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Business model innovation through Industry 4.0: A review

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Abstract

The following article presents a brief literature review conducted to extend our knowledge about how Industry 4.0 affects business models and to identify business model innovations derived in consequence. Based on the results, a set of features, issues and requirements have been identified and three different approaches has been suggested to make firms getting closer to the industry 4.0 phenomenon such as service orientation, networked ecosystems and customer orientation. Furthermore, the impacts on the creation, delivery, and capture of value through the reconfiguration of Business Models due to embracing the Industry 4.0 are depicted. As a result, four different ways to innovate the business models based on different degrees of innovation are proposed to embrace the digitalization. Those paths goes from optimizing internal and external processes or improving customer relationship to creating new value networks or smart products and services through disruptive business models.

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1. Introduction

The increasing fusion of Industrial Production and Information and Communication Technologies (ICT) has brought the so-called Industry 4.0 into the manufacturing world [1]. This phenomenon is making possible to connect information, objects and people due to the convergence of the physical and the virtual (cyberspace) worlds in the

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form of Cyber-Physical Systems (CPS). Therefore, it is enabling the transformation of factories into smart environments [2, 3].

According to some authors [4], this phenomenon considered the Fourth Industrial Revolution, will be the most powerful driver of innovation over the next few decades triggering the next wave of innovation. Thus, the main features related to the Industry 4.0 such as real-time capability, interoperability and the horizontal and vertical integration of production systems through ICT systems, are regarded to be the response to current challenges that companies must face to stay competitive in terms of globalization and intensification of competitiveness, the volatility of market demands, shortened innovation and product life-cycles and the increasing complexity around products and processes[5, 6].

By this way, the business world's rapid digitalization is breaking down the traditional barriers of the industry, and many academics and practitioners are emphasizing the need to rethink the existing Business Models [7]. However, the recent researches are mainly focused on the technological development and less in the new business models that are emerging through the integration of those technological innovations.

Nevertheless, this new industrial paradigm is transforming the current ways of value creation, since it involves changes in the technical and production developments, which in turn has brought extensive organizational consequences and opportunities [5, 6] providing more cooperative environments, improved customer relationships or new product and services offers. Consequently, new and adapted business models are needed [3].

Finally, the discussion and initiatives that promote the digital transformation of factories are increasing between researchers, industries and policy makers around the world. Germany was the first referring to the digitalization of the industry publicly as "Industrie 4.0" in 2011. Then, the term was expanded to the Anglo-Saxon world as "Industry 4.0", while other countries has been introducing other expressions to describe the phenomenon. Thus, Unites States focuses on "Smart Manufacturing" as Japan and Korea do too. General Electrics popularized the "Industrial Internet" concept. Finally, other commonly related words found in the literature are "intelligent manufacturing", "advanced manufacturing", "Integrated Industry", "Smart Industry" and "Smart Factory" [2, 8].

Hence, in response to the increasing interest of the topic and the need of a deepen understanding of its impact in Business Model Innovation, the aim of this paper is to present a brief literature review conducted to address the following goals: To have a clear vision of how Industry 4.0 impacts on business models and to identify business model innovations that are derived in consequence.

2. Research Methodology

The literature survey was conducted in articles indexed in Web of Science, Engineering Village, Scopus and Business Source Premier Databases, as they are the referents in our field, for the purpose of carrying out a critical analysis of collected data and the exposition of some conclusions and future research opportunities.

The method of analysis used is the one proposed by Becheikh [9]. In order to do this, the steps related to the establishment of the inclusion criteria and the strategy for the selection of potential studies are particularly important. In our case, the criteria used are the following: 1) The content must show the impact of Industry 4.0 from a managerial approach and not be focused in concrete technological implementations into specific cases, 2) the research must illustrate Business Model Innovations from the Industry 4.0 approach and 3) the papers must reveal how the adoption of the Industry 4.0 affects the Business Models components.

On the one hand, the time period of the literature review was defined between 2011 and the present, since the term "Industry 4.0" became publicly known in 2011. Furthermore, only conference papers and journal articles related to business and management were taking into account to avoid a too technical approach.

On the other hand, to select the keywords within the search, the synonym terms mentioned above were taken into account. The keywords included in the title, abstract and/or full text were combined using the Boolean operators "AND" and "OR" in the following form: "Business Model" AND "Industry 4.0" OR "Industrie 4.0" OR "Smart Manufacturing" OR "Advanced Manufacturing" OR "Integrated Industry" OR "Smart Industry" OR "Smart Factory" OR "Industrial Internet" OR "Fourth Industrial Revolution" OR "Intelligent Manufacturing".

