U.PORTO

FEP FACULDADE DE ECONOMIA UNIVERSIDADE DO PORTO

IMPACTS ON BUSINESS MODELS RESULTING FROM DIGITALIZATION

Sílvia Manuela Teixeira Ribeiro

Dissertation

Master in Economics and Business Administration

Supervised by

Ana Correia Simões

José Coelho Rodrigues

2020

Acknowledgments

This journey was only possible because of all the fond and support I had received.

In the first place, I would like to express my gratitude to my supervisors, Professor Ana Correia Simões and Professor José Coelho Rodrigues, whose expertise, guidance, and advice were crucial for the development and conclusion of this dissertation.

As well, I could not forget the Neutroplast' CEO and Simoldes Aços Commercial Director and appreciate once more their time and availability to contribute to this work.

I am also thankful to the FEP community, especially all the professors and colleagues, who have been part of my academic life over the five years I spent there.

Finally, and as I could not fail to mention, to my beloved parents, my dearest sister, and, of course, to all friends that were always there for me when I most needed, with a special thanks to Tiago.

Abstract

The development of the Internet created new technologies that are changing the way of doing business. Industry 4.0 marked the beginning of the Fourth Industrial Revolution and it has been capturing the attention of researchers, industries, and policymakers (Ibarra, Ganzarain, & Igartua, 2018). One of the challenges of the implementation of new technologies is the innovation of the companies' business models (Kagermann, Wahlster, & Helbig, 2013). However, the literature concerning Industry 4.0 is mainly focused on technological innovations themselves and less in their impact on business models. Besides, the scarce research about the later topic is related to big companies (Ibarra et al., 2018). Therefore, and considering the relative importance of small and medium enterprises in the Portuguese context, this dissertation aims to understand the impacts on business models resulting from the digitalization process inherent to Industry 4.0. To achieve this purpose, an exploratory multiple-case study based on semi-structured interviews was conducted in two Portuguese medium companies from two different sectors.

Findings show that besides companies being able to change to a customer-oriented approach, individualized mass production may not be always the final response. Also, networking is particularly appealing for small and medium enterprises, once they usually have fewer resources to dedicate to investigation projects. Additionally, in the era of globalization, logistic costs are still an obstacle for serving international markets. Finally, social media are seen as an internal tool of communication for business-to-business companies.

Due to the methodology used, this work does not attempt to do statistical generalizations, but instead to highlight patterns from the empirical investigation and then corroborate or reflect on theoretical concepts. Being one of the first empirical studies of the Portuguese context, it aims to diminish the lack of literature concerning this particular case and enabling futures researches on the use of business models as a management tool. Secondly, it intends to help managers to develop or redesign business models more adjusted to a more dynamic and competitive environment.

Keywords: Business Model; Business Model Innovation; Digitalization; Digital Technologies; Industry 4.0; Manufacturing; Small and Medium Enterprises; SME; Portuguese Case Study

Resumo

O desenvolvimento da Internet trouxe novas tecnologias que têm alterado o modo de fazer negócios. A Indústria 4.0 marcou o início da Quarta Revolução Industrial e tem vindo a atrair a atenção de investigadores, industriais e legisladores (Ibarra et al., 2018). Um dos desafios da implementação de novas tecnologias passa pela inovação dos modelos de negócios das empresas (Kagermann et al., 2013). No entanto, a literatura sobre a Indústria 4.0 é principalmente focada nas próprias inovações tecnológicas e menos no seu impacto nos modelos de negócios. Além disso, os poucos trabalhos de investigação sobre o último tema estão relacionados com grandes empresas (Ibarra et al., 2018). Por isso, e considerando a importância relativa das pequenas e médias empresas no tecido empresarial português, esta dissertação visa compreender os impactos nos modelos de negócio resultantes do processo de digitalização inerente à Indústria 4.0. Para atingir este objetivo, foi realizado um estudo exploratório de casos múltiplos, com base em entrevistas semiestruturadas, em duas empresas portuguesas de média dimensão de dois setores diferentes.

Os resultados mostram que além das empresas poderem mudar para uma abordagem orientada para o consumidor, a produção individualizada em massa nem sempre é a resposta final. Além disso, a criação de parcerias é particularmente atraente para pequenas e médias empresas, uma vez que elas geralmente têm menos recursos para atribuir a projetos de investigação. Para além disso, na era da globalização, os custos logísticos ainda são um obstáculo para servir mercados internacionais. Por fim, as redes sociais são vistas como uma ferramenta interna de comunicação para empresas *business-to-business*.

Devido à metodologia utilizada, este trabalho não procura fazer generalizações estatísticas, mas sim destacar padrões que emergem da investigação empírica e, corroborar ou refletir sobre conceitos teóricos. Sendo um dos primeiros casos práticos no contexto português, visa diminuir a escassez de literatura referente a este caso em particular e possibilitar trabalhos de investigação futuros sobre o uso de modelos de negócio como uma ferramenta de gestão. Em segundo lugar, pretende ajudar os gestores a desenvolver ou redesenhar modelos de negócios mais ajustados a um ambiente mais dinâmico e competitivo.

Palavras chave: Modelo de Negócio; Inovação de Modelo de Negócio; Digitalização; Tecnologias Digitais; Indústria 4.0; Pequenas e Médias Empresas; PMEs; Caso de Estudo Português

Index

Acknowledgments i
Abstract ii
Resumo iii
1. Introduction 1
2. Literature Review 3
2.1 Business Model 3
2.1.1 The Business Model Canvas 4
2.1.2 Business Model Innovation 7
2.2 Industry 4.0 8
2.2.1 Industry 4.0 Definition, Related Concepts, and Features 8
2.2.2 Implementation Challenges 10
2.3 Industry 4.0 challenge: Business Model Innovation 12
3. Materials and Methods 17
3.1 Case Design 18
3.2 Data collection and Data Analysis 19
4. Results 21
4.1 Neutroplast Case 21
4.1.1 Neutroplast Business Model Innovation 21
4.2 Simoldes Aços Case 26
4.2.1 Simoldes Aços Business Model Innovation 26
4.3 Cross-Case Comparison 29
5. Discussion 32
6. Conclusions, Limitations and Future Research 36
Appendices 38
Appendix A 38
Appendix B 39
Appendix C 40
Appendix D 40
Appendix E 41
Appendix F 43
Appendix G 43
References 44

Tables Index

Table 1. Business Model Building Blocks description……...6

Table 2. Four ways to conduct digital transformation on manufacturing companies and their impact on their value creation, delivery, and capture……..14

Table 3. General information of the companies…….18

Table 4. Interviews characterization……....19

Table 5. The effects of the new digital technologies' implementation on the business model elements of Neutroplast…….22

Table 6. The effects of the new digital technologies on the business model elements of Simoldes Aços……...27

Table 7. Summary of the impacts on each business model element observed……31

Figures Index

Figure 1. The Business Model Canvas 5

Figure 2. Methodology steps 17

List of Abbreviations

B2B – Business-to-Business

BM – Business Model

BMI – Business Model Innovation

CEO – Chief Executive Officer

CPS – Cyber-Physical Systems

CRM – Customer Relationship Management

ERP – Enterprise Resource Planning

ICT – Information and Communication Technologies

IoS – Internet of Services

IoT – Internet of Things

SMEs – Small and Medium Enterprises

1. Introduction

Hitherto, the industrial world is essentially delineated by three periods, initiated each by a revolution. The three revolutions were boosted by the water and steam powers, the electricity, and the Information and Communication Technologies (ICT), respectively (Xu, Xu, & Li, 2018). Nowadays, due to the advances in the Internet, we are facing the beginning of the Fourth Industrial Revolution, also known as Industry 4.0 (Hermann, Pentek, & Otto, 2015; Kagermann et al., 2013; Thoben, Wiesner, & Wuest, 2017; Xu et al., 2018). Industry 4.0 features are seen as the response to the current challenges – global, highly competitive, and volatile markets, shortened innovations and product life cycles, and the increasing complexity of products and services (Bauer, Hämmerle, Schlund, & Vocke, 2015). Some authors believe that the Fourth Industrial Revolution will be the most powerful driver of innovation over a few decades (Kagermann, 2015). Besides the increasing research about Industry 4.0, this is a topic also stirring up among industries and policymakers around the world (Ibarra et al., 2018).

The literature concerning Industry 4.0 is mainly focused on technological developments and their implementation, lacking efforts on the emerging new business models (BM) as a consequence of such technological innovation (Ibarra et al., 2018). Besides that, the little research about the topic is especially focused on large companies (Ibarra et al., 2018). Given the large presence of Small and Medium Enterprises (SMEs) in the Portuguese economy, it becomes especially important in this context to clarify the impact of new digital technologies, resulting from Industry 4.0 paradigm, on them. Therefore, the present research aims to explore the impacts on BM resulting from the implementation of new digital technologies on SMEs. It aims to contribute to the lack of literature concerning the particular case of small and medium manufacturing companies and to enable futures researches on the use of BM as a management tool. Furthermore, it intends to help managers to develop or redesign BM more adjusted to more dynamic and competitive markets.

This document is organized as follows. Section 2 presents the relevant theoretical background of Industry 4.0 and business model innovation (BMI). It is initiated by the presentation of the origin of Industry 4.0, providing a clarification of the term Industry 4.0 and related concepts, its features, and finalizing with the implementation challenges identified. The second part concerns the definitions of the term BM are presented, as well as a conceptual framework of its elements – the BM Canvas - followed by the definition of BMI. The last subsection reviews the theoretical studies focused on BMI resulting from Industry 4.0. Section 3 corresponds to the methodology followed by this academic work,

describing the research design, data collection, and analysis processes. Section 4 displays the two cases results, while section 5 presents the discussion of those results based on the theoretical background previously presented. Finally, the last section concerns the conclusions, limitations, and recommendations for future research.

2. Literature Review

2.1 Business Model

The term BM appeared for the first time in the academic literature in 1957 in a paper by Bellman, Clark, Malcolm, Craft, and Ricciardi (1957). Hereafter, the unspecific definitions contextualize BM in the information technology field, being only recognized as a management tool 18 years later by Konczal (Wirtz, Pistoia, Ullrich, & Göttel, 2016). Nevertheless, the use of the term just gained notoriety in the 90s during the proliferation of the "dotcom"[1] companies (Osterwalder, Pigneur, & Tucci, 2005; Wirtz et al., 2016). However, there is still no consensual definition of the BM in the literature (Al-Debi, El-Haddadeh, & Avison, 2008; Chesbrough, 2007; Petrovic, Kittl, & Teksten, 2001).

