity development tools		Brainstorming lateral thinking, TRIZ, Mental maps, Six thinking hats
TTec	Technology surveillance techniques		Technology surveillance, Matrices, Road mapping Tech. prospective
TIintel	Business intelligence		Corporate Intelligence Tech. and Mktg., Information Management
TPers	Special techniques for personnel management		Tele-working, Online recruiting e-Learning, Competencies, HHRR management
TRed	Collaborative approaches		Teamwork and collaborative Software, Supply chain management, tools, Web 2.0
TDis	Design management tools	Engineering Tools $\alpha = 0.792$	CAD systems, Quick prototyping tools, Usability tests, Value analysis
TFabr	Lean manufacturing tools		Lean tools, Just in Time, MRP
TProy	Tools for project managements		Project management, Project portfolio management, Risk management

Table 4. (Continued)

Abbrev.	Name	IMTs group	Techniques
TOrg	Production management		Miniplants, Self-managed teams
TLNP	NPD techniques		Concurrent engineering, Quality Function, Deployment (QFD), Lead users, NPD, Benchmarking
TFinan	Innovation financing search	Management Tools $\propto = 0.885$	Access to national & European R&D funds, Venture Capital, Private R&D funding
TMarkt	Marketing of innovation		Market research and analysis, Product Communication techniques, CRM distribution and sales
TMej	Continuous improvement		Process-based management, EFQM models, Six sigma and problem-solving quality auditing
TEstr	Competitive strategic techniques		SWOT, Value chain audits, Portfolio business analysis
TProp	Patent management		Patent registration design and brand registration, Secret protection intellectual, rights
TEmpr	Entrepreneurial techniques		Business plan, models and simulation, Transfer mechanisms spin offs/spin outs development

*Notes:* CRM: Customer Relationship Management

EFQM: European Foundation for Quality Management

SWOT: Strengths, Weaknesses, Opportunities & Threats)

### Analysis and statistical methods

To test our model, we employed partial least squares structural equation modelling (PLS-SEM) using SmartPLS3 software (Ringle *et al.*, 2020). This approach was chosen as it suits models that include manifest and latent variables (Hellberg *et al.*, 1985), both reflective and formative (Diamantopoulos and Winklhofer, 2001), and multiple causal relationships (Hair *et al.*, 2019). Additionally, PLS-SEM does not rely on distributional assumptions, making it suitable for complex models (Fornell and Larcker, 1981).

We analysed two phases: the measurement (outer) model and the structural (inner) model, following Chin’s (1998) guidelines. Reflective constructs were evaluated by their reliability and validity. To ensure the reliability of each indicator, we verified that the loadings exceeded 0.7, demonstrating that the latent variables explained a significant portion of item variance. We assessed internal consistency reliability using composite reliability (CR) and the Dijkstra–Henseler statistic (rho A). According to Nunnally and Bernstein (1994), a CR above 0.7, or a rho A value above 0.6 (Dijkstra and Henseler, 2015), indicates acceptable reliability.

We followed Fornell and Larcker’s (1981) criterion for convergent validity, with average variance extracted (AVE) values of at least 0.5, showing that each set

