Dóra Horváth

Digital transformation and business model innovation: in the manufactu-ring industry, energy- and financial sectors

Department of Management and Strategy

Thesis supervisors:

Roland Zsolt Szabó, Ph.D, habil.

Tamás Mészáros, CSc

CORVINUS UNIVERSITY OF BUDAPEST

Doctoral School of Business and Management

Digital transformation and business model innovation:

in the manufacturing industry, energy and the financial sectors

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Dóra Horváth

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I. Introduction

I.1. Research field

In my doctoral research[1], I aim to explore the business model innovation opportunities provided by digital transformation. Digital technologies are present in all parts of our lives nowadays and companies are increasingly building on these solutions during the renewal of their value propositions. Successful business model innovation can even lead to complete renewal and several positive consequences. These positive effects may include improving financial performance, targeting new customers, markets, and increasing the sustainability of the model. In my doctoral dissertation, I examined three strategically important sectors and wanted to explore the business model innovation opportunities provided by digital transformation. The examined areas are the following: manufacturing industry (Industry 4.0), energy sector and the financial sector.

I compiled my dissertation from my published publications. Details of the publications are shown below:

- **Dóra Horváth** – Zsolt Roland Szabó (2019): Driving forces and barriers of Industry 4.0: Do multinational and small and medium-sized companies have equal opportunities? TECHNOLOGICAL FORECASTING & SOCIAL CHANGE 146 pp. 119-132. (Ranking of the journal based on the Scimago database: Q1-A+)
- **Dóra Horváth** – Zsolt Roland Szabó (2018): Evolution of photovoltaic business models: overcoming the main barriers of distributed energy deployment. RENEWABLE & SUSTAINABLE ENERGY REVIEWS 90 pp. 623-635. (Ranking of the journal based on the Scimago database: Q1-A+)
- **Dóra Horváth** (2020): Examination of the effect of the fintech phenomenon on traditional commercial banks. BUDAPEST MANAGEMENT REVIEW 51:9 pp.

[1] „PREPARED WITH THE PROFESSIONAL SUPPORT OF THE DOCTORAL STUDENT SCHOLARSHIP PROGRAM OF THE CO-OPERATIVE DOCTORAL PROGRAM OF THE MINISTRY OF INNOVATION AND TECHNOLOGY FINANCED FROM THE NATIONAL RESEARCH, DEVELOPMENT AND INNOVATION FUND”

16-29. (Ranking of the journal based on the ranking system of the Hungarian Academy of Sciences, Section of Economics and Law: B)

Articles published in journals are expected to be complete in themselves, as a result of which certain parts of the dissertation (e.g. introduction, theoretical background, research methodology) are repeated in different chapters.

In the „I.2. Theoretical background" chapter of my dissertation, some parts (written by me) from the following publication were used:

Dóra Horváth – Péter Móricz – Zsolt Roland Szabó (2018): Business model innovation. BUDAPEST MANAGEMENT REVIEW 49:6 pp. 1-12. (Ranking of the journal based on the ranking system of the Hungarian Academy of Sciences, Section of Economics and Law: B)

In the case of the articles included in my dissertation and in the reference to them, I used the plural first-person conjugation in the co-authored publications and the singular first-person conjugation in the case of my single-authored paper.

I.1.1. Relevance and main theoretical background of the research

The relevance of the choice of the research topic can be described along several dimensions. On the one hand, it is essential to emphasize the multitude of the affected companies and their role in the national economy. The number of companies operating in the industries that are the subject of my research is on the order of thousands at the domestic level, and a significant part of GDP is provided by these actors. It is also important that the studied industries are expected to be completely transformed in the future in connection with digital transformation, and by properly addressing the emerging challenges, the stage of industry maturity can be extended or even fully renewed.

The areas that I focus on are based on my personal interest and my work in university research projects. The examined areas are the following:

Manufacturing industry – Industry 4.0: The Fourth Industrial Revolution, which is currently taking place, sets a number of challenges for manufacturing companies from the technological, organizational and management points of view (Szabó, Horváth and Hortoványi, 2019). The emergence of innovative technologies is transforming traditional value chains and enabling the emergence of completely new business models that increasingly involve customers (Spath et al., 2013). Industry 4.0 can also lead to significant changes in existing business models, leaving room for new forms of value creation (Kagermann, Wahlster and Helbig, 2013; Ustundag and Cevikcan, 2017).

The increasing use of Industry 4.0 technologies requires companies to be flexible and adapt quickly to market conditions, which also involves the transformation of business models (Grabowska, 2019). In connection with the renewal of business models, Mihardjo et al. (2019) drew attention to the importance of cooperations due to the increasing digitalization of supply chains and interdependence. According to Montanus (2016), in the context of Industry 4.0, one of the main pillars of the value proposition of innovative manufacturing business models should be a high level of customizability. Müller (2019) found that regarding Industry 4.0, key resources and value proposition are the most affected elements of business models, while channels is the least affected element. It was also revealed that the business models of Industry 4.0 service providers are typically significantly more affected than those of users.