The majority of research work in the field is focused on defining the purpose, the scope, the primary elements of a BM, and their relationships with the strategy and business processes (Pateli & Giaglis, 2017). The first definition that captured the attention of many researchers is attributed to Timmers (1998). He defines BM as an architecture of products, services, and information flows and the description of the business actors and their roles, of the value proposition, and the sources of revenue (Timmers, 1998). Osterwalder and Pigneur (2010) give special attention to the value offered by the company, defining the BM as "… the rationale of how an organization creates, delivers, and captures value" (Osterwalder & Pigneur, 2010, p. 14). Amit and Zott (2015, p. 37) focus on the activities performed by actors of an organization and the relationships between them: "We define a company's business model as a system of interconnected and interdependent activities that determines the way the company "does business" with its customers, partners and vendors". Also, Bouwman, Nikou, Molina-Castillo, and Reuver (2018, p. 1) emphasize value creation: "Business model is defined as the business logic to create and capture value for both consumers and businesses". More definitions can be founded in Appendix A. However, the literature appears to converge to the idea of BM as the sum of complementary elements, mainly value creation, value capture, and value offer (Chesbrough, 2007; Foss & Saebi, 2016; Osterwalder et al., 2005).

Many of those definitions are also dedicated to identifying the BM components or elements (Auer & Follack, 2002; Linder & Cantrell, 2000; Osterwalder et al., 2005; Petrovic et al., 2001) or even specifically focused on them (Alt & Zimmermann, 2001; Chesbrough, 2007). Linder

[1] "Dotcom" companies are pure Internet companies, this is, operating only online (Auer & Follack, 2002).

and Cantrell (2000) recognize BM's components as "pieces" of BM and point some examples such as pricing model, revenue model, channel model[2], value proposition, and organizational forms. Alt and Zimmermann (2001) identify six generic components – mission (goals, vision and value proposition), structure (actors and governance, focus in determinate industry, customers and products), processes (customer-orientation and coordination mechanism), revenues (source of revenues, and business logic), and legal and technological requirements and constraints. Besides different authors refer or denominate different components, the literature review indicates that there is a relative consensus among them (Foss & Saebi, 2016; Pateli & Giaglis, 2017). The components proposed by the different authors are all related to the Nine Building Blocks proposed by Osterwalder et al. (2005) and can the grouped in three main categories – value creation, value delivery or offer and value capture (Osterwalder et al., 2005). For that reason, the following section is related to the Nine Building Blocks and the Canvas framework.

2.1.1 The Business Model Canvas

Conceptual models are representations, usually graphical, of BM elements and their relationships (Pateli & Giaglis, 2017). Osterwalder and Pigneur (2010) offer the most recognized and used model in both academic and practical field (Ruggieri, Savastano, Scalingi, Bala, & D'Ascenzo, 2018; Sun, Yan, Lu, Bie, & Thomas, 2012). The BM Canvas, shown in Figure 1, is defined as "a shared language for describing, visualizing, assessing, and changing business models" (Osterwalder & Pigneur, 2010, p. 12) and it is based on the Nine Building Blocks, described in Table 1. The authors consider that there are four core areas of a business: customers, offer, infrastructure, and financial viability. The Nine Building Blocks cover all these four areas and consist of: key partners, key activities, key resources, value proposition, channels, customer relationships, customer segments, revenue stream, and cost structure.

[2] "Channel model" concerns the distribution channels/ channels of the Nine Building Blocks proposed by Osterwalder et al. (2005).

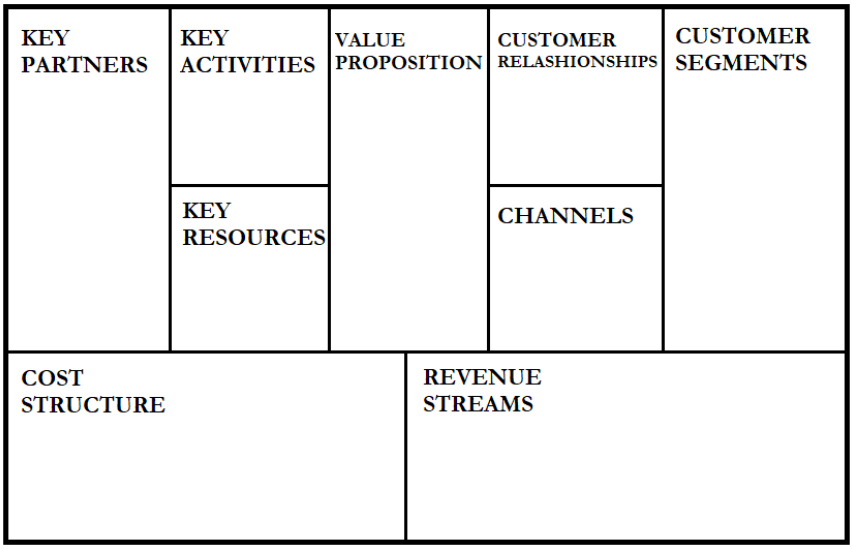


Figure 1. The Business Model Canvas

Source: Adapted from Osterwalder and Pigneur, 2010

	Core Area	Building Block	Description
Value Creation	Infrastructure Management	Key Partners	The network of suppliers and partners that make the BM work. There are four different types of partnerships: strategic alliances between non-competitors, strategic partnerships between competitors, joint ventures, and buyer-supplier relationships.
		Key Activities	The most important actions a company must do to operate successfully, for example, design, production, delivery of a product, problem solving activities or platform management.
		Key Resources	The most important assets required to create and offer a value proposition, reach markets, maintain relationships, and earn revenues. Key resources can be physical, financial, intellectual, or human, and can be owned or leased by the company or acquired from partners.

Value Delivery	Offer	Value Proposition	A distinct mix of elements that satisfy a customer problem or need. These elements could be quantitative such as price or speed of service, or qualitative such as customization and status.
	Customers Interface	Customer Relationships	Types of relationships a company establishes with each customer segment They can be more automated or more personal.
		Channels	How a company delivers its value proposition to its customer segments. A company can have owned channels and partner channels or both.
		Customer Segments	Companies need to create different groups of customers based on different needs, behaviors, types of relationship required, profitability, or other attributes, in order to adjust the approach with each of these groups.
Value Capture	Financial Aspects	Revenue Streams	The way a company makes money through different revenue flows. Each revenue stream may have different pricing mechanisms, such as fixed list prices, dynamic prices, bargaining, auctioning, market dependent, volume dependent, or yield management.
		Cost Structure	All costs incurred to operate a BM. Every company wants to minimize costs, but it can have different weights for every company. Many businesses fall in cost-driven or value-driven cost structures.

Table 1. Business Model Building Blocks description

Source: Adapted from Osterwalder and Pigneur, 2010

The BM of a company is not static and maybe change through time. As Mitchell and Coles (2003) refereed for the first time, companies should use BM as a tool to help innovate their business (Aagaard, Presser, & Andersen, 2019; Amit & Zott, 2015; Foss & Saebi, 2016; Sun et al., 2012). This argument is becoming more powerful in the literature as some established companies are facing a hard time, while new start-ups appear in the market and turn the fastest growing and very successful (Zott & Amit, 2017). For that reason, the following section is dedicated to the exploration of BMI.

2.1.2 Business Model Innovation

Companies see the implementation of technological innovations as a strategy to remain competitive. However, these cannot represent necessarily the most successful solution nowadays. Current markets are characterized by higher uncertainty, dynamic environments and high levels of competition than ever (Al-Debi et al., 2008; Lindgardt, Reeves, Stalk, & Deimler, 2009), with reduced barriers to entry, consequences of the Internet and mobile technologies proliferation (Al-Debi et al., 2008). As mentioned by Chesbrough (2007) "it's not about technology anymore", and nowadays innovation must also include BM. Later in 2010, he additionally refers that a technology innovation needs an appropriate BM to be successful and that a company can gain at least as much from an innovative BM as from an innovative technology (Chesbrough, 2010). There is a need to adapt the traditional BM or develop new ones that better exploit the opportunities enabled by technological innovations (Pateli & Giaglis, 2017).

One cannot find in the literature a consensus about the BMI concept, due to the fact that it is a recent topic and perhaps also due to the difficulty of defining BM itself (Bouwman et al., 2018). As already mentioned previously, the first reference to the idea of BM as a subject of innovation was only made by Mitchell and Coles (2003). The authors define BMI as the BM replacements that allow offering new products and services to customers and end-users, including the process of developing those replacements themselves. Amit and Zott (2015) suggest that BMI is the adoption of novel activities, new linkages between the existing activities, or the replacement of business actors in the firm's value network. Bouwman et al. (2018, p. 1) define it "… as a change in a company's BM that is new to the firm and results in observable changes in its practices toward customers and partners". However, the discussion about the representation of novelty to the firm or not is still ongoing. According

to Foss and Saebi (2016), BMI can represent novelty to the firm or the industry, and Zott and Amit (2017, p. 2) even add that it just needs to be "new to the world", not just "new to the company". These few studies about the conceptualization of this subject seem to converge to define BMI as the result of the modification and/or introduction of one or more BM components and/or the links between them. Therefore, it can create a new market or new opportunities in existing markets, and, even when innovation might not disrupt the market, it can still be beneficial to the innovator (Amit & Zott, 2015).

2.2 Industry 4.0

2.2.1 Industry 4.0 Definition, Related Concepts, and Features

The term "*Industrie 4.0*" was introduced during the German Hannover Fair in 2011, being then announced in 2013 as the official government High-Tech Strategy 2020 Action Plan, aiming to establish Germany as the manufacturing revolution leader (Kagermann et al., 2013; Xu et al., 2018). Similar plans were launched around the globe in countries such as China (Made in China 2025), United States of America (Industrial Internet Consortium), Japan, Singapore, South Korea (Manufacturing Innovation 3.0), and European Union (Factories of the Future) (Müller, Buliga, & Voigt, 2018). The term evolved to the Anglo-Saxon world as "Industry 4.0" and as "Smart Manufacturing" in the United States, Japan, and Korea. There are other related designations such as "Intelligent Manufacturing", "Advanced Manufacturing", "Integrated Industry", "Smart Industry", "Smart Factory", and "Industrial Internet" (Ibarra et al., 2018).