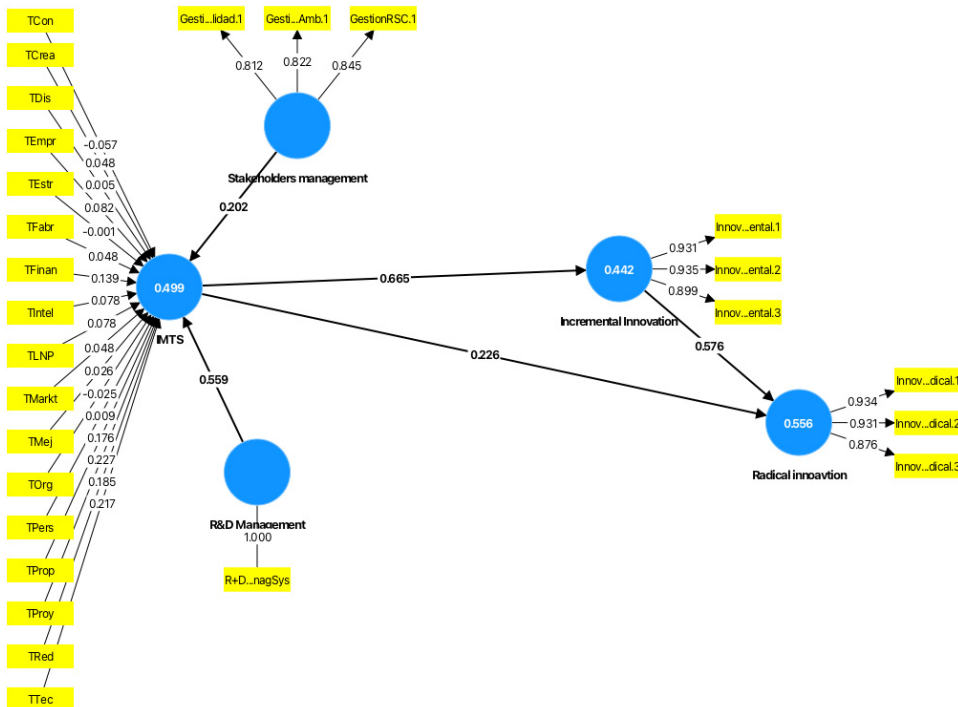


Fig. 3. Structural model.

of indicators reflected a common underlying concept. We used the heterotrait–monotrait (HTMT) ratio for discriminant validity, where values below 0.85 indicated sufficient differentiation between concepts (Kline, 2015; Rasoolimanesh *et al.*, 2022).

When evaluating formative constructs, we addressed multicollinearity by examining the variance inflation factor (VIF), with values below 5 suggesting no collinearity issues (Hair *et al.*, 2019). Additionally, we confirmed the significance of the indicator weights via bootstrapping and followed the procedure of Hult *et al.* (2018) for handling non-significant weights.

The structural model was analysed using the path weighting scheme algorithm to compute the path coefficients (Fig. 3). We assessed the structural model by reviewing the explained variance ( $R^2$ ) and testing the significance of the standardised path coefficients ( $\beta$ ) derived through a bootstrapping procedure using 5,000 resamples. The PLS predict  $Q^2$  value (Shmueli *et al.*, 2016) provided insight into the model’s predictive relevance.

## Results and Discussion

### PLS results

We evaluated the results of the measurement model, attending to the reflective or formative nature of the different latent variables therein. Table 4 illustrates the reliability and validity measures for the reflective measures. All reflective measures showed item loadings and CR values above the suggested 0.7 value, indicating sufficient reliability. AVE values in Table 4 over 0.5 and HTMT values lower than 0.85 in Table 5 confirmed the measures’ convergent and discriminant validity. For the formative measures (the IMTs), VIF values below 5 in Table 4 indicate no multicollinearity problems (Hair *et al.*, 2019). The analysis of the

Table 5. Measurement model.

Dimensions	Loadings	Weights	AVE	CR/rho A	VIF
Stakeholder Mgmt			0.683	0.866/0.800	
MSQ	0.812				
MSEnv	0.822				
MSCSR	0.845				
IMTS					
TCon	0.801***	-0.057 n.s.			3.808
TCrea	0.718***	0.048 n.s.			2.358
TDis	0.723***	0.005 n.s.			2.488

Table 5. (Continued)

Dimensions	Loadings	Weights	AVE	CR/rho A	VIF
TEmpr	0.834***	0.082 n.s.			3.377
TEstr	0.738***	0.001 n.s.			2.833
TFabr	0.446***	0.048 n.s.			1.438
TFinan	0.766***	0.139*			2.531
TIntel	0.797***	0.078 n.s.			3.121
TLNP	0.722***	0.078 n.s.			2.098
TMarkt	0.759***	0.048 n.s.			2.615
TMej	0.71***	0.026 n.s.			2.793
TOrg	0.65***	-0.025 n.s.			2.267
TPers	0.772***	0.009 n.s.			3.235
TProp	0.802***	0.176**			2.496
TProy	0.801***	0.227***			2.706
TRed	0.81***	0.185**			2.930
TTec	0.805***	0.217***			2.466
Incremental Innovation					
II1			0.850	0.944/0.918	
	0.931				
II2	0.935				
II3	0.899				
Radical Innovation					
RI1			0.836	0.938/905	
	0.934				
RI2	0.931				
RI3	0.876				