Weking et al. (2020) identified three main components of Industry 4.0 business models in their research, which are: integration, servitization, and expertization. Integration involves a high level of involvement of customers and possibly other communities in the design processes, while servitization refers to the emergence of additional services in addition to traditional manufacturing activities, such as remote monitoring or preventive maintenance. The third element, expertization, typically takes the form of complementary consulting activities (e.g. consulting related to products, business processes).

It can be seen that Industry 4.0 offers many opportunities to renew the business model of manufacturing companies. However, it becomes questionable what factors, in addition to the benefits provided by new technologies, may hinder the introduction of these solutions and, at the same time, business model innovation.

Energy sector (renewable energy sources): The goals of the Paris Agreement - also signed by Hungary in 2015 - require a significant amount of green investment (Raberto *et al.*, 2019). Targets to mitigate global average temperature rise require the transformation of energy systems, leading to the widest possible use of low-carbon technologies (Rogelj *et al.*, 2016). Thanks to climate change programs, growing demand, and the emergence of new markets and technologies, the renewable energy industry has started to grow significantly globally in recent years (REN21, 2016). Solar systems play a key role in the production of energy from renewable sources (Michas *et al.*, 2019). However, the spread of renewable energy sources can be hampered by several factors.

Nowadays, more and more research is looking for answers to how to maintain the high growth rate of the increasingly intensive use of solar energy, which research typically focuses on innovative business models and financing mechanisms (Stauch and Vuichard, 2019). One of the most innovative solutions of photovoltaic business models is the community-shared business model, which allows access to solar energy to the widest possible range of customers through virtual net-metering using digital technologies (Mirzania, Balta-Ozkan and Ford, 2020). The use of digital technologies in renewable energy sources improves the availability, usability, storage and transferability of information, thus enabling the reduction of transaction costs and the more efficient use of resources (Rossetto, Dos Reis and Glachant, 2019).

Innovative business models also provide an opportunity for renewal for traditional energy utilities, which can thus develop their market position and achieve sustainable strategic advantage (Richter, 2012). Incumbents should strive to renew their business model while providing the critical infrastructure for energy supply, which, however, may pose challenges for both energy suppliers and regulators (Hall and Roelich, 2016).

Financial sector: The financial sector is undergoing significant changes nowadays. The effects of the global economic crisis, ever-changing customer needs, and the intensifying digital transformation are all inducing the transformation of the financial services market (Gelis, 2016; Toit and Burns, 2016). In the examined field, a number of new business models and market players have emerged in recent years, encouraging traditional commercial banks to renew their business models (Eisenegger and Künstle, 2011). It is therefore questionable how digital technologies will transform the business model of incumbents, what types of services will be dominant in the future, what obstacles commercial banks will face, and to what extent they will be threatened by large technology companies that are increasingly active in financial services (e.g. Google, Apple).

Several researchers (e.g. Kawai, 2016; Brandl and Hornuf, 2017; Puschmann, 2017) and international organizations (e.g. Bank for International Settlements, 2018) have pointed out that new types of players - FinTech and BigTech companies - can have a negative impact on the competitiveness of traditional banks, but it has also become apparent that innovative digital solutions offer many opportunities for innovation for banks. According to Brandl and Hornuf (2017), commercial banks in many cases provide their services at higher costs compared to new types of players in the financial sector. As a result, in the future, FinTech companies may even take over several key functions of traditional commercial banks (Li, Spigt and Swinkels, 2017).

Regarding the innovation potential, the integration of digital innovations can have a significant positive impact on banks' performance, both in terms of sales and operating costs (Scott, Reenen and Zachariadis, 2017). Wang, Xiuping and Zhang (2021) explored that by using financial technologies, commercial banks can reduce costs, improve risk management mechanisms, the efficiency of services, and renew their value proposition, thereby improving their overall competitiveness. Integrating new solutions can present a number of challenges for banks, but in order to keep up with market trends and maintain their position, they should strive to renew their business model (Horváth, 2019).

Overall, digital transformation and, in parallel with the emergence of new technologies, business model innovation play a key role in all three areas examined. The successful implementation of business model innovation can have several positive consequences for companies, as well as can lead to the renewal of industries.

I.2. Theoretical background

In the following chapters, the theoretical background of business model innovation and digital transformation is discussed, and then the two areas are linked.

I.2.1. Business model innovation

In the case of business model innovation, we can find several conceptual approaches, the most common of which are summarized in Table 1.

Giesen et al. (2007) identified three main ways of business model innovation: industry model, revenue model, and enterprise model innovation. Industry model innovation involves renewing the supply chain by entering new industries, redefining existing industries, or creating entirely new industries, identifying and leveraging unique assets. Revenue model innovation refers to renewing how a company generates revenue by re-combining its offerings (e.g. product/service) and/or introducing new pricing models. The third direction, enterprise model innovation, is the renewal of the enterprise structure and its role in new or existing value chains through changes in the enterprise's network of employees, suppliers, consumers, or other actors, including capability and asset configurations.

In the related literature, some authors make a distinction between replicating and renewing business models. While replication refers to, for example, exploiting the opportunities offered by an existing business model in another geographic area (Winter and Szulanski, 2001), renewal means introducing a new business model that goes beyond the previous model (Nunes and Breene, 2011).