In the end, the papers recollect were 229. After removing duplicates, a first quick content check was conducted by reading titles and abstracts to check whether the content of the articles was aligned with the criteria mentioned above, excluding the ones that did not meet them.

Bearing in mind all the criteria set, a total of 22 papers were taken into account. In addition, after reading through the lists of references in the reviewed articles, 4 papers that had been missed in the search and provided meaningful insights were included as well (snowball technique). Finally, a total of 26 articles were encompassed.

3. Results of the Literature Review

The final sample of 26 documents was analyzed in depth and the various authors' contributions were divided in three main topics that enabled the research group to respond to the purpose of the review. Due to the nature of the study, interpretation of the results was conducted in a descriptive way rather than applying statistical tools. The three issues defined and their relation with the objectives are described below:

- Features, challenges and requirements of the Industry 4.0 regarding Business Models: Meets the objective of understanding how the Industry 4.0 impacts on Business Models.
- Different approaches affecting Business Models: Responds to the previous aim too, describing in more detail how those features and challenges results in three main visions to conduct the business model innovation.
- Four ways to conduct the Digital Transformation in Manufacturing Companies: Meets the objective of identifying different Business Model Innovations types through the identification of how the implementation of different enabling technologies affects Business Models components and the level of innovation required for that purpose.

In the following subchapters each subject is depicted in detail.

3.1. Features, challenges and requirements of the Industry 4.0 regarding Business Models

After reviewing the different works, it has been concluded that each author describe the industrial digitalization responding to the needs and strategies adopted in the industry or country which their study is based on. As a result, different definitions and approaches based on distinct challenges or enabling technologies can be found. Nevertheless, despite the lack of a common definition, it seems to be a consensus on the description of the features of the Industry 4.0 since all the analyzed authors take them into account on their articles. On the other hand, the articles also revealed how those features related to the Industry 4.0 are affecting traditional Business Models. Lastly, some authors define the main requirements to face those challenges mentioned before. Thus, if we consider as an example the “interoperability”, which means the connection and communication between humans and smart factories, it will reveal that barriers both, inside the companies and with suppliers or associates, are reduced to a more networked environment, and as a consequence, standardization of systems, platforms, protocols and connections among others should be fundamental requirements. The table below summarizes the findings related to this issue [2, 10]

Table 1. Features, Challenges and requirements related to the Industry 4.0

Main Features of the Industry 4.0	Main issues affecting traditional Business Model	Main requirements to face digital transformation
Interoperability	Networking and reduction of barriers	Standardization
Virtualization	Flexibility and personalization	Work organization
Decentralization of decision making	Individualized mass production	Availability of products
Real-time capability	Local production	New Business Models
Service orientation	Low price	Know-how protections
Modularity	Smart goods and services	Availability of skilled workers
	Fragmentation of the value chain	Research investment
	Globalization and decentralization of production	Professional development
	V-H integrated production systems	Legal frameworks

3.2. Different approaches affecting Business Models

In the following, we suggest the approaches identified in the literature review that respond to the features and challenges described before. On the other hand, it has to be mentioned that despite each one focuses in a particular issue, they all are interrelated between them. Thus, three proposals such as service-oriented approach, network-oriented approach and user-driven approach can be appreciated below.

3.2.1. A Service-oriented approach

The need to rethink the optimal mix of product and service business has been identified, since the digital part of a hybrid solution is always a service. Besides, Business Model patterns which were reserved to digital industries until now, are becoming relevant to traditional goods sales industries. Consequently, the Industry 4.0 is pushing companies to a change from product to service mindset [11, 12]. Moreover, many researchers have suggested that manufacturing firms in developed economies should expand their role in the value chain by extending their products with services so they do not have to compete solely on manufacturing cost. The result is the so-called product-service system (PSS) concept, a framework describing the integrated development, realization, and offering of specific product-service bundles as a solution for the customer. As a result, suppliers, customers, and other partners become part of a networked ecosystem around the CPS.

3.2.2. A network-oriented approach

The horizontal and vertical integration of the value chain and the related interoperability expands firms' traditional boundaries due to the organization and the stakeholders' network. New actors arise and the role of existing ones is changing. As a consequence, new ways of creating and offering value through ecosystems that go beyond individual value chains are raising. Accordingly, traditional manufacturing companies oriented to product sales, feel increasingly compelled to revise their existing Business Models in response to new competitive dynamics and to tap into those Industry 4.0 inspired opportunities [12].