Although Industry 4.0 was been a topic of interest for many companies and researchers in the last few years (Ibarra et al., 2018), a generally accepted definition of the designation does not exist (Hermann et al., 2015; Ibarra et al., 2018). The Final Report of the *Industrie 4.0* Working Group (Kagermann et al., 2013) highlights the importance and the results of the introduction of the Internet of Things (IoT) and Services (IoS) into the manufacturing companies. It underlines that the Cyber-Physical Systems (CPS) will allow companies to establish global networks, incorporating smart machines, warehousing systems, and production facilities capable of autonomously exchanging information, triggering actions, and independently controlling each other (Kagermann et al., 2013). Besides this vision, Hermann et al. (2015) recognize the importance of clarifying the term for further researches,

and provide the following definition for Industry 4.0 in the entitled article "Design Principles for *Industrie* 4.0 Scenarios: A Literature Review":

"*Industrie 4.0* is a collective term for technologies and concepts of value chain organization. Within the modular structured Smart Factories of *Industrie 4.0*, CPS monitor physical processes, create a virtual copy of the physical world, and make decentralized decisions. Over the IoT, CPS communicate and cooperate with each other and humans in real-time. Via the IoS, both internal and cross-organizational services are offered and utilized by participants of the value chain" (Hermann et al., 2015, p. 11).

Historically, the first three industrial revolutions were consequences of mechanization powered by water and steam, electricity, and Information and Communication Technologies (ICT), respectively (Xu et al., 2018). Though, Industry 4.0 has initiated the Fourth Industrial Revolution (Hermann et al., 2015; Kagermann et al., 2013; Thoben et al., 2017; Xu et al., 2018), triggering the first predictive revolution. The Fourth Industrial Revolution was fueled by news developments in these ICT (Xu et al., 2018) however, while the Third Industrial Revolution was focused on the automation of machines and processes, the latest one is, besides the full automation (Roblek, Meško, & Krapež, 2016), focused on the integration at an intra and inter-organizational levels (Kagermann et al., 2013; Xu et al., 2018). The interaction and exchange of information will happen among humans, humans and machines, and machines themselves (Monostori, 2014; Sun et al., 2012). Communication among machines will be the most significant in this new industrial revolution, allowing high levels of automation (Roblek et al., 2016).

Hermann et al. (2015) define CPS, IoT, IoS, and Smart Factory as the four key components of Industry 4.0. CPS are considered the core foundation of Industry 4.0 (Monostori, 2014). They can be defined as systems of collaborating computational entities that are in intensive connection with the surrounding physical world and its on-going processes (Monostori, 2014). These systems include smart machines, storage systems, and production facilities that automatically exchange information, trigger actions and control each other independently (Kagermann et al., 2013), with feedback loops where physical processes affect computers and vice versa (Roblek et al., 2016). IoT and IoS can be defined as a global network in which numerous interrelated devices (CPS) cooperate with each other through unique addressing schemas, transferring, storing, processing, and analyzing data over that network without requiring human-to-human or human-to-computer interaction (Kagermann, 2015; Xu et al., 2018). Smart Factory can be defined as a factory where CPS communicate over the IoT and assist people and machines in the execution of their tasks. Another relevant concept of the

field is the smart product. A smart product is a product inserted with sensors and microchips that, when are being used, allow communication through the IoT (for example, using a smartphone) with each other and with human beings. Roblek et al. (2016) also insist on mentioning Cloud Computing and Big Data as the base of Industry 4.0. Could Computing is an affordable technology that allows the upload, storage, and computation to a cloud computing center a large volume of data. This stored data is known as "Big Data" and can be mined using smart algorithms in order to identify patterns that generate information that if correlated can produce new knowledge. Although other authors also mention other technologies such as Enterprise Architecture, Service-Oriented Architecture (SOA), Business Process Management, Blockchain, Big Data (BD), Artificial Intelligence (AI) and Industrial Information Integration (Xu et al., 2018), they are not particularly crucial for the understanding of the present research.

Besides the lack of a common definition of Industry 4.0, Hermann et al. (2015) based on their four basic components, defined six design principles to help managers identifying Industry 4.0 pilots that can be then implemented, later reinforced by the literature review of Ibarra et al. (2018):

(i) interoperability between CPS
(ii) virtualization of the physical world made by CPS
(iii) decentralization of planning and control decisions – enabling CPS of decision-making
(iv) real-time capacity for data collection and analysis
(v) service orientation - extending their product offer with services
(vi) modularity (flexible systems).

In the last years, there have been remarkable developments in Industry 4.0 applications and technologies however, their implementation still affords some challenges (Xu et al., 2018). More emerging technologies will appear to face these challenges and facilitate Industry 4.0 implementation (Xu et al., 2018).

2.2.2 Implementation Challenges

Industry 4.0 implementation addresses actions in the following key areas:

(i) Standardization and reference architecture: Communication, identification, and security standards are required in order to improve the interoperability of different

applications and systems (Hermann et al., 2015; Xu et al., 2018). Collaborative partnerships between different companies will only be possible if an architecture framework with a technical description of these standards is developed (Kagermann, 2015; Kagermann et al., 2013). Xu et al. (2018) refer that the actual ICT infrastructures of some companies do not permit horizontal and vertical integration.

(ii) Managing complex systems: The higher complexity of systems and products requires appropriate planning and explanatory models for their management, including new BM (Kagermann et al., 2013). It will be needed to adopt a more systemic approach to innovation and technological development, this is, new technologies need to be supported by the strategy and the BM (Kagermann, 2015). It will also be needed a change in the management, once it is necessary to change paradigms to an open innovation using systemic platform cooperation - platform that ensembles actors from industry, academia, government, and civil society (Kagermann, 2015).

(iii) Comprehensive broadband infrastructure for industry: IoT requires a reliable, comprehensive, secure, and high-quality communication network infrastructure (Kagermann, 2015; Kagermann et al., 2013). Since a wider variety of large volume transactional data and information will be processed at a high speed, some scalability issues need to be exceeded (Xu et al., 2018).

(iv) Safety and security: Manufacturing systems must not harm people or the environment. Furthermore, IoT automatically collects a huge amount of personal and private information, and the existing technologies available for protecting information security may not be enough (Xu et al., 2018). Besides, the importance of keeping the information far away from unauthorized access (Kagermann et al., 2013), it is also important to take into account values and ethical considerations and balance the privacy and the potential economic benefit (Kagermann, 2015).

(v) Work organization and design: Along with machines, work content, processes and environment will change as well, giving the workers more autonomy, variety of tasks, and responsibility. Humans will continue to be at the center of the new BM (Kagermann, 2015). Less complex jobs will quickly disappear however, white-collar roles in the fields of systems planning, engineering, and integration or coordination and orchestration will increase (Kagermann, 2015). For example, as a massive amount of real-time data will be automatically produced by IoT applications and ICT systems, it will be required data scientists and analysts to process this information

and provide meaningful value to decision-making and applications able to work with big data (Xu et al., 2018).

(vi) Training and continuing professional development: The employees need to be qualified through suitable, interdisciplinary, personalized training, and life-long learning (Kagermann, 2015; Kagermann et al., 2013). In fact, digitalization can support this learning process (Kagermann, 2015).

(vii) Regulatory framework: All these changes have to go along with legislation updates that take into account innovations particularly for privacy and liability regulations (Kagermann et al., 2013).

(viii) Resource efficiency: By improving productivity and resource efficiency, raw material and energy consumptions should be lowered. However, it will be necessary to measure the trade-offs of the additional resources, resulting from high production capacity (Kagermann et al., 2013).

(ix) Economic factors: Recent technologies are usually expensive. This could be particularly problematic for the diffusion of Industry 4.0 technologies into SMEs (Sun et al., 2012). Research investments will also be needed, especially for technical challenges (Ibarra et al., 2018).

The potential positive economic, social, and environmental benefits of Industry 4.0 (Müller et al., 2018) can overcome the challenges of implementing the new technologies (Xu et al., 2018). Kagermann (2015) considers that the Industry 4.0 will be the most powerful driver of innovation over the next few decades. Industry 4.0 features are seen as the response to the current challenges – global, highly competitive, and volatile markets, shortened innovation and product life cycles and the increasing complexity of products and services (Bauer et al., 2015). Therefore, new ways of value creation are necessary (Bauer et al., 2015), this is, adapted or new BM are needed (Kagermann et al., 2013). This will be the challenge explored by this research.

2.3 Industry 4.0 challenge: Business Model Innovation

Ibarra et al. (2018) summarize the Industry 4.0 features and its challenges in three different approaches affecting BM – service-oriented, network-oriented, and user-driven approaches. Industry 4.0 is pushing manufactories into a service-oriented approach, this is, to develop and offer product-service bundles, expanding that way their role in the value chain and

escaping from the competition solely on manufacturing costs. The horizontal and vertical integration of the value chain and the related interoperability, reduction of barriers and transparency, is leading companies to a network-oriented approach. The new competitive market dynamics are compelling companies to creating partnerships with stakeholders, leading to ecosystems instead of individual value chains. This idea of networking also can provide new and more flexible value propositions once it is possible to obtain more information about the specific customers' needs, enabling individualized mass production (now profitable due to the automated and flexible production). This is known as a user or customer-oriented approach (Ibarra et al., 2018).

Regarding the previous approaches, and based on Osterwalder's BM definition and the theories describing innovation levels, Ibarra et al. (2018) define four different types of digital innovation (second column of Table 2) and their impact on the value creation, the value delivery and in the value capture (third, fourth, and fifth columns of Table 2). These changes or innovations can be less or more extensive, which represent what is respectively called as incremental or radical in the innovation theories (first column of Table 2).

The first and less risky step for traditional companies to embrace Industry 4.0 usually consists of an internal and external process optimization that increases efficiency and improves performance by applying new digital technologies such as Big Data, Cloud Computing, or Augmented Reality. This incremental innovation is focused on optimizing the value creation architecture, with a special impact on key resources and activities. The next investment should be focused on customer interface improvement, using these new technologies to create new ways of interaction with customers, allowing a better understanding and satisfaction of customer's needs. This step will impact the value delivery elements. The third stage refers to the creation of new ecosystems and value networks. These new technologies could improve not just the relationships with customers, but also with new or established partners. Allowing to share the uncertainty and the acquisition of new skills and resources, new ways of value capture could be arranged, although, many changes in other BM elements can occur. The most radical innovation and so the most risk charged is the use of new technologies to the development of smart products and services, which implies a change in almost all the BM elements (Ibarra et al., 2018).