According to Amit and Zott (2012), companies can implement their business model innovations in many ways. These include the addition of new activities to the business operation, the innovative linking of activities or the change that who to perform the activity.

Related to business model innovation, it is also important to highlight the role of business models which are based on open innovation. According to Chesbrough (2006) the open approach suggests that companies should use ideas and technologies coming from outside, such as customers, during their business model innovation efforts, while allowing other companies to use their unused ideas. By applying open innovation approaches, companies can reduce their innovation costs, speed up time to market and share the emerging risks with other players in the innovation process. Business model innovation and open innovation approaches are closely linked to Hax's (2009) Delta model which is based on collaboration. In connection with the model, the author emphasizes that one of the most important functions of strategy is to achieve customer engagement. Furthermore, Hax (2009) also highlights that companies during their operations have to pay special attention to the recognition of customers and their needs, which can serve as a basis for unique and differentiated value creation, thus enabling them to occupy an industry-leading position.

Table 1: Overview of business model innovation definitions in chronological order

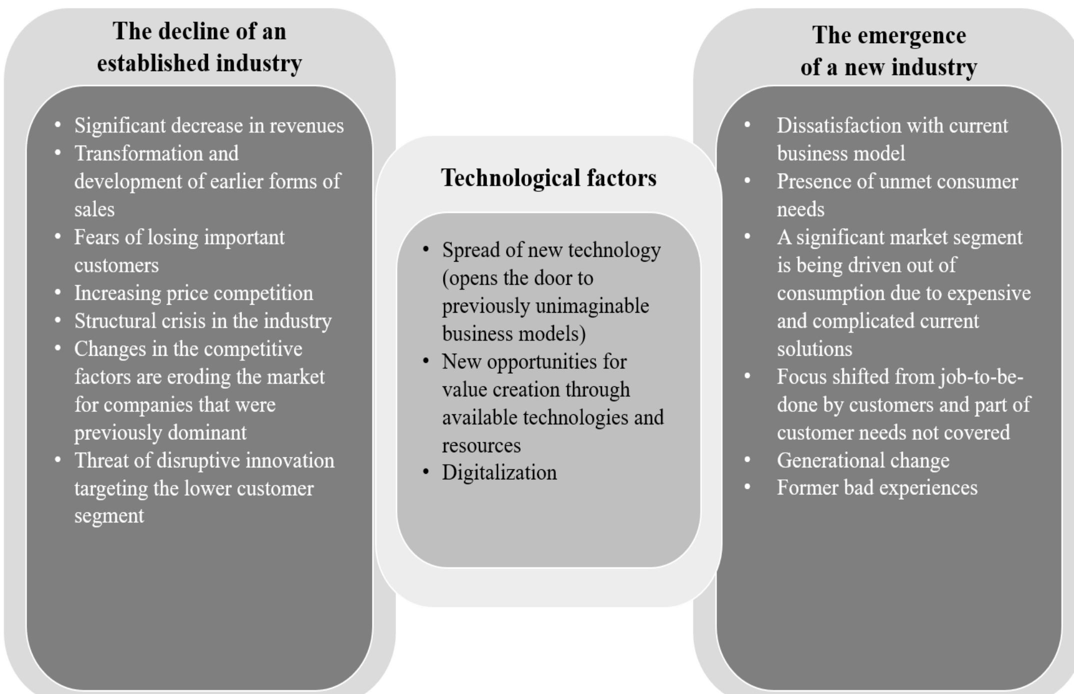
Author	**Definition**
Markides (2006)	Business model innovation is the discovery of a fundamentally different business model in an existing business.
Santos, Spector and Van der Heyden (2009)	Business model innovation is a reconfiguration of activities in the existing business model of a firm that is new to the product service market in which the firm competes.
Bucherer, Eisert and Gassmann (2012)	We define business model innovation as a process that deliberately changes the core elements of a firm and its business logic.
Csath (2012)	Business model innovation is nothing else than completely renewing a business.
Amit and Zott (2012)	Business model innovation involves designing a modified or new activity system.
Abdelkafi, Makhotin and Posselt (2013)	A business model innovation happens when the company modifies or improves at least one of the value dimensions.
Berglund and Sandström (2013)	A BMI can thus be thought of as the introduction of a new business model aimed to create commercial value.
Khanagha, Volberda and Oshri (2014)	Business model innovation activities can range from incremental changes in individual components of business models, extension of the existing business model, introduction of parallel business models, right through to disruption of the business model, which may potentially entail replacing the existing model with a fundamentally different one.

Source: *Own table*

I.2.2. Drivers and motivation factors of business model innovation

Companies may strive to business model innovation because of a wide range of motivational factors. The drivers of innovation can lead to significant modifications in business models, and the forthcoming changes can generate long-term benefits for companies resulting in the durable restructuring of the industry. Macro-level causes and motives discussed in the literature are related to three main phenomena. Based on this, the root causes can be related to (1) the decline of an established industry, (2) the emergence of a new industry, or (3) technological change (Figure 1).