Notes: \*\*\*significant at  $p < 0.001$ , \*\*significant at  $p < 0.01$ , \*significant at  $p < 0.05$ , n.s., not significant.

weights indicates that some of the IMTs are not statistically significant. However, following [Hult et al. \(2018\)](#), keeping these items in the formative constructs is recommended as all the loadings were higher than 0.5 or significant. These results confirmed that the measurement model was assessed with confidence.

Item weights of first-order IMT constructs also provide some interesting insights. These weights suggest that some IMTs are predominant. For instance, only Tfinan ( $w = 0.139$ , sig at  $p < 0.05$ ), Tproy ( $w = 0.227$ , sig at  $p < 0.001$ ), Ttec ( $w = 0.217$ , sig at  $p < 0.001$ ), Tprop ( $w = 0.176$ , sig at  $p < 0.01$ ), and Tred ( $w = 0.185$ , sig at  $p < 0.001$ ) are essential determinants in IMTs. Thus, the search and selection of financial resources to fund innovation, the project management tools, the TM tools, the networking tools, and, finally, the patent management tools stand out for their relevance.

Table 6. HTMT ratio results.

	Incremental innovation	Radical innovation
Radical innovation	0,799	
Stakeholder Mgmt.	0,471	0,429

In the case of Stakeholders management, the loadings of its components CSR, quality, and sustainable management, were similar and the reliability factor ( $\alpha = 0.800$ ) high for the latent variable (Table 6).

Once we assessed the measurement model, we tested the hypothesised relationships between the latent variables. Table 5 reports the path coefficients, indicating the strength and direction of the relationships, the *t*-value from the bootstrapping procedure (which facilitates evaluating the statistical significance of the relationships), the variance explained by each endogenous variable, and the PLS-Predict  $Q^2$  value.

Results indicate a satisfactory predictive relevance as all the PLS predict  $Q^2$  values (see Table 7) were higher than 0 (Henseler *et al.*, 2009), indicating that the model can reproduce the observed values and estimates. The analysis of the path coefficients indicates that stakeholder management ( $\beta_2 = 0.202, p < 0.001$ ) and R&D management ( $\beta = 0.559, p < 0.001$ ) impact significantly and positively on the use of IMTS. However, the R&D management function on IMTS effect size ( $f^2 = 0.368$ ) is much more important than the one from stakeholder management ( $f^2 = 0.048$ ), indicating that the contribution of R&D management to IMTS is much higher. The use of IMTS has an essential impact on innovation results, both in incremental innovation ( $\beta_{1.1} = 0.665, p < 0.001$ ) and radical innovations ( $\beta_{1.2} = 0.226, p < 0.001$ ). The weaker relationship between IMTs and radical innovation implies that while IMTs can support breakthrough innovations, their

Table 7. Bootstrapping and blindfolding procedure results.

Direct effects	Path ( <i>t</i> -value)	Variance explained	$Q^2$
Effects on IMTS		49,9%	0,268
H2: Stakeholder Mgmt.	0,202 (4,142)***		
H3: R&D Mgmt.	0,559 (13,521)***		
Effects on incremental innovation		44,2%	0,325
H1.1: IMTS	0,665 (25,958)***		
Effects on radical innovation		55,6%	0,477
H1.2: IMTS	0,226 (5,13)***		
H4: Incremental innovation	0,576 (13,332)***		

Note: \*\*\*significant at  $p < 0.001$ .

impact on radical innovations is comparatively less than on incremental innovation. This may indicate that additional factors beyond standardised techniques, such as creativity and risk-taking, play more crucial roles in radical innovation.