		Value Creation	Value Delivery	Value Capture
Incremental Innovation/ Traditional BM	**Internal and External Process Optimization**	Product and resources traceability Internal processes connection with suppliers' processes Possibility of remote work, faster and greater communication, knowledge exchange Data-driven decision making	Flexible offer: individualized mass product, customization, etc.	Cost optimization from more efficient processes and use of resources
	Customer Interface Improvement	New touchpoint Data collection and analysis Development of new services	Segmentation based on data analysis More direct, closely, efficient, and long-term relationships Improved digital sales	Cost reduction New revenue streams (dynamic pricing, pay-per-use, online payments, etc.)
Radical Innovation/ New Business Model	**New Ecosystems and Value Networks**	Business infrastructure connected to key partners infrastructures Real-time data	Access to new customer segments Broader products offering	Potential cost reduction for all stakeholders
	New Business Models: Smart Product and Services	New resources needed	Smart products and services offer Products and services co-creation with customers Direct relationships	New revenue streams

Table 2. Four ways to conduct digital transformation on manufacturing companies and their impact on their value creation, delivery, and capture

Source: Adapted from Ibarra et al. (2018)

Another categorization was provided by Müller et al. (2018) that presents the four stages for manufacturing SMEs in the context of Industry 4.0, built on two aspects – the company's role and motivation for Industry 4.0 implementation. The authors supported the idea, initially exposed by Kagermann et al. (2013), that SMEs can adopt two different roles – user and/or provider of Industry 4.0 As the own designations indicate, a provider manufacture CPS solutions then implemented by the users (Kagermann et al., 2013; Müller et al., 2018). Furthermore, while some companies have external motivations for implementation Industry 4.0, such as the pressure of larger customers (Kagermann et al., 2013) or changes in the competition (Bouwman et al., 2018; Foss & Saebi, 2016), others have internal motivations like the perceived market opportunities inherent to it, proceeding with changes in their strategy (Bouwman et al., 2018; Foss & Saebi, 2016; Kagermann et al., 2013). Taking that into account, the four stages are described next:

(i) Craft manufactures: Companies with no interest in Industry 4.0. They are characterized as high dependence on human labor or little automation.
(ii) Preliminary stage planners: Those companies recognize the Industry 4.0 potential, but they are not ready yet. They plan to follow Industry 4.0 in the mid or long term, and they are initiation automation of manufacturing, because of that, no impact on their BM is perceived yet.
(iii) User in value creation: Companies that fear being driven out of the market and that for that reason react following the Industry 4.0 trend. They aim essentially production process efficiency and efficient data exchange with customers and suppliers, impacting their value creation elements.
(iv) Full-scale adopters: Companies that truly believe in the Industry 4.0 profitability, seeking for remaining or becoming industry leaders. They have high automation degrees and they are usually providers or user/providers, supporting and equipping other companies with tools for Industry 4.0. The innovation can affect all their BM elements.

The conclusions of Ibarra et al. (2018) and Müller et al. (2018) studies converge to the idea that the first step took by companies interested in pursuing the benefits of Industry 4.0 is usually the automation, with no significant impacts on BM. In the second phase, the optimization of processes is amplified with the implementation of new technologies such as Big Data and Cloud Computing. The first impacts on BM are starting to be noticed, especially in the value creation elements such as the key resources and activities. The next stage is

related to the importance of data collection and analysis, impacting customers, and partners. Only the last stage, represented by high levels of automation and integration at an intra and inter-organizational level, can create impacts on all BM elements (Ibarra et al., 2018; Müller et al., 2018).

3. Materials and Methods

The methodology applied should depend on the research problem to be explored (Noor, 2008), and therefore, the methodology of the present work was designed based on the "research onion" model provided by Saunders, Lewis, and Thornhill (2007). The methodology steps are described in the following Figure 2, and each step of the "research onion" model is presented in Appendix B.

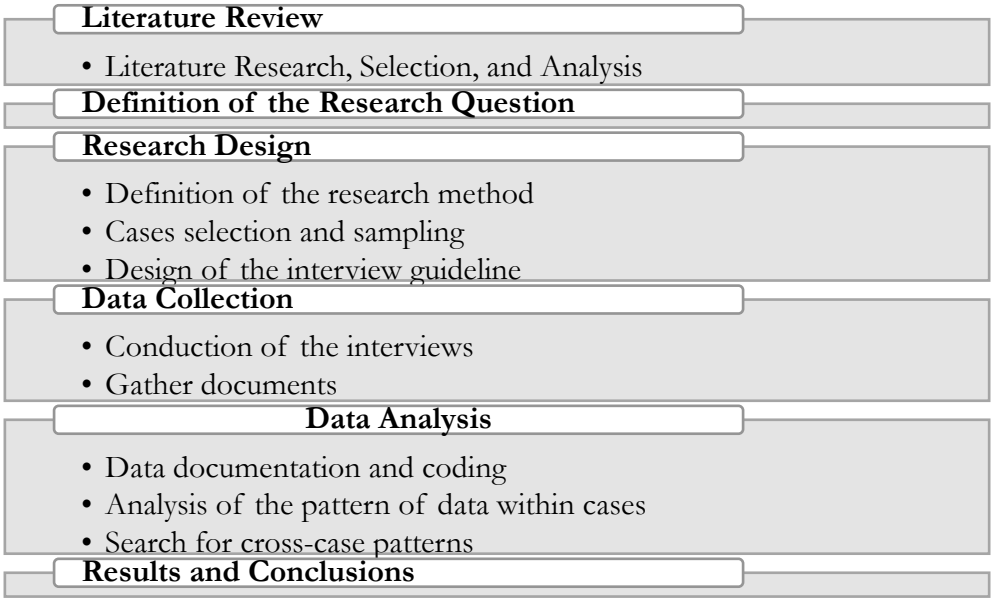


Figure 2. Methodology steps

The research method used was case research. According to Yin (2018), case studies should be used (1) for "how" and/or "why" research questions, (2) when the researcher has no control over the actual behavioral events under studied, and (3) focus on contemporary events. The aim of this work is to study the impacts on BM resulting from digitalization, i.e., "how" new digital technologies are affecting the BM of small and medium Portuguese companies. In order to do so, it is intended to study an event (the BMI occurring in Portuguese SMEs) that cannot be manipulated, and that can be characterized as a contemporary occurrence, insofar as it produces results in the recent past and present. Therefore, the research method chosen in this research was a qualitative multiple case study, using interviews as the main source of data.

Due to the exploratory nature of the multiple case study and the sample size, this research does not make an attempt to do a statistical generalization, but instead an analytic generalization. Therefore, as an analytic generalization, this study aims to (a) corroborate,

modify, reflect, or advance theoretical concepts or (b) based on the conclusions of this case, produce new concepts and contribute to future researches (Yin, 2018).

3.1 Case Design

The target of this case study is Portuguese SMEs. SMEs represent 99.9% of the total national companies, according to the last data available on the website PORDATA related to the *Instituto Nacional de Estatísticas* study of 2018 (https://www.pordata.pt/DB/Portugal/Ambiente+de+Consulta/Tabela). The criteria settled for the SMEs' definition is presented in Appendix C.

After meticulous research, using the SMEs list available in the website COMPETE 2020[4] and some news published in the last year (2019) in national journals and websites (Jornal Têxtil, APPICCAPS, Jornal de Notícias, Observador, etc.), a list of 22 companies with projects in the Industry 4.0 field was obtained. The list can be consulted in Appendix D. Followed by another online research, the companies contacts were acquired through their websites, and, they were contacted by email. Those contacts were made in the months of March, April, and May 2020, during which the country faced the most critical phase of the COVID-19 pandemic. That can explain the fact that only two companies were able to collaborate with this study. The two cases are characterized in the following Table 3.

The overall case study analyzes the actual BM of two different Portuguese companies and, therefore, can be classified as a holistic multiple case study.

Company	Core Business/ Sector	Year of foundation	Target	Number of employees	Typology
Neutroplast	Plastic packaging / pharmaceutical industry	1993	B2B	53	Medium
Simoldes Aços	Molds / automotive industry	1959	B2B	210	Medium

Table 3. General information of the companies

[4] COMPETE 2020 is a structure of the Central Administration of the State, created on December 16th, 2014. It mobilizes Structural and Investment European Funds to national companies to promote competitiveness and internationalization during the period 2014-2020 with the final purpose of increasing the Portuguese economy.

3.2 Data collection and Data Analysis

For data collection, multiple sources of evidence were used. One source of the data was documents provided by the companies' websites and social media as well as the public databases of funded projects such as COMPETE 2020 (https://www.compete2020.gov.pt/Projetos). The other data collection method used was the interviews, one of the most important sources of evidence in case studies (Yin, 2018). For the semi-structured interview, an initial guideline was written and can be consulted in Appendix E. Its first section was related to the general information of the companies (core business, age, number of employees, etc.), in order to construct the context of each case. The closed-ended questions allowed the collection of companies' basic characteristics, background, and specific expertise of the interviewee. In the other three sections, open-ended questions were approached the topic of this research. These sections were related to the strategies implemented in the company related to the Industry 4.0 initiatives, the impact of those on each of the nine building blocks of the company's BM, and the digital technologies implementation challenges, respectively.

The two interviews were scheduled for two consecutive days, May 4th and 5th, and they last between one and two hours. The interviews were conducted using a video call platform due to the pandemic situation previously referred to. This information is summarized in Table 4.

Company	Date of the interview	Duration (hours)	Interviewee Function	Meeting Type
Neutroplast	04/05/2020	2	Chief Executive Officer (CEO)	Video call
Simoldes Aços	05/05/2020	1	Commercial Director	Video call

Table 4. Interviews characterization

After the data collection, the data analysis started with the elaboration of a coding scheme suggested by Strauss and Corbin (1990). Starting with a thorough reading of the interview line-by-line, relevant words and phrases were marked and memos were written. Then, related statements were summarized into categories and subcategories. Secondly, a within-case analysis was performed accompanied by a pattern matching with the theoretical background.

Finally, a cross-comparison of the BMs of the companies was made to search for similarities and differences between the cases, with the intention of reaching more generalizable conclusions (Yin, 2018)

As Yin (2018) noted, reliability and validity in case studies are crucial for the quality of the research. Therefore, during the research design and implementation, these aspects were considered. For external validity reasons, a multiple case study and a replication logic was the research method chosen, enhancing a more robust and compelling study. Likewise, in order to establish correct operational measures during data collection, i.e., to ensure construct validity, multiple sources of evidence (documents and interviews) were used. Finally, and towards ensuring reliability, for the semi-structured interview, an interview guideline was created and followed during the interviews (Yin, 2018). In the next section, the results from these two case analyses are presented.