3.2.3. A user-driven approach

This context opens up inroads to make manufacturing more responsive to user-driven design and to align it better with customer value creation processes and contexts [13]. From this approach, companies need to develop new capabilities in both, learning more about their customers (using digital capabilities to obtain information about customers, promoting evidence-based decision making, developing integral customer experiences, etc.) and becoming more of an ecosystem beyond individual value chains (become great at building partnerships with new stakeholders). Thus, the Industry 4.0 provides opportunities to create new and more flexible value propositions to respond to customer demands such as the provision of individualized products and even batch-size-line production [1]. Moreover, an enhanced customer orientation is shown by the expansion of innovative service offering.

3.3. Four ways to conduct the Digital Transformation in Manufacturing Companies

To study the implications of the Industry 4.0 in Business Model Innovation a framework based on Osterwalder's Business Model definition and the theories describing Innovation levels has been developed as both have been mentioned by some of the authors of the articles selected and are commonly accepted in the academic field.

Thus, four ways to conduct the digital transformation in manufacturing companies has been identified according to the innovation degree applied that goes from modifying such a few elements of the business model through an incremental innovation, to the transformation of all the elements of the business models due to a radical innovation (see figure 1).

As mentioned above, to analyze each type of innovation in depth, the definition of the Business Model provided by Osterwalder and Pigneur [14] has been followed. According to the authors, a Business Model describes "the

rationale of how an organization creates, delivers, and captures value”. Each proposal is described thereby, showing the changes in the value creation (that takes into account the key activities, resources and partnerships), the value delivery (which encompasses the product and services offered, the distribution, communication and sales channels, the customer segments and the established relationships) and the value capture (that describes the costs and revenues gained by the firm).

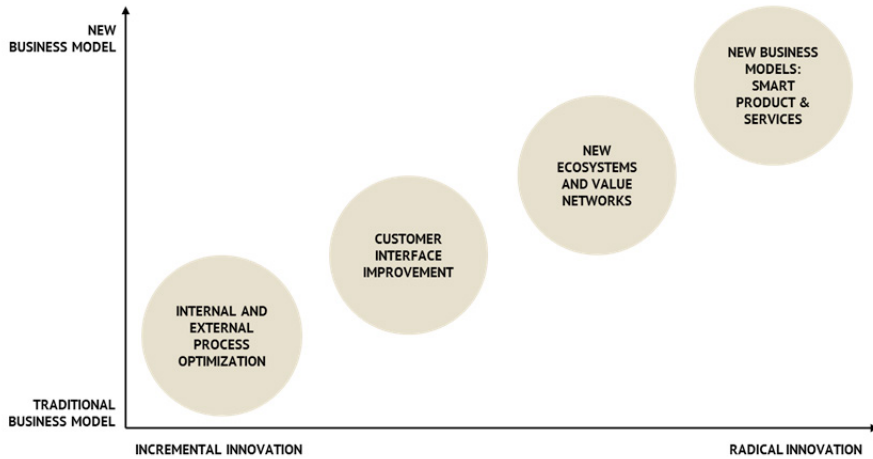


Fig. 1. Four ways to conduct digital transformation in manufacturing companies.

3.3.1. Internal and External Process Optimization

This transformation represent an incremental innovation that optimizes the actual business without involving big changes. New enabling technologies such as Big Data, Cloud Computing, Collaborative Robots, Additive Manufacturing, Artificial Vision or Augmented Reality are introduced just to optimize the value creation architecture (key resources and activities) due to increasing efficiency and improving performance (reducing costs, time and failures, employee training, etc.). This could be the first step for traditional manufacturing companies to embrace the Industry 4.0 without addressing high risks. The table below describes the impacts on each component of the Business Model.

VALUE CREATION	VALUE DELIVERY
<ul style="list-style-type: none"> • Product and resources traceability: More efficient production, logistics, quality control, inventory management and better maintenance. • Machine to machine: Connect internal processes/Connect Internal processes with suppliers processes. • Employee training: Work from any place at any time, greater and faster communication, knowledge exchange. • More transparent management: Data-driven decision making. 	<ul style="list-style-type: none"> • More flexible offers: Individualized mass production, customization, etc.
	VALUE CAPTURE

Fig. 2. Changes in Business Model components to achieve the internal and external processes optimization.

3.3.2. Customer Interface Improvement

This other incremental innovation is focused on the value delivery (value proposition through product and service offering, customer segment, channels and customer relationship) improvement. By the introduction of technologies such as Big Data, Cloud Computing, Augmented Reality or Virtual Reality, new ways of interaction through new or improved touchpoints are created, allowing a better understanding of customers’ needs and greater customer experiences. Once internal and external process are optimized, this could be the next investment to add more value to the traditional business.