Figure 1: Drivers and motivation factors of business model innovation



Source: *Own figure*

Economic pressure, such as a significant drop in revenues, can in many cases be identified as the strongest driver of business model innovation, requiring companies to explore new sources of revenue generation (Amit and Zott, 2010; Eppler and Hoffmann, 2011; Stampfl, 2016).

Developing new products or exploring further application opportunities of existing products may require the development and transformation of previously used forms of sales, activities, and thus the innovation of the business model (Stampfl, 2016).

Customer-related triggers can be divided into three parts. These reasons may include dissatisfaction with the current business model, the presence of unsatisfied customer needs that are not addressed by offers available on the market, and fears of losing important customers (Stampfl, 2016).

The gradation of price competition is another factor that can also be identified among the root causes when for example, the value proposition provided by a company is no longer distinctive and price becomes the only selection criterion during the buying process. Related to this, several authors agreed that products can nowadays be copied more easily and their production can be relocated to regions with lower production costs which results that companies search the source of renewal in the innovation of the business model. (Plantes and Finfrock, 2008; Csath, 2012; Eichen, Freiling and Matzler, 2015; Stampfl, 2016; Bashir and Verma, 2017). The need for a strategic shift is closely related to the increasing price competition when, for example, due to changing environmental conditions, an earlier manufacturing company starts to open its business towards services.

Johnson, Christensen and Kagermann (2008) identified five strategic circumstances that may require the alteration of the existing business model. (1) Typically, this is the case when the cost or complexity of solutions on the market excludes a large group of potential customers from consumption. (2) With the emergence of significant new technology, there may be opportunities to create entirely new business models (for example, Apple has built its innovative music store around its MP3 player). (3) When an industry is excessively immersed in segmentation and product refinement, a new approach may be needed: by focusing on customers' job-to-be-done tasks, previously neglected customer needs can be uncovered. Pioneering innovations, if successful, pose a significant threat to traditional industry players, so the need for protection against (4) disruptive innovation serving previously excluded groups, may be another strategic circumstance.

Finally, (5) a shift in competitive factors can be such a strategic circumstance, for example, when low-priced, “just acceptable” quality products erode the market for previously successful companies with premium quality.

In their research, Klepakova and Wolf (2017) identified two main reasons as the driver of business model innovation among SMEs. They identified underlying conditions as the first group, such as a structural crisis in an industry, or previous bad practices or experiences that could encourage companies to consider renewing their business model. Secondly, the group of situational triggers appeared, one of which was the generation change in family businesses, while another was the aspiration to exploit the potential of available technologies and resources.

Pateli and Giaglis (2005), Wirtz, Schilke and Ullrich (2010) also emphasized the opportunities provided by new information and communication technologies as potential sources of business model innovation. Furthermore, Maglio and Spohrer (2013) confirmed that, with the spread of info-communication tools, service-based business models dominate the global economy.

I.2.3. Expected consequences of business model innovation

Companies can gain many benefits by renewing their business models, but these benefits are rarely immediate, so measuring and quantifying them is a major research challenge. Most research examines the impact of business model innovation on company profitability and performance, but additional positive consequences are also presented in this chapter.

According to Zott and Amit (2007) business model innovation can result in an outstanding performance, even for companies in mature industries. An example of this is Apple's success with the iPod and iTunes in the music industry, which has achieved tremendous growth and allowed the company to outperform its competitors. Könczöl (2010) emphasized that by renewing the value proposition, with the novel combination of resources and overall, by changing their business model, companies can not only gain financial benefits but also essentially develop a more sustainable model.

Based on Csath (2012), besides product and technological innovation, an innovative business model can in some cases be even more effective, as a result of which companies can gain new markets and customers and strengthen their competitive advantage. Compared to product and process innovations, revenues which come from business model innovation are much more sustainable in the long run (Eichen, Freiling and Matzler, 2015).

This statement is also supported by Bashir and Verma Bashir and Verma (2017) who claim that competitive advantage is no longer derived from cost advantage or differentiation, as it is difficult for a company to determine its own and its competitors' operating costs, while products and services become more and more replicable. Business model innovation can serve as a sustainable competitive advantage, as copying a whole new system is much more difficult than copying a product or service, and in the future, the business model of a company may become more important in competition.

Heij, Volberda and Van Den Bosch (2014) investigated the impact of business model replication and renewal on corporate performance based on Winter and Szulanski (2001), and Nunes and Breene (2011). With *replication*, the company strives to leverage even more value from its business model by fine-tuning and moving it to new areas. As a result, the mutually reinforcing effect of the components within the business model is increased, so the replication of the business model also makes it difficult for competitors to replicate the company's competitive advantage.