4. Results

4.1 Neutroplast Case

Neutroplast is a Portuguese manufacture of plastic packaging for the pharmaceutical and health care industries, founded in 1993, and it is classified as a medium enterprise. Its products include pill bottles, bottles for liquids and powder to droppers and medical devices and caps. For a better understanding of this company's BM, its main relevant aspects are presented in Appendix F.

The current leadership replaced almost two years ago, defined a new chapter in the company's strategy. The new CEO advocates that the company, despite being relatively successful compared to the national competitors, was lagging behind in the international competition, as a result of years without innovation. Since 2019, Neutroplast is going through a deep reformulation in order to adapt to the Industry 4.0 vision. Neutroplast continues to automate its processes. In the production, the company is implementing its first quality control machines, and regarding the logistics, the warehouse will be fully automatized. Neutroplast implemented an Enterprise Resource Planning (ERP) software a few years ago and now is also implementing a Customer Relationship Management (CRM) for cloud service, the software responsible for all the online campaigns and data analysis.

4.1.1 Neutroplast Business Model Innovation

The implementation of new digital technologies under the Industry 4.0 program initiated in 2019 by Neutroplast already led to BMI. The findings are presented in six main areas: value proposition, customer relationships, costs, key activities, key resources, and key partners. Table 3 synthesizes the impact of those digital technologies in each BM element, and a deeper explanation is provided after.

Value Offer	**Value Proposition**	Smaller product portfolio More eco-friendly products offer Flexible production Products with higher quality Personalized products according to the customer needs Development of smart products
	Customer Relationships	More personal and long-lasting relationships More digital communication and less home visits needed for established customers Better perception of each customer need Higher customers' satisfaction Improved social media contacts
Value Capture	**Costs**	Savings with raw material annual acquisition Less resources consuming
Value Creation	**Key Activities**	Data analysis Customer assistance Higher production capacity and efficiency Less defected products More decentralized decision-making Remote work
	Key Resources	New job positions Less manufacturing positions Less commercials needed Value of the most technical jobs
	Key Partners	New partnerships with academic institutions, associations and even with other companies Innovative partnerships Co-development of products Integration of the regional community

Table 5. The effects of the new digital technologies' implementation on the business model elements of Neutroplast

Value proposition. Neutroplast is in the premium sector of plastic packaging for pharmaceutical and health care industries, so quality is essential, but is no longer enough. The interviewee emphasized that what differentiates the choice of its customers is the guarantees, regularity, and security of the packaging manufacturing, something that now can be ensured by a more efficient production.

Recognizing the importance of flexibility and customization approach, Neutroplast production currently dedicates one-third of its production to personalized packaging. However, the interviewee reveals that it is not a very profitable activity yet. Neutroplast products' portfolio also changed. It comprises five product lines, which include one range of standard products. This standard line represents the most profitable to the company and it is something that differentiates it from its competitors. They also reduce the number of products they offer – passing from the 400 products in 2017, for 110 nowadays. All these changes allowed them to improve the quality of its products and its production efficiency and capacity by requiring less specific machinery and reducing setup times. In terms of ecological concerns, the manufacturing company developed mono-material packages[5] in order to facilitate the recycling process.

In terms of product innovation, Neutroplast is currently working with some partners in the development of smart products. For example, ensembled with its spin-off unit BeyondDevices, the University of Medicine of Amsterdam, and the Centre of Nanotechnology and Smart Materials (CENTI), they are participating in a project called DOSEA. This project aims to develop smart labels to monitor and alert the need to take medication, using innovative technologies such as smart packaging, printed electronics, and IoT[6]. Also, with BeyondDevices and *Universidade Nova de Lisboa*, they are developing a vaginal applicator with printed biosensors that measure the vaginal PH allowing women to know by themselves, at home, if their infections are healing.

Customers Relationships. Neutroplast starts to use one CRM software to manage its relationships with its customer. This allowed it to manage much more data, much more efficient and less time and resources (especially human resources) consuming. Using this

[5] Mono-material packages are produced with resourcing to just one type of plastic (PET, PVC, PEAD, etc.), contrasting the previous production that usually used various types of plastic.

[6] Source : https://www.beyondevices.eu/projeto-dosea/. BeyonDevices is a spin-off unit of Neutroplast, representing a specialized unit of high-technological medical product research and development. The DOSEA project is one of its main projects.

technologies allowed Neutroplast to establish more personalized relationships, once they register data from every email or phone call from each of its 409 customers and potential clients.

Besides the fact the company communicates using mainly emails and the telephone, the interviewee recognizes the importance of participating in events to establish and build new relationships with the customers. The company is reinforcing its presence in three international fairs on the sector where it tries to build its own "*event inside the event*" with site conferences personalized for each customer. The home visiting is getting less importance for established relationships however, Neutroplast still uses it for building new ones.

Regarding social media, Neutroplast started using LinkedIn and Facebook three years ago. They recognized that they are not as active in social media as they could be, however, they are applying some efforts to increase communication using them. They use LinkedIn essentially to communicate with customers and partners, and Facebook for employees and their regional community. The interviewee also referred WhatsApp as a very used social media for business communicating however, he avoids it once he cannot capture and process data automatically.

Key Activities. The interviewee emphasized production as the business main key activity *"In other parts, I can take risks, in production I cannot."* However, it is visible its engagement in the assistance of its customers during all the manufacturing processes since the mold's design to the support of the industrial implementation of its product in the customer's factory. The interviewee also desired to decentralize the decision-making process. Hitherto, everything was decided by the CEO, including, for example, the acquisition of new raw materials. Additionally, currently with the ERP and the CRM software, it is far easier to make an informed decision. "*To delegate, you have to have a lot of good information to help you controlling or it is very hard. You have to have super people in each department and then, there are a lot of companies that do not have resources to have those people.".* By that, it is noticeable that data analysis began to have an important role in the company's activities.

Key Resources. When questioned about the most important resource of Neutroplast, the interviewee answered immediately *"clearly people, the rest are machines"*. However, the number of people that are part of the organization and their job roles have changed over time. From a general perspective, Neutroplast passed from 80 to 53 people in three years, as a result of the processes automation, and not followed by a reduction in the capacity. Part of this reduction was in the commercial area, where they decreased for four people, as a

consequence of the implementation of the CRM. The interviewee even refers that *"two years ago, I used to have the double of commercials and used to do half of the proposes."* Additionally, a new position for data analysis was created.

Key Partners. Neutroplast has established a lot of new partnerships with other companies (for example, BeyondDevices), associations (Portuguese Plastic Industry Association and Smart Waste Portugal) and universities and research centers (Centre of Nanotechnology and Smart Materials, Faculty of Medicine of the University of Amsterdam, INESTEC Microsystems and Nanotechnologies, *Universidade Nova de Lisboa*, INEGI Porto, Technological Center for the Molds, Special Tools and Plastics Industry). The interviewee recognizes the importance of networking and attributes to these partnerships the possibility to innovate.

Costs. The interviewee recognizes that investment in digital technologies allowed some cost reduction. For example, Neutroplast saved 20% in costs related to the annual plan of the raw material needed, due to the use of historical data. The annual production planning allowed Neutroplast, consulting historical data, to estimate the annual quantities to purchase of each raw material, allowing it to take advantage of quantity discounts. However, the biggest impact was on personnel expenses. This reduction enabled the manufacturing company to value the technical professions once the company decided to spend the same amount of salaries despite the reduction of employees, resulting in the valuation of all the job positions, especially more technical ones.

4.2 Simoldes Aços Case

Simoldes Aços is a 60 years-old medium Portuguese manufacturing company. Initially, in 1959, the company started by producing plastic molds for houseware and toys for the Portuguese market. Since the 1970s, it changed to the automotive industry, and, consequently, to external markets such as Spain, France, Germany, Scandinavia, Turkey, China, and Iran. Until now, the main business remained, and it has established itself as the European leader in the molding making industry. The company has a strong innovation DNA, and, also being a reason for its leadership, has always an internal motivation to be the one that leads the next trend in the industry. A representation of this company's BM is presented in Appendix G.

In order to face the current challenges, Simoldes Aços had created the project "Simoldes 4.0", which has the main goal to develop a mold with artificial vision and intelligent sensors which allowed the monitorization and control of the temperature and pressure during the production. In other words, Simoldes Aços aims to develop a smart product that in this case is a smart mold and an e-mold. Moreover, the molds company also has another project called "Simone" that aims to update its marketing strategy, especially for the use of social media networks. Simoldes Aços only uses Facebook and LinkedIn and mainly for internal communication. The interviewee refers that the company's customers do not privilege the use of social media as a method of communication, but the internal community likes to use it.

4.2.1 Simoldes Aços Business Model Innovation

The fact that Simoldes Aços is embedded in an intensive technological industry such as the automotive, induced them, since the beginning, to be in the vanguard on the adoption of the new production technologies, with consequences in its high level of automation. Therefore, for this company, the major impact of Industry 4.0 is more the interconnectivity and monitorization in real-time than in automation. Simoldes Aços is in an earlier stage of Industry 4.0 technologies adoption, so the Industry 4.0 program impacts are not so visible as in the Neutroplast case. Table 4 synthesizes those impacts in each BM element, followed by an explanation.

Value Offer	**Value Proposition**	Improved customer orientation Higher-value products offer Innovative products Improved customer technical assistance and information Granted delivery time Development of smart products
	Customer Relationships	More personal and long-lasting relationships Higher customers' satisfaction
Value Capture	**Costs**	Cost reduction
Value Creation	**Key Activities**	Strong customer assistance and information along all process Higher efficiency
	Key Resources	More sense of community between the employees and the regional community
	Key Partners	New partnerships with regional schools and universities, customers, suppliers, and local associations Innovative partnerships Co-development of products and brainstorming

Table 6. The effects of the new digital technologies on the business model elements of Simoldes Aços

Value Proposition. The interviewee says that product quality is a requirement in the sector. He emphasizes the characteristics that define Simoldes Aços as the industry leader – long term product quality, innovative products, very strong customer assistance, and information along all process, granted delivery time. It is also relevant to refer that, due to its products'

nature, Simoldes Aços always offered customized products, i.e., the mold it is designed to fit the product of its customer.

"Total quality, granted delivery time, competitive prices. Very strong sales strategy and customer orientation."[7]

Customers Relationship. Simoldes Aços has a small number of customers and, therefore, the customer relationship is and aims to be very personal. The communication with the customer is made by in-person visits. The interviewee explains that in-person visits are a common communication channel in the industry. Even when, the company identifies a potential client, the proposal is made in-person. By that, the relationships with customers are not being affected directly by some new digital technology. However, what they are now willing to offer to their customers is improving their satisfaction, and thereby their present and future relationship.