The indirect effects measure how certain independent variables influence another variable through mediators. Thus, the minor indirect effects of stakeholder management on incremental and radical denote the low impact that these management policies have on innovation results. Indeed, the indirect effects indicate that the R&D management canalised through the IMTS is a significant mechanism for achieving innovation. Thus, the structure provided by an R&D management function and the systematisation of the procedures provided by the IMTs is critical in achieving small innovations in companies. The larger values of the indirect effects of IMTS on radical innovation than the direct ones indicate that IMTS and incremental innovation serve as essential mediators, especially in pathways leading to radical innovation.

The strong relation between incremental and radical innovations ( $\beta_4 = 0.576$ ,  $p < 0.001$ ) uncovers the critical role of incremental innovation in obtaining radical innovation results. In other words, companies that innovate regularly through small innovations are more likely to introduce radical innovations. This reinforces the view that incremental changes can accumulate or act as stepping stones towards more radical, transformative innovations. Nevertheless, is this process the same in low-tech than in medium or high-tech companies?

To answer this question, we performed additional tests to evaluate the effect of the technological level on the relationships in the model. First, based on NACE (Nomenclature of Economic Activities) Rev. 2, 2 codes, we grouped companies in the sample in three technological levels: high, medium (high and low), and low, following Eurostat classification. We used multigroup analysis (PLS\_MGA) for the technology groups to reveal differences in the proposed relations. Table 8

Table 8. PLS-MGA comparison results.

Relations	Low-Tech (1)	Med-Tech (2)	High-Tech (3)
Number of companies	354	118	57
Stakeholders' management → IMTS	0.203**	0.191 n.s.	0.092 n.s.
R&D management → IMTS	0.578***	0.533***	0.534**
IMTS → Incremental innovation	0.653***	0.727***	0.665***
IMTS → Radical innovation	0.249***	0.413***	0.158 n.s.
Incremental innovation → Radical innovation	0.586***	0.373***	0.573**

Notes: No significant differences were found between groups, resulting in a  $p$ -value of 0.05 (one-tailed) according to the PLS-MGA bias corrected confidence interval comparison. \*\*\*significant at  $p < 0.001$ , \*\*sig. at  $p < 0.001$ , n.s., not significant.

reflects the results of the three groups' path coefficients, their significance, and the multi-group analysis.

The paths show no significant differences between the groups. Indeed, relationships present many similarities, and the differences in the significance of the path coefficients are inconclusive, as their significance might be affected by the group sample size. Thus, we discarded the technological level as moderator.

In addition to how the firm's technological levels can affect the relative impact of innovation techniques over incremental or radical innovation, it is interesting to evaluate the actual value of using innovation techniques and the corresponding innovation results, as well as the level of R&D management. We conducted a one-way ANOVA with Scheffe's pairwise comparison procedure to test differences between individual pairs of groups across the firm's technological levels (Table 9). This was particularly useful in our study to compare the innovation and technology use across different technological levels (Jaccard *et al.*, 1984).

Table 9. Latent variable and variable scores mean values for different technological levels.