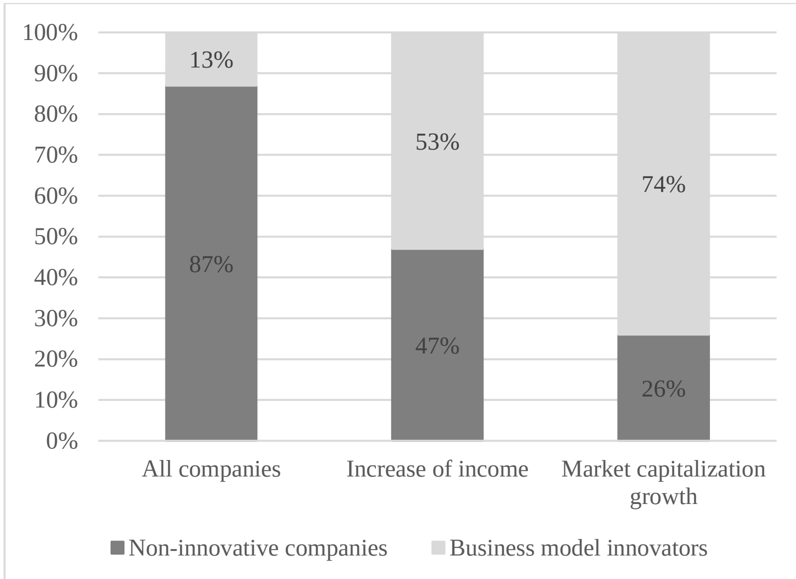
The *renewal* of the business model seeks to do the same by introducing new business model elements and leveraging new connections and impacts between them. During the *renewal,* a company radically improve the value it provides to customers to protect or regain its position and profitability in its existing markets. In addition, the renewal of the business model will allow the company to create more value for itself and its customers in new markets with less intense competition. Research by Poetz et al. (2015) also confirmed that by changing several components of the business model, the uniqueness of the company could be increased. Furthermore, the degree of innovation in a company's business model -if a new product or process has recently been introduced - positively influences innovation performance.

Klepakova and Wolf (2017) identified four possible consequences when analyzing business model innovation practices in family businesses in mature industries. (1) *Family-related consequences* can include benefits that are specific to family businesses, such as creating more jobs and thus bringing more family members into the business, maintaining family unity, and ensuring business continuity. (2) As a result of business model innovation, the authors also identified a group of *social and environmental impacts* whereby, among other things, infrastructure investments (such as setting up a biogas plant) allowed companies to achieve significant environmental and social benefits by launching new business activities.

(3) According to their research, the third group is formed by *strategic consequences*. In this case, the family business retained its competitiveness or profitability by reversing industry-unfavorable business processes by business model innovation. (4) Finally, when examining the *financial consequences*, it was found that as a result of business model innovation, each company achieved higher than expected financial results. Thus, based on the research of Klepakova and Wolf (2017), it can be seen that business model innovation can have many positive effects also in the case of family businesses.

Deeken and Yoon (2013) refer to category creation as a combination of breakthrough product and breakthrough business model innovation. The authors, based on a survey of Fortune's 100 fastest-growing US companies between 2009 and 2011, found that only 13 out of 100 companies are considered category creators. More importantly, these 13 companies account for more than half of the organic revenue growth of the 100 companies surveyed, while in terms of market capitalization, the 13 category creators account for three-quarters of the total capitalization growth of the 100 companies (Figure 2).

Figure 2: Business success through business model innovation



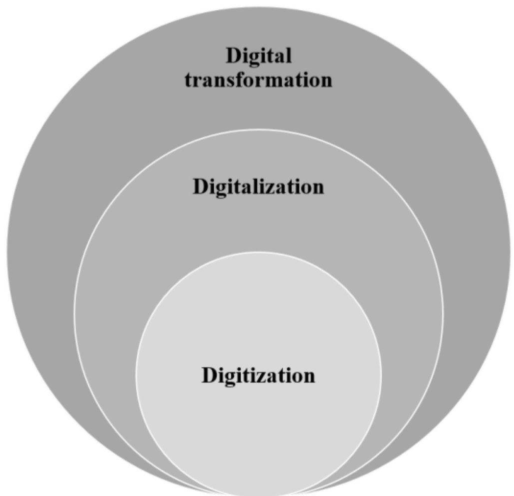
Source: *Own editing based on Deeken and Yoon (2013)*

In addition, a company with a creative, innovative business model can be more attractive to potential employees who usually prefer these companies when choosing. An innovative business model can increase the commitment and loyalty of existing employees.

I.2.4. Digital transformation

To examine business model innovation enabled by digital transformation, it is necessary to distinguish between the terms digital transformation, digitalization, and digitization, which the authors use erroneously, often as synonyms, in the related literature. The relationship between the three concepts is shown in Figure 3.

Figure 3: The relationship between digital transformation, digitalization and digitization



Source: *Own editing based on Saarikko, Westergren and Blomquist (2020)*

Digitization is a technical process in which analog signals are converted to digital signals (Tilson, Lyytinen and Sorensen, 2010). Examples of digitization include scanning paper documents or converting movies, videos from analog storage (VHS tape, audio, etc.) to digital (Schumacher, Sihn and Erol, 2016).

Digitization and digitalization are often used as synonyms, but there are significant conceptual differences between the two concepts. While digitization describes a technology or the nature of a technology system and its capabilities, digitalization provides the answer to why these technologies are relevant to a particular process or organization (Saarikko, Westergren and Blomquist, 2020). As defined by Brennen and Kreiss (2016), digitalization is the adaptation or increase in the use of digital or computer technologies by an organization, industry, or country.