Key Activities. The interviewee identifies production as the main key activity, although the monitoring and technical advice are gaining emphasis and even distinguish Simoldes Aços among the industry players.

Key Resources and Key Partners. The interviewee emphasis the relevance of the people and their specific know-how of the industry, saying *"The right people with bad and old machines work better than new machines and wrong people"*. However, the company struggles with talent acquisition once the industry requires very specific knowledge and skills. In order to face this challenge, Simoldes Aços has established some partnerships with regional higher education institutions (Aveiro and Minho Universities, Aveiro Superior School), providing them machinery and also promoting educational examples/cases to introduce and motivate students to initiate their carriers in the industry.

The interviewee emphasizes the extreme importance of its partners, even saying that they provide the most disruptive ideas. He particularly refers to its partnerships with local higher education institutions, and with local associations (Technological Center for the Molds, Special Tools and Plastics Industry), which are in fact helping the development of its actual innovation projects such as the e-mold.

[7] Source : http://www.simoldes.com/tool/en/html/m29.html.

4.3 Cross-Case Comparison

Context. Besides the different positions they occupy in their markets, both companies have a very strong innovation culture that is supported and boosted by the company's leadership. However, while for Simoldes Aços this innovation culture is established for years and it is even essential in their market, for Neutroplast this is a recent approach linked with the new leadership.

Actions. While for Simoldes Aços, Industry 4.0 is being implemented focused on improving interconnectivity and monitorization in real-time, as automation was already well established, for Neutroplast Industry 4.0 is still being implemented to improve processes through automation.

Value Proposition. For both manufacturing companies, even though they are in different sectors, product quality is no longer a key success factor. Because of that, they are betting to improve customer assistance during all production processes. They also explore new product possibilities, including what is known in the field as smart products. Besides that, and due to the products' nature, Simoldes Aços always has produced customized products. For Neutroplast, this customization is possible but it not so profitable as the result of the low-value product they offer.

Customers Relationships. The two companies have international customers, and, in fact, they represent the majority of customers. These companies are seizing the benefits of globalization. The customer relationships are managed with the right software available for customer care, helping them to do segmented marketing to an individualized level. Maybe due to the fact that they are B2B companies and they do not have several customers, besides the contact using telephones and emails, they privilege in-person contacts including home visits.

Moreover, because they are B2B companies they do not attribute as much importance as it could be expected to social media. They both used LinkedIn and Facebook, but they are more as an internal tool of communication.

Customer Segments. While Simoldes Aços thinks globally in terms of customers, Neutroplast has more strict geography mainly due to the high logistic costs that become not worthy to the company serving more distant countries. Neutroplast extracts reduced profit margins from its products and usually, its customers are sensitive to price variations on such

a low-value product, turning countries such as Germany, Russian and even Italy not profitable due to the high costs that shipping companies practice to deliver these products.

Key activities. For both interviewees, production continues to be the most important action for their company to operate successfully, besides their commitment to customer support. Simoldes Aços seems to attribute more importance to customer assistance during all the processes than Neutroplast. Although, Neutroplast explores more the potential of a service-oriented approach.

Key resources. Also, both manufacturing companies recognized their human resources as their most valuable asset.

Key partners. The two companies attribute high importance to their partners and there are essentially partnerships with academic and research centers institutions. The main propose of these partnerships is the alignment of the specific knowledge and mainly monetary resources of the company and the time to investigate.

The impacts on BM pointed and observed in the two cases are summarized in the following Table 5. The following section provides a discussion of these results.

Building Block	Impact
Key Partners	New partnerships, especially academic institutions that are the base of support of their innovation (B)
	Increased importance of networking (B)
Key Activities	More efficient product (B), logistics, quality control and inventory management (N)
	Work from any place at any time, greater and faster communication, knowledge exchange (N)
	More transparent, data-driven decision making (N)
	Real-time information about production, inventories, personnel, etc. (B)
Key Resources	New physical, human, and intellectual resources are needed (B)
	More qualified human resources (B)
	Less defected products (N)
Value Proposition	Increased customer orientation (B)
	New products offering (B)
	Smart products development (B)
Customer Relationships	New and improved touchpoints (N)
	Better understanding of customer's needs (N)
	Greater customer experiences (B)
	More direct, closely, and long-term relationships (N)
	Personalized marketing (B)
Customer Segments	Global customers (S)
Cost Structure	Cost optimization due to the more efficient use of resources and processes (N)
	Possibility of low price (N)

Table 7. Summary of the impacts on each business model element observed

Legend: N – Neutroplast, S – Simoldes, B - Both

5. Discussion

The present section provides a discussion of the results of this study presented in the previous section.

The first considerations are concerning the perception of the term Industry 4.0 in the practical world. When questioned about it, both interviewees have shown clarity in their speech, referring to the automation process, but giving special emphasis to the interconnectivity and data collection and analysis. However, while Simoldes Aços has already reached high levels of automation, for Neutroplast automation still represents a significant effort of its investment. This difference seems only to be based on the less risky strategy followed by the company's previous leadership. Until two years ago, Neutroplast's leadership was averse to high risk, do not supporting innovation inside the company, leading to a period of stagnation, and loss of competitive advantage. For this reason, Neutroplast's Industry 4.0 initiatives include greater investments in process automation than in interconnectivity, data collection and analysis, while for Simoldes Aços most investments are in these last points. It bears out the important role of leadership in the success of the implementation of new technologies (Chesbrough, 2007). This also supports Bouwman et al. (2018) conclusions of innovation activity and strategy as two internal drivers of BMI. Moreover, as Khanagha, Volberda, and Oshri (2014) argued that a change to the strategy implies a change in the BM.

Likewise, the motivation to pursue such an innovation path has an important impact on BM (Kagermann et al., 2013). Indeed, both companies referred to internal motivation as the main driver of Industry 4.0 technologies implementation strategy. Neutroplast's initiative derives essentially from a change in the strategy, while Simoldes Aços derives from its innovation culture and ambition to dictate the next industry's trend and the maintenance of its leadership position. Derived from this reason, the two interviewees had actively searched for innovative projects, establishing important partnerships with universities, other companies, and associations, in line with the study results of Müller et al. (2018). However, Neutroplast also referred to external motivations, namely competitiveness, once the company recognized its undesired competitive position and decided to improve its competitiveness through digital transformation. This seems to support the hypothesis of the competitiveness intensity as one external driver identified but not supported by the study of Bouwman et al. (2018).

Concerning Ibarra et al. (2018) proposed four stages of the digital innovation framework, it is possible to verify that both companies already had implemented actions on the first three stages and are starting to implement the last one with their recent investments on the

development of smart products. However, while Simoldes Aços conducted this process gradually over the years, Neutroplast is implementing all the innovations as a single project. That is the reason why Neutroplast identifies more immediate results. Regarding the Müller et al. (2018) distinction of Industry 4.0 users and providers, Neutroplast can be surely defined as a user in the value creation, once competitiveness pressure was one of the main drivers of the adoption of Industry 4.0. Meanwhile, Simoldes Aços had already achieved high levels of automation, and in order to remain as the industry leader, aims to develop smart products and tools, craving their use and adoption by other players in the market. For that reason, Simoldes Aços can be considered as a full-scale adopter. Impact on all BM elements would be expected however, Simoldes Aços denotes only cost reductions, which could be explained by the forehand implementation stage of the Industry 4.0 initiatives. Overall, the two case studies verify the conclusion of Ibarra et al. (2018) and Müller et al. (2018) studies - the main and first impacts are noticed on the value creation and value delivery.

Now especially addressing the main goal of this work, the impacts of the implementation of new digital technologies on BM are discussed next. Firstly and related to the value offer, in the Neutroplast case is observed a shift to a more customer-oriented approach, offering the possibility of product customization. Although, for Neutroplast, this customization is possible but it not so profitable, which can be attributed to the low-value product they offer and the fact that its production is not fully automatized. This point supports the idea that Industry 4.0 decreases the cost of customized products in the long term. However, these costs will continue to be higher than the mass production strategy, due to the investments in new technologies (Da Xu, He, & Li, 2014). In Simoldes Aços case, this customer-oriented approach is not new, due to its products' nature, the company only produces customized products. Both companies also decided to invest in the development of smart products and services. This strategy can be a good justification for practicing higher prices as some researches have pointed (Müller et al., 2018). That can be in fact especially relevant in companies offering low-value products as the Neutroplast case.

Both companies already took the first steps into a service-oriented architecture by offering more data transparency through the production process, increasing interconnectivity with customers. Simoldes Aços went far by providing after production assistance and repair to its customers, exploring more the potential of a service-oriented approach. Despite all, for both interviewees, production continues to be the most important activity to operate successfully.

Therefore, it is possible to notice that the value proposition was the building block that suffered the most significant changes, which can be supported by the literature once it is

identified as the most important building block of IoT based companies (Johnson, Christensen, & Kagermann, 2008; Metallo, Agrifoglio, Schiavone, & Mueller, 2018).

The second relevant point is related to the customers. The two companies have international customers, and, in fact, they represent the big majority of them. Therefore, they are seizing the benefits of globalization. However, Neutroplast has more strict geography mainly due to the high logistic costs that become not worthy to the company serving countries more faraway. While the full automation of processes in its production might reduce the product cost, increasing the margin, vertical integration in the value chain or even a new partnership with a logistics company could solve this issue, enabling the scale economies.

Also, because they are B2B companies they do not attribute as much importance as it would be expected to social media. They both use LinkedIn and Facebook, but more as an internal tool of communication. The wide use of social media is always associated with big data generation and further analysis, as pointed by Wamba, Akter, Edwards, Chopin, and Gnanzou (2015). However, in cases of B2B, those analyses may not be beneficial, as companies' social media publications are carefully planned, only showing the image they aim to show.

Related to value creation, there are three points to highlight. Firstly, as already mentioned, both SMEs recognize the importance of data collection and analysis enabled by high-grade digitalization. The most noticeable positive impact highlighted by the interviewees is the production optimization, failure reduction, and higher productivity, enabling a more efficient value creation, supporting the main literature benefits of Industry 4.0 (Ibarra et al., 2018; Müller et al., 2018). Secondly, as Kagermann (2015) predicted, humans will continue to be at the center of the new BM. In both cases, people were the first answer when asked about the most important resource of their BM. Here, regarding the workforce, the literature results (Kagermann, 2015; Xu et al., 2018) are verified in the Neutroplast case. In fact, employees are more autonomous, with higher responsibilities and tasks. One of the Neutroplast's main goal was the decentralization of the decision-making and planning process, something that was achieved due to the new digital technologies that enable workers to make data-driven decisions, as Xu et al. (2018) noticed. Besides that, as the literature already pointed, the decrease of monotonous tasks and the manufacturing jobs in sum as one of the impacts of Industry 4.0 (Kagermann, 2015; Müller et al., 2018; Xu et al., 2018).