Variable	Group1 Mean	Group2 Mean	Group3 Mean	Mean Diff (1–2)	Mean Diff (2–3)	Mean Diff (1–3)
RD_Management	-0.140	0.282	0.286	-0.423*	-0.004	-0.427*
Stakeholders_Management	-0.051	0.252	-0.205	-0.303*	0.457*	0.153
Incremental_Innovation	-0.133	0.184	0.447	-0.318*	-0.262	-0.580*
Radical_Innovation	-0.086	0.071	0.386	-0.157	-0.315	-0.472*
TCon	1.908	2.291	2.345	-0.383*	-0.054	-0.437*
TCrea	1.801	2.123	2.114	-0.322*	0.009	-0.313*
TDIs	2.105	2.648	2.382	-0.544*	0.267	-0.277
TEmpr	1.943	2.332	2.529	-0.388*	-0.198	-0.586*
TEstr	2.314	2.682	2.971	-0.368*	-0.289	-0.657*
TFabr	2.421	2.668	2.321	-0.247*	0.347*	0.100
TFinan	2.121	2.341	2.509	-0.220*	-0.168	-0.388*
TIntel	1.931	2.161	2.447	-0.230*	-0.286*	-0.516*
TLNP	2.229	2.587	2.636	-0.358*	-0.049	-0.407*
TMarkt	2.139	2.370	2.501	-0.231*	-0.131	-0.363*
TMej	2.267	2.587	2.580	-0.320*	0.007	-0.312*
TOrg	2.022	2.542	2.345	-0.520*	0.197	-0.323*
TPers	2.028	2.387	2.648	-0.359*	-0.261	-0.620*
TProp	1.819	2.038	1.941	-0.219*	0.096	-0.123
TProy	2.457	2.901	3.076	-0.444*	-0.175	-0.619*
TRed	1.865	2.121	2.266	-0.255*	-0.146	-0.401*
TTec	1.816	2.237	2.148	-0.421*	0.089	-0.332*

Notes: \*indicates that the difference significantly differed at  $p < 0.05$  level according to Scheffe's (1999) pairwise comparison procedure.

We can see that firms in high and medium-tech industries are significantly more inclined to use IMTs than those in low-tech sectors. Similarly, the incremental innovation results are notably higher in high and medium-tech firms (with mean HT = 0.447 and mean MT = 0.184) than low-tech firms (with mean LT = -0.113). Furthermore, radical innovation results are significantly higher in companies belonging to high-tech (with mean HT = 0.386) compared to low-tech clusters (with mean = -0.086). This highlights the significant impact of the firm's technological level on the use and results of IMTs.

R&D management results revealed differences only between low-tech and the other groups, while stakeholder management was significantly greater in medium-tech industries, mainly due to the QM component. This highlights the importance of R&D management in the technological level context and its impact on innovation results.

Thus, the results invite the literature to think that the overall innovative activity within companies relies on a well-structured innovation system, where innovation techniques of different kinds give a systematic approach to innovation, enhancing the launch of successful innovations to the market.

## **Discussion, Theoretical and Practical Implications**

### **Theoretical contribution and implications**

The statistical analysis (ANOVA and SEM) confirms the contingent aspect of innovation management practices suggested by a stream of literature (Tidd, 2001; Hobday, 2005; Oke, 2007; Eveleens, 2010; Aas *et al.*, 2015; Valentim *et al.*, 2016, Bollinger, 2020). Additionally, it provides a comprehensive taxonomy of IMTs in three groups: creativity and teamwork, engineering-focused, and management tools. The PLS analysis and subsequent model showed the relevance of specific tools, such as project management, TM, networking, and patent management tools. Some of them have been outlined by published research (Blindenbach-Driessen and Van Den Ende, 2010; Pittaway *et al.*, 2004; Brady *et al.*, 1997; Butler, 1999; Drejer, 1997; Phaal *et al.*, 2000, 2004, 2006; Cetindamar *et al.*, 2006). However, the frequent use of financing innovation tools is significant considering the research gap. It also is relevant to the low use of KM tools.

The results of the SEM analysis indicate that Hypothesis 1, related to the impact of IMT utilisation on firms' innovation performance, is partially confirmed since the use of IMTs impacts incremental innovation (H.1.1). At the same time, it does not predict a high level of radical innovation (H.1.2). This finding suggests that while the use of IMTs can lead to incremental innovation, it may not be sufficient for radical innovation, which may require additional factors or a different

approach. The findings not only align with but also build upon the specific proposals of authors such as Daroch and McNaughton (2002), Oke (2007), Foss and Laursen (2012), and Albors-Garrigos *et al.* (2018). They also resonate with the study of Oerlemans *et al.* (2013) on the moderating role of TM tools.