According to Mazzone (2014), *digital transformation* is nothing more than the intentional and continuous development of a company, business model, or methodology from a strategic and tactical point of view. According to Berman (2012), digital transformation refers to the redefinition of business models through the application of new technological solutions, in which companies build significantly on customer needs. In connection with the definition, the author highlighted two activities that companies need to focus on for a successful digital transformation: (1) transforming the value proposition, and (2) transforming operations using digital technologies to support customer interactions and cooperation with them. Matt, Hess and Benlian (2015) pointed out that digital transformation goes beyond process automation and optimization, as it involves transforming products, services, and the business model as a whole, and its implications. An important element of digital transformation is the transformation of skill sets, which become not only necessary during the transformation but are also essential for the new operation.

Digital transformation can support organizational internal cultural and behavioral changes, and the applied solutions can provide deep, real-time insight into customer behavior that can help win new customer segments (Fenton, Fletcher and Griffitsh, 2019). Based on interviews with 157 senior executives, Westerman, Bonnet and McAfee (2014) found that in connection with digital transformation, companies have data that allows them to better understand the ever-changing external environment, the market position of the company, and customers' behavior and expectations. In addition, new technologies improve knowledge sharing within the organization, thereby supporting transparency and building a better organizational culture.

Kreinsen-Hirsch and Hompel (2016) drew attention to the social and economic consequences of digital transformation. New digital technologies can greatly transform markets, leading to a transformation of economic structures and, as a result, significant changes in the world of work. Related to this Singh and Hess (2017) highlighted, that because digital transformation affects every part of an organization, it requires new types of skills and competencies from all employees, thereby generating a number of challenges in working.

I.2.5. Digital transformation of business models

Regardless of the industry, the ongoing digital revolution can have a significant impact on the existing business models of companies, and completely new business models can appear through the application of digital technologies and platforms. Companies need to constantly explore new ways to increase revenue and adapt their activities to new opportunities that can help them become a key player in existing or new industries (Berman, 2012). According to Schallmo and Williams (2018), the digital transformation of business models can be tied to individual elements of the business model, the overall model, value chains, and the network organization of actors in value chains. Changes in business models due to digitalization were identified by Prem (2015) along four building blocks - value proposition, key activities, channels, revenue sources - which are presented in Table 2.

Table 2: The impact of digitization on certain building blocks of business models

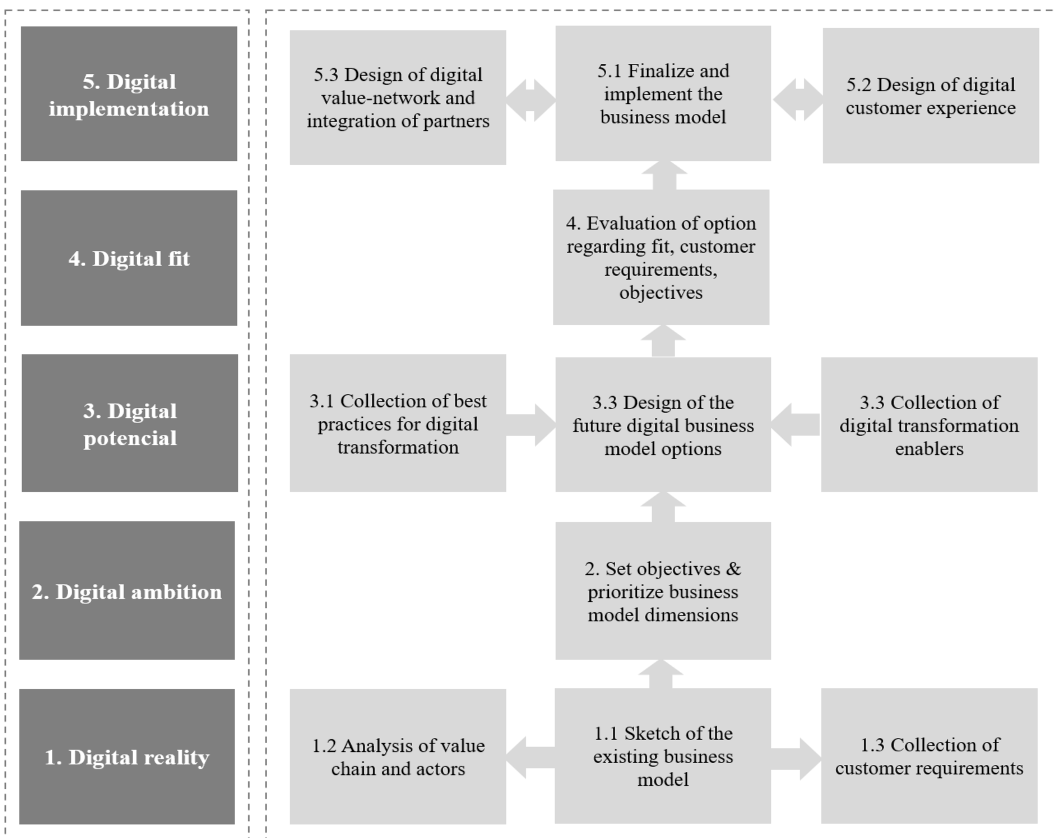
Building block	Expected changes
Value proposition	Renewal of value proposition through production and analysis of large amounts of data
Key activities	Facilitation of process automation
	Improving resource efficiency, manufacturing flexibility, and quality
Channels	Unidirectional channels become bidirectional
	Direct access to new customer segments
Revenue streams	The increasing digitalization of products and services: brokerage, service and leasing fees