Relatively to the key partners, the results are aligned with the literature findings. The two companies are building a network-oriented approach, recognizing the high importance of

their partnerships, namely for research purposes. As Chesbrough (2003) mentioned, global networking is promoting a shift from closed to open innovation systems. Although, Neutroplast seems to have more partnerships and be more dependent on them, possibly due to the smaller dimension and availability of resources that this company has compared to Simoldes Aços, a larger company within a group. Neutroplast seems to be more dependent on community funds to finance its investigations, with three already approved projects and with 13 more on the waiting list.

Finally, the impacts on value capture were predictably less stressed, besides the usual cost reduction resultant from the increased efficiency, and planning. Some changes in the value capture such as new revenue streams pointed by the literature (Ibarra et al., 2018), do not even appear to be in the short-term strategy of both companies.

6. Conclusions, Limitations and Future Research

Industry 4.0 will result in extraordinarily complex systems, which have to be supported with appropriate management tools, such as strategy and BM. In fact, one of the implementation challenges of Industry 4.0 identified in the literature is precisely that, the BMI that will be needed to the success of the application of new digital technologies (Kagermann, 2015; Kagermann et al., 2013) Thereby, the present work contributed for the academic literature by fulfilling the lack of studies on the impacts of Industry 4.0 on BM in the specific case of manufacturing SMEs (Ibarra et al., 2018). For that purpose, a multiple-case study was conducted in two Portuguese medium companies from two different sectors – automotive and pharmaceutical.

The findings show that companies tend to change their BM, primarily focused on modifying their value proposition. This point was in fact expected, once companies are created, and so their BM, around a defined value proposition. Taking that into account, it is expected that their BMI initiates with the value proposition modification. The BMI can be caused by external factors, such as competition, but also by internal factors, such as a change into the company's strategy. The empirical evidence from this multiple-case study confirmed some patterns already highlighted by the existing literature. Among them the change to an open innovation paradigm (Chesbrough, 2003) in the base of a network-oriented approach (Ibarra et al., 2018) in order to face more competitive markets (Bauer et al., 2015). Moreover, the human factor will be the center of the new model. It will create a customer-oriented approach that will lead companies to individualize mass production, now possible to make profitable due to the high automation that decreases the production costs in the long term. Therefore, new products and ideally new services will be part of the new value proposition of companies. The inclusion of services into manufacturing companies' value proposition will allow them to do a vertical integration into the value chain, justifying high prices. It will also improve work conditions, despite decreasing the number of jobs, especially in less complex positions. Customers are now global and customer relationship management will be improved with the support of digital technologies.

Overall, more cooperative environments, improved customer relationships, and new products and services are key to remain competitive in the actual markets. Additionally, the present study demonstrates clear benefits from the adoption of new digital technologies for manufacturing SMEs, despite the perceived challenges that the implementation of Industry 4.0 paradigm represents. In fact, the two SMEs demonstrated interest to reinforce the

investments and efforts in their Industry 4.0 actions. As also sustained in the literature (Chesbrough & Rosenbloom, 2002) the BM different components can influence one another, as there is a need for congruence between components in order for the BM to work. For example, a service-oriented approach will not only affect the value proposition but probably also the company's key activities.

This work concerns some limitations that need to be underlined. Firstly, the qualitative nature of the study and the small number of companies analyzed do not allow the generalization of the results. Instead, this work aims to highlight patterns from practical cases, allowing guidance to other manufacturing companies. Additionally, the number of interviews in each company, only one person, increases the possibility of a single informant bias. Moreover, data collection using interviews are also subject to errors and different interpretation of concepts on both sides (interviewer and interviewee). The attempt to minimize this issue was settled by the use of the BM Canvas framework, the most recognized framework in both the academic and practical world (Ruggieri et al., 2018; Sun et al., 2012), in order to reduce significant differences of BM conception.

Moreover, the studies concerning Industry 4.0 are still recent. Future research could incite longitudinal BMI studies in order to capture more robust impacts. Another suggestion would be to conduct case researches that address a wider sample, in different economies, and in different sectors. Finally, and in a more long-term perspective, quantitative research could be created in order to achieve results that can be generalized.

Appendices

Appendix A

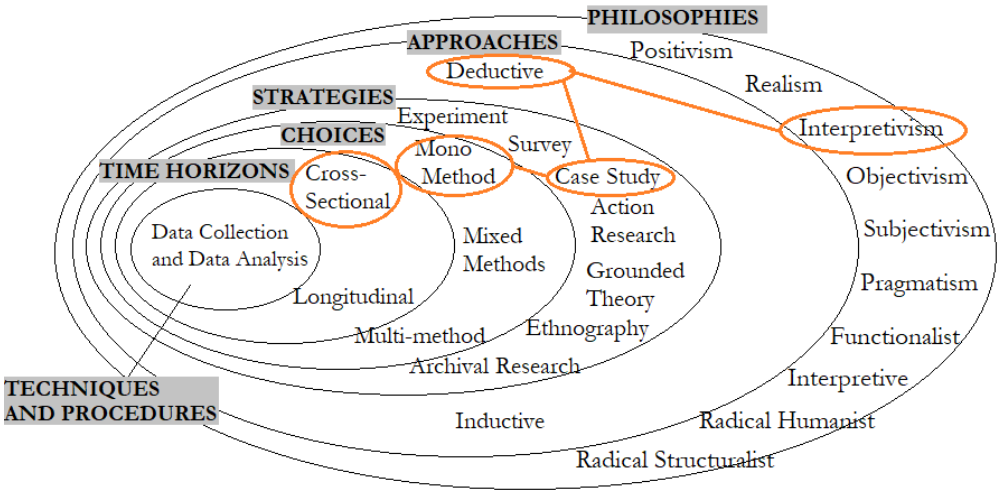
Business Model Definitions

Author(s)	Definition
Timmers (1998, p. 4)	"Definition of a business model • An architecture for the product, service and information flows, including a description of the various business actors and their roles; and • A description of the potential benefits for the various business actors; and • A description of the sources of revenues."
Rappa (2010)	"In the most basic sense, a business model is the method of doing business by which a company can sustain itself - that is, generate revenue. The business model spells-out how a company makes money by specifying where it is positioned in the value chain."
Linder and Cantrell (2000, p. 1)	"When people speak about "business models," they could be speaking about three distinct things: components of business models, real operating business models, and what we call change models. A business model, strictly speaking, is the organization's core logic for creating value. A change model is the core logic for how a firm will change over time in order to remain profitable."
Petrovic et al. (2001, p. 2)	"A business model is based on a mental representation of certain aspects of the real world that are relevant for the business."
Osterwalder et al. (2005, pp. 17 -18)	"A business model is a conceptual tool that contains a set of elements and their relationships and allows expressing the business logic of a specific firm. It is a description of the value a company offers to one or several segments of customers and of the architecture of the firm and its network of partners for creating, marketing, and delivering this value relationship capital, to generate profitable and sustainable revenue streams."

Osterwalder and Pigneur (2010, p. 14)	"A business model describes the rationale of how an organization creates, delivers, and captures value".
Amit and Zott (2015, p. 37)	"We define a company's business model as a system of interconnected and interdependent activities that determines the way the company "does business" with its customers, partners and vendors."
Zott and Amit (2017, p. 2)	"The business model can be described as a system of interconnected and interdependent activities that determines the way the company "does business" with its stakeholders. In other words, a business model is a bundle of specific activities – an activity system – conducted to satisfy the perceived needs of the market."
Bouwman et al. (2018, p. 1)	"Business model is defined as the business logic to create and capture value for both consumers and businesses".

Appendix B

Research Onion Model



Source: Saunders et al. (2007)

Appendix C

Criteria of the European SMEs definition

Category	Number of employees	Annual Turnover (EUR)	and/or	Annual Balance Sheet Total (EUR)
Medium	< 250	≤ 50 million		≤ 43 million
Small	< 50	≤ 10 million		≤ 10 million
Micro	< 10	≤ 2 million		≤ 2 million

Source:
https://ec.europa.eu/growth/smes/businessfriendlyenvironment/smedefinition_en

Appendix D

List of companies contacted	
Lemon Jelly	Morphis
Balanças Marques	Moldmark
Vicoustic	HJDP
Enamorata	Inovafil
Simoldes Aços	Orfama
Polopique	Carfi
Silvex	Controlar
BeyonDevices	Aleluia Cerâmicas
Neutroplast	Mtex
Fobric	Gladz
Cor	Paula Borges
Plastimago Transformadora de Plásticos Lda.	

Appendix E

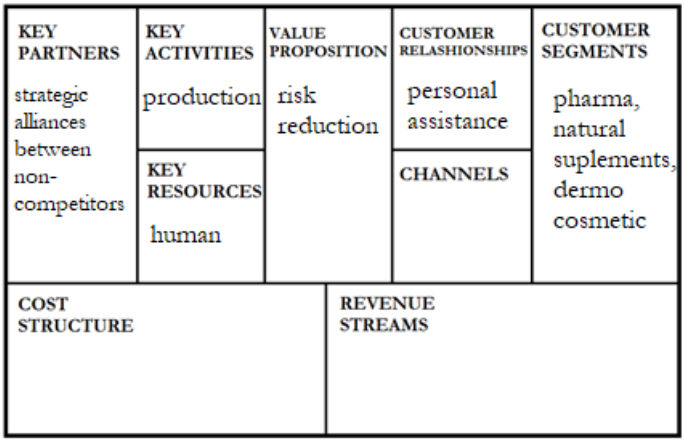
Interview Guideline

Part I General Information	1) Company's age 2) Main Business/ Sector 3)Target (B2B/B2C) 4) Number of employees 5) Position of the interviewed
Part II Industry 4.0	6) Have you heard / are you familiar with the term "Industry 4.0"? (if not, give a brief explanation) 7) What measures would you say the company has been implementing that fall within Industry 4.0? (e.g., digitization of production processes, use of "cloud services", data analysis using, uses of social media, etc.). Please, describe them. 8) What are the reasons for this implementation? (internal or external) 9) How important is innovation in organizational culture?
Part III BM impacts	10) What are the effects of these measures on your business model? a) Value proposition What is the company's value proposition? / What do you propose to offer to your customers? (E.g., competitive price, fast service, customized products ...) b) Customer segments What is your target audience? What are your customer segments? c) Relationship with customers How many are and what are the points of contact with customers? Is this relationship more automated or personal? d) Key partners Who do you consider to be the company's key partners?