VALUE DELIVERY	VALUE CREATION
<ul style="list-style-type: none"> • Segmentation based on data analysis: Greater knowledge of customers' real needs based on data/social networks, predictive and personalized marketing. • More direct, closely, efficient and long term relationships. • Improved digital sales: Wide range of devices, coherence between channels, comprehensive customer experience, self-service channels that offered time and cost saving and instant answers. 	<ul style="list-style-type: none"> • Management of new touchpoints. • Data collection, monitoring and interpretation. • Development of new services.
	VALUE CAPTURE
	<ul style="list-style-type: none"> • Cost saving • New revenue streams: dynamic pricing, pay-per-use, online payment, etc.

Fig. 3. Changes in Business Model components to achieve the customer interface improvement.

3.3.3. New Ecosystems and Value Networks

This model proposes a radical innovation of the actual Business Model which follows the purpose of focusing on the core business (key or distinctive activities of the firm), sharing the uncertainty with other agents or achieving new required skills and resources from associates, due to the introduction of technologies such as Big Data, Cloud Computing, Augmented Reality or Virtual Reality. By this way, the focal firm's value creation process is linked with the stakeholders' processes. Moving from value chains to ecosystems and, in consequence, increasing stakeholders' knowledge, requires a radical change in many of the Business Model elements (key activities, channels and relationships) with both customer and partnerships. As a result, new ways of capturing value should be defined too.

VALUE CREATION	VALUE DELIVERY
<ul style="list-style-type: none"> • Business infrastructure connected to key partners infrastructures • Real time information about production, inventories, sales, availability of personnel, etc. 	<ul style="list-style-type: none"> • Access to new customer segments • Broader offering of products
VALUE CAPTURE	
<ul style="list-style-type: none"> • Potential increase in value capture due to cost reduction for all stakeholders 	

Fig. 4. Changes in Business Model components to achieve new ecosystems and value networks.

3.3.4. New Business Models: Smart products and services

In contrast to the previous cases, this type proposes a completely new Business Model based on new technologies focused on Big Data, Cloud Computing, Intelligent Sensorisation and Embedded Systems, among others, that allow to offer innovative and smart goods and services (e.g. remote installation of maintenance or activation of product upgrades). Thus, a disruptive innovation that provides the change of almost all the elements of the Business Model is needed. This kind of new Business Models might provide the opportunity to firms to diversify or expand their markets. It also could be implemented parallel to the actual Business Model. In this way, the company could experiment with the new Business Model while the old one still provides revenues.

VALUE DELIVERY	VALUE CREATION
<ul style="list-style-type: none"> • Smart Products that constantly collect information from customers, the environment and about its performance. • Innovation in associated services: predictive maintenance, activation of product upgrades, ordering spare parts, etc. • Co-creation: Customers are part of the value creation process. • Direct relationship: between the firm and the customers 	<ul style="list-style-type: none"> • New physical, human and intellectual resources are needed
	VALUE CAPTURE
	<ul style="list-style-type: none"> • New revenue streams: dynamic pricing, pay-per-use, performance-based revenues, etc.

Fig. 5. Changes in Business Model components to achieve New Business Models.

4. Conclusions and future research

As a result of the conducted literature review, the goals defined at the beginning have been fulfilled. We have expanded our understanding about the impacts of the Industry 4.0 in Business Models as well as the possible innovations that can be applied to transform Business Models through Industry 4.0.

On the one hand, a set of features, issues and requirements have been identified and three different approaches has been suggested to make firms getting closer to the industry 4.0 phenomenon such as service orientation, networked ecosystems and customer orientation.

On the other hand, the implications of the Industry 4.0 in the Business Model components have been identified enabling the identification of different ways to transform Business Models. Firstly, the improvement of traditional Business Model due to an incremental innovation of both, value creation and value delivery has been defined. Secondly, the diversification of the actual Business Model through the reconfiguration of value networked ecosystems has been described as a radical innovation. Finally, a new Business Model typology based on the smartization of products and services has been proposed.

To conclude, the need of a further research on the topic has been detected to provide a deeper understanding of the process of Business Model Innovation and archetypes derived from the introduction of the Industry 4.0 in the manufacturing world. Moreover, the role of value in new ecosystems and how it is recognized and generated should be analyzed too in order to develop different ways to support the Business Models discovery-driven process. Lastly, a wider survey of methodological approaches, techniques and tools to help firms to deal with the opportunities and threats of the Industry 4.0 should be covered in future researches.

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