Source: *Own table based on Prem (2015)*

According to Zott and Amit (2017) the increasingly intense digital transformation - which affects not only products and services but also company processes and systems - offers many opportunities for value creation and thus business model innovation. The authors also point out that because of startups like Airbnb, which rely heavily on digitalization, traditional banks, merchants, travel agencies and other similar companies face a number of difficulties and often struggle to survive.

Schallmo and Williams (2018b) defined a roadmap for digital transformation of business models in five main steps (Figure 4), which are as follows: 1. digital reality; 2. digital ambition; 3. digital potential; 4. digital fit; 5. digital implementation. During the steps, companies need to analyze, among other things, the current business model, customer segments and needs, additional players involved in value creation, and best practices in the market. After defining the goals to be achieved, exploring best practices and supporting factors, a business model based on new digital solutions that respond to customer needs can be developed and implemented.

Figure 4: Roadmap for digital transformation of business models



Source: *Own editing based on Schallmo and Williams (2018b)*

I.3. Objectives of the research, main research questions

In the following, I describe the objectives and the main questions of the researches carried out in the studied areas.

I.3.1. Manufacturing industry – Industry 4.0

The goal of the Industry 4.0 research was to get a comprehensive picture of how manufacturing companies are affected by Industry 4.0. The main research questions were the following:

- How do corporate executives interpret the concept of Industry 4.0?
- What factors can motivate companies to implement Industry 4.0 technologies?
- What barriers can be identified related to the introduction of Industry 4.0 technologies?
- How are Industry 4.0 technologies implemented?
- What changes are expected within the organizations? (e.g. processes, organizational structure etc.) How does Industry 4.0 affect the business models of companies?

I.3.2. Energy sector

Research in the energy sector - focusing on renewable energy sources and mainly on photovoltaic solutions - aimed to identify factors that may hinder the spread of renewable energy sources. In addition, globally identifiable solar business models have been examined in order to determine how each business model can help to reduce and eliminate emerging obstacles.

I.3.3. Financial sector

In the financial sector, a number of factors can be identified that encourage traditional commercial banks to renew their business model. These factors include changing customer needs, digital transformation, and the emergence of new types of players in the market. Nowadays, only a few scientific works are available in the field I have studied, so my goal was to contribute to the expansion of the Hungarian literature. During the research, I examined the following questions through 13 in-depth interviews:

- How do players in the financial sector interpret the concept of FinTech?
- What impact do new types of players have on traditional commercial banks?
- What changes are expected in the business model of traditional commercial banks?
- What regulatory and other challenges can be identified in relation to the digital transformation of players in the Hungarian financial sector?

I.4. Applied research methodologies in the dissertation

In this chapter, the methodologies used in the doctoral dissertation are presented. In all three articles in my dissertation, the research questions outlined above were explored in the framework of qualitative research. In the research related to Industry 4.0, we applied the methodology of grounded theory with my co-author, and in the research in the energy sector, the methodology of the systematic literature review was used. To examine the financial sector, I conducted semi-structured in-depth interviews.

I.4.1. Industry 4.0 – Grounded theory

To investigate the topic of Industry 4.0, the grounded theory methodology was applied. Given the limited amount of information and empirical research available in this field, we have considered it important to apply a methodology where the theory develops from empirical data. At the time of data collection, publications dealing mainly with technological features were available from the examined area, and management aspects were only explored to a limited extent. Consequently, in our research we did not want to test hypotheses, but in accordance with the methodological recommendations suggested in similar cases (e.g. Suddaby, 2006; Mitev, 2012) we sought to explore participants' interpretations of reality - in our case, the Industry 4.0 phenomenon - in order to gain a deeper understanding of the field and to map previously unidentified topics. The main features of the research are summarized in Table 3.

The purpose of grounded theory is to provide a comprehensive explanation of a given phenomenon. The methodology is usually applied to construct theories based on systematically collected and analysed data (Glaser and Strauss, 1967). According to Strauss and Corbin (1990), *"the procedures of grounded theory are designed to develop a well-integrated set of concepts that provide a thorough theoretical explanation of social phenomena under study".* The grounded theory employs systematic techniques to identify concepts and develop a theory based on qualitative data collection (Corbin, 2008). The methodology includes continuous comparisons, which may encompass comparisons of different people, cases, categories, data, and data from the same people which has been recorded at different times (Glaser, 1992). Mitev (2012) pointed out the fact that, despite the positives of the methodology, the number of research conducted in the field of management applying the grounded theory is quite low.