	How important do you think these partners are? (very important, important, not important) Do you have a partnership? (e.g., do you have an agreement with a supplier or competitor for R&D?) e) Key resources What do you consider to be the company's key resources? (that is, what are the assets - physical, financial, intellectual, or human - needed to effectively offer the value proposition to your customers) f) Key activities What do you consider to be the company's key activities? (understand key activities such as the most important actions the company has to take to be successful, e.g., design, production, product delivery, problem solving activities or platform management) g) Revenue streams and costs Did you noticed any increase in the company's revenues? And in the costs?
Part IV Implementation Challenges	11) What do you consider to be the main obstacles in implementing Industry 4.0 as an SME? a) shortage of qualified human resources b) high investment in the acquisition and maintenance of technologies c) low standardization of production processes d) small order size e) other 12) Despite all this, does the company plan to continue to invest in Industry 4.0 in the coming years?

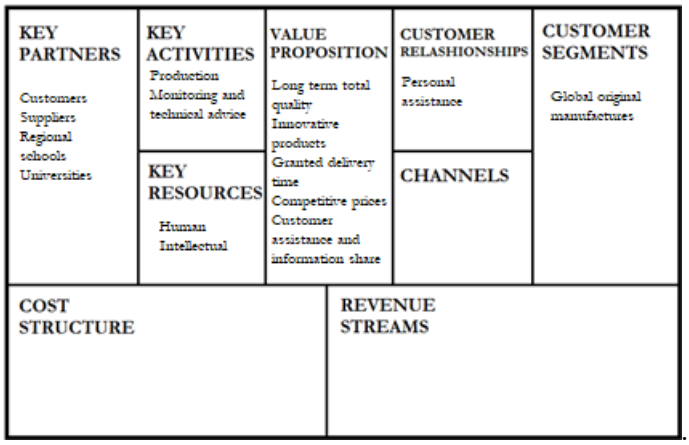
Appendix F

Current Neutroplast business model



Appendix G

Current Simoldes Aços business model



References

Aagaard, A., Presser, M., & Andersen, T. (2019). *Applying Iot as a leverage for business model innovation and digital transformation.* Paper presented at the 2019 Global IoT Summit (GIoTS).

Al-Debi, M. M., El-Haddadeh, R., & Avison, D. (2008). Defining the business model in the new world of digital business. *AMCIS 2008 proceedings*, 300.

Alt, R., & Zimmermann, H.-D. (2001). Preface: Introduction to Special Section - Business Models. *Electronic Markets, 11*(1), 3-9. doi:10.1080/713765630

Amit, R., & Zott, C. (2015). Creating value through business model innovation: could your company benefit from a new business model? Consider these six questions. *MIT Sloan Manag Rev, 53*(3), 36-44.

Auer, C., & Follack, M. (2002). Using action research for gaining competitive advantage out of the internet, s impact on existing business models. *BLED 2002 Proceedings*, 45.

Bauer, W., Hämmerle, M., Schlund, S., & Vocke, C. (2015). Transforming to a Hyper-connected Society and Economy – Towards an "Industry 4.0". *Procedia Manufacturing, 3*, 417-424. doi:10.1016/j.promfg.2015.07.200

Bellman, R., Clark, C. E., Malcolm, D. G., Craft, C. J., & Ricciardi, F. M. (1957). On the Construction of a Multi-Stage, Multi-Person Business Game. *Operations Research, 5*(4), 469-503. doi:10.1287/opre.5.4.469

Bouwman, H., Nikou, S., Molina-Castillo, F. J., & de Reuver, M. (2018). The impact of digitalization on business models. *Digital Policy, Regulation and Governance, 20*(2), 105-124. doi:10.1108/dprg-07-2017-0039

Chesbrough, H. (2007). Business model innovation: it's not just about technology anymore. *Strategy & Leadership, 35*(6), 12-17. doi:10.1108/10878570710833714

Chesbrough, H. (2010). Business Model Innovation: Opportunities and Barriers. *Long Range Planning, 43*(2-3), 354-363. doi:10.1016/j.lrp.2009.07.010

Chesbrough, H., & Rosenbloom, R. S. (2002). The role of the business model in capturing value from innovation: evidence from Xerox Corporation's technology spin-off companies. *Industrial and corporate change, 11*(3), 529-555.

Chesbrough, H. W. (2003). *Open innovation: The new imperative for creating and profiting from technology*: Harvard Business Press.

Da Xu, L., He, W., & Li, S. (2014). Internet of things in industries: A survey. *IEEE Transactions on industrial informatics, 10*(4), 2233-2243.

Foss, N. J., & Saebi, T. (2016). Fifteen Years of Research on Business Model Innovation. *Journal of Management, 43*(1), 200-227. doi:10.1177/0149206316675927

Hermann, M., Pentek, T., & Otto, B. (2015). Design principles for Industrie 4.0 scenarios: a literature review. *Technische Universität Dortmund, Dortmund.*

Ibarra, D., Ganzarain, J., & Igartua, J. I. (2018). Business model innovation through Industry 4.0: A review. *Procedia Manufacturing, 22*, 4-10. doi:10.1016/j.promfg.2018.03.002

Johnson, M. W., Christensen, C. M., & Kagermann, H. (2008). Reinventing your business model. *Harvard business review, 86*(12), 57-68.

Kagermann H., (2015). Change through digitization—Value creation in the age of Industry 4.0. In *Management of permanent change* (pp. 23-45): Springer.

Kagermann, H., Wahlster, W., & Helbig, J. (2013). *Recommendations for implementing the strategic initiative INDUSTRIE 4.0: Final Report of the Industrie 4.0 Working Group*. Retrieved from

Khanagha, S., Volberda, H., & Oshri, I. (2014). Business model renewal and ambidexterity: structural alteration and strategy formation process during transition to a C loud business model. *R&D Management, 44*(3), 322-340.

Linder, J., & Cantrell, S. (2000). *Changing Business Models: Surveying the Landscape*. Retrieved from

Lindgardt, Z., Reeves, M., Stalk, G., & Deimler, M. S. (2009). Business model innovation. *When the Game Gets Tough, Change the Game, The Boston Consulting Group, Boston, MA*.

Metallo, C., Agrifoglio, R., Schiavone, F., & Mueller, J. (2018). Understanding business model in the Internet of Things industry. *Technological Forecasting and Social Change, 136*, 298-306.

Mitchell, D., & Coles, C. (2003). The ultimate competitive advantage of continuing business model innovation. *Journal of Business Strategy*.

Monostori, L. (2014). Cyber-physical Production Systems: Roots, Expectations and R&D Challenges. *Procedia CIRP, 17*, 9-13. doi:10.1016/j.procir.2014.03.115

Müller, J. M., Buliga, O., & Voigt, K.-I. (2018). Fortune favors the prepared: How SMEs approach business model innovations in Industry 4.0. *Technological Forecasting and Social Change, 132*, 2-17. doi:10.1016/j.techfore.2017.12.019

Noor, K. B. M. (2008). Case study: A strategic research methodology. *American journal of applied sciences, 5*(11), 1602-1604.

Osterwalder, A., & Pigneur, Y. (2010). *Business model generation: a handbook for visionaries, game changers, and challengers*: John Wiley & Sons.

Osterwalder, A., Pigneur, Y., & Tucci, C. L. (2005). Clarifying Business Models: Origins, Present, and Future of the Concept. *Communications of the Association for Information Systems, 16*. doi:10.17705/1cais.01601

Pateli, A. G., & Giaglis, G. M. (2017). A research framework for analysing eBusiness models. *European Journal of Information Systems, 13*(4), 302-314. doi:10.1057/palgrave.ejis.3000513

Petrovic, O., Kittl, C., & Teksten, R. D. (2001). Developing business models for ebusiness. *Available at SSRN 1658505*.

Rappa, M. (2010). Business Models On The Web. Retrieved from http://digitalenterprise.org/models/models.html

Roblek, V., Meško, M., & Krapež, A. (2016). A Complex View of Industry 4.0. *SAGE Open, 6*(2). doi:10.1177/2158244016653987

Ruggieri, R., Savastano, M., Scalingi, A., Bala, D., & D'Ascenzo, F. (2018). The impact of Digital Platforms on Business Models: an empirical investigation on innovative start-ups. *Management & Marketing. Challenges for the Knowledge Society, 13*(4), 1210-1225.

Saunders, M., Lewis, P., & Thornhill, A. (2007). Research methods. *Business Students 4th edition Pearson Education Limited, England*.

Strauss, A., & Corbin, J. (1990). *Basics of qualitative research*: Sage publications.

Sun, Y., Yan, H., Lu, C., Bie, R., & Thomas, P. (2012). A holistic approach to visualizing business models for the internet of things. *Communications in Mobile Computing, 1*(1). doi:10.1186/2192-1121-1-4

Thoben, K.-D., Wiesner, S., & Wuest, T. (2017). "Industrie 4.0" and Smart Manufacturing – A Review of Research Issues and Application Examples. *International Journal of Automation Technology, 11*(1), 4-16. doi:10.20965/ijat.2017.p0004

Timmers, P. (1998). Business Models for Electronic Markets. *Electronic Markets, 8*(2), 3-8. doi:10.1080/10196789800000016

Wamba, S. F., Akter, S., Edwards, A., Chopin, G., & Gnanzou, D. (2015). How 'big data'can make big impact: Findings from a systematic review and a longitudinal case study. *International Journal of Production Economics, 165*, 234-246.

Wirtz, B. W., Pistoia, A., Ullrich, S., & Göttel, V. (2016). Business Models: Origin, Development and Future Research Perspectives. *Long Range Planning, 49*(1), 36-54. doi:10.1016/j.lrp.2015.04.001

Xu, L. D., Xu, E. L., & Li, L. (2018). Industry 4.0: state of the art and future trends. *International Journal of Production Research, 56*(8), 2941-2962. doi:10.1080/00207543.2018.1444806

Yin, R. K. (2018). Case study research and applications. *Design and methods, 6*.

Zott, C., & Amit, R. (2017). Business Model Innovation: How to Create Value in a Digital World. *GfK Marketing Intelligence Review, 9*(1), 18-23. doi:10.1515/gfkmir-2017-0003