Regarding H2, related to stakeholders' effect-focused management, the research findings do not allow its confirmation. However, the research indicates that stakeholder management promotes the use of IMTs. In this direction, this result reinforces the contingent role of the firm context, suggesting a reinterpretation of the contribution of the stakeholder's engagement to the use of certain IMTs, such as cooperation and networking, confirming the results of Secundo *et al.* (2000), Albats *et al.* (2020), Loureiro *et al.* (2020), and Grama-Vigouroux *et al.* (2020) or Wang and Hu (2020). Despite the differences pointed out by the literature, the contribution of CSR, quality, and sustainable management was similar. We must outline that our results are related to innovation performance rather than innovation capabilities or activities, reinforcing our contribution to a research gap.

Equally, the risk reduction associated with innovation is related to using IMTs. The variance attributed to stakeholder management in using IMTs was 11.63%.

Finally, the research confirms H3. The results establish that firms with an active R&D function are more likely to achieve incremental innovation. Additionally, the R&D management function in medium and high-tech industries explains a significant 38.35% of the variance in the use of IMTs, further reinforcing the robustness of the findings.

This conclusion outlines the crucial role of the R&D function in contributing to the use of IMTs and the innovation outcome. The R&D function appears as the structural path for firms' innovation development. Thus, this research aligns with the orthodox school of thought posed by authors such as Love and Mansury (2007), Huang and Lin (2006), and Hameed *et al.* (2018). Additionally, it suggests that firms must manage open innovation alternatives through R&D (Hameed *et al.*, 2018) and improve their engagement with stakeholders, as suggested by various authors (Albats *et al.*, 2020; Secundo *et al.*, 2020; Grama-Vigouroux *et al.*, 2020; Ardito *et al.*, 2020). This idea implies that firms should consider open innovation and stakeholder engagement as part of their innovation management strategy, as these factors can significantly impact their innovation performance.

Such results allow us to infer specific theoretical considerations. In principle, there are discrepancies with the authors supporting the hypothesis of the IMTs' relationship with radical innovation (Igartua *et al.*, 2014a,b). These authors emphasise that certain IMTs, such as networking, financing, creativity techniques, IPR management, and business intelligence (technology watch), are necessary to develop radical innovations. In our case, the structural model posed that IMT

utilisation per se could not predict a radical innovation outcome but rather the achievement of incremental innovation.

Recent literature suggests that radical innovation is attained by firms searching for problem-solving rather than technology push (Coccia, 2017) or driven by an innovative mindset (Ringberg *et al.*, 2019). However, our results confirm the classical theories of the autonomous routes followed by radical and incremental innovation (Leifer *et al.*, 2013). It also supports the idea that each type of innovation requires a different strategy and organisational structure (Ettlie *et al.*, 1984) and that the essential skills for radical innovation could be developed through training on incremental innovation (McDermott and O'Connor, 2002).

### **Managerial implications**

This research study offers explicit management implications, equipping managers with actionable insights ready to be applied in their organisations. It highlights the prevalence of certain IMTs, such as entrepreneurial techniques, networking and collaborative techniques, industrial property administration, and the under-utilisation of others due to their production profile. The holistic approach to IMTs allows for a comprehensive analysis of their diverse impact and use, providing practical guidance for IMT utilisation.

The investigation underscores innovation's systemic and contingent nature from a management perspective. A management framework that places a high value on stakeholder engagement can facilitate the effective use of IMTs and achieve high innovation results, providing practical guidance for innovation management. Additionally, it shows the synergy between open innovation models and the structural role of R&D management, allowing the management of innovation risks and external knowledge sources. This suggests that firms should consider open innovation and stakeholder engagement as part of their innovation management strategy, as these factors can significantly impact their innovation performance.

When implementing IMTs, the firm's expertise, human resources, and industry must be considered. This research also underscores the importance of learning innovation management skills. It suggests businesses should focus on incremental innovation and gradually transition to radical innovation initiatives, ensuring a smooth and successful innovation journey.

### **Limitations and future research**


The limitations of this research are mainly due to the sample size. Future research should focus on the most recent developments in IMTs linked with AI.


## Acknowledgements

This research has been funded by the Conselleria de Educaci3n, Universidades y Empleo (Generalitat Valenciana) under the project CIAICO/2023/228.

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