Table 3: Key features of Industry 4.0 research

Method of the research and applied tools	• Iterative data collection (semi-structured interviews) and analysis (coding) • Theoretical sampling • Making notes • Defining validation and reliability strategies (triangulation, peer review, verification) • Theorizing
The role of the researcher	• Strives to get a deeper understanding of the patterns and practices applied by the participants • Continuous review • Strives to clarify their assumptions and expectations
Challenges during the research	• The applied methodology is very time consuming • Finding relevant actors and interviewees is difficult • The researcher's assumptions and prior knowledge can have a significant impact on theory development, making the choice of strategies to ensure validity and reliability critical • Industry 4.0 is a significant new area, so it is questionable that in what stage of development are the domestic companies currently
Utilization of results in the examined area	• The number of empirical researches related to Industry 4.0 is currently low, so knowledge elements and theories that may emerge during the research can significantly contribute to the expansion of the literature.

Source: *Own table*

I.4.2. Energy sector – systematic literature review

A systematic review of the literature is used to identify, evaluate, and interpret relevant research available on a particular research question, area, or phenomenon. Studies contributing to the systematic review can be considered as primary studies, while the systematic review itself is considered as a secondary study/source (Kitchenham, 2004). According to Bapuji and Crossan (2004), systematic reviews improve the quality of review processes by creating a systematic, transparent and reproducible literature review. The systematic literature review differs from the traditional narrative review in that it provides a scientific, replicable, transparent process that aims to minimize bias through a comprehensive literature search of published and unpublished studies, and provides an audit trail of the entire process, decisions, and conclusions of the researchers (Cook, Mulrow and Haynes, 1997).

The systematic literature review may have different purposes:

- summary of knowledge related to existing technology and topic, e.g. a summary of empirical evidence to demonstrate the benefits and limitations of a particular method,
- identifying research gaps in the current literature and identifying areas for further study,
- providing a framework/background to properly position new research activities (Kitchenham, 2004).

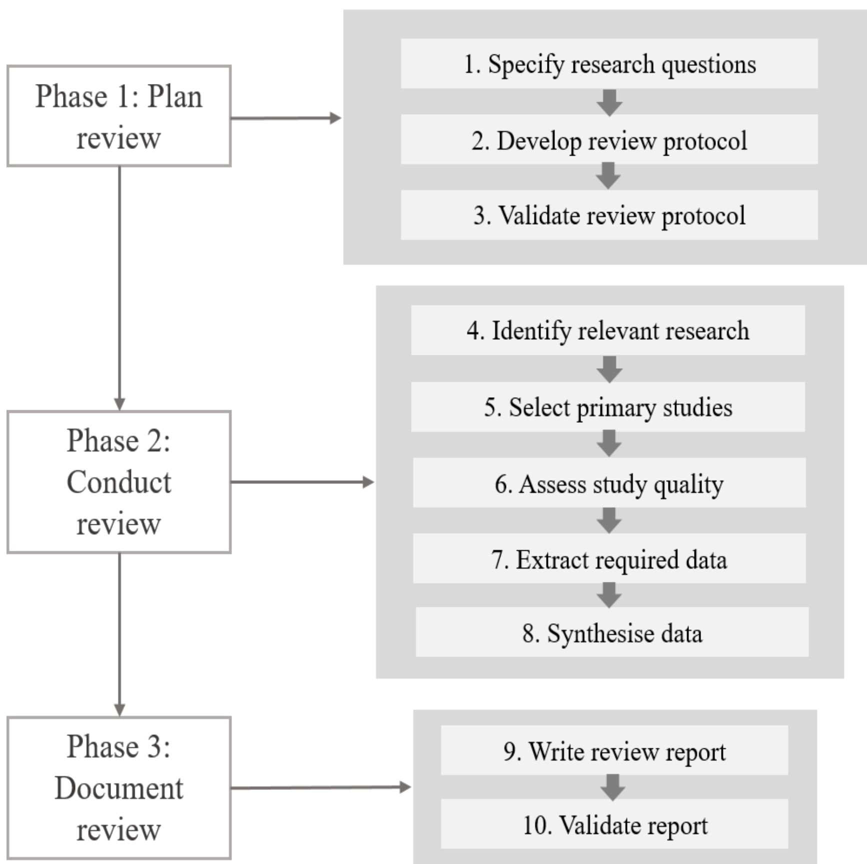
The systematic literature review should include the followings:

- clearly defined criteria for the selection of necessary and non-necessary publications,
- a clear strategy for finding relevant literature,
- systematic coding and analysis of the literature,
- synthesis of the results of qualitative and quantitative researches (Baska, Pondel and Dudycz, 2019).

The systematic literature review includes several activities that can be grouped into three main phases (Figure 5):

- The first phase is *planning*, which includes the definition of research questions, the development of a protocol for literature research, and validation.
- This is followed by the *review*, which refers to the identification of the relevant literature, quality control, data extraction and synthesis.
- The third phase is the review of documents, during which the researcher finalizes and validates the steps of the systematic literature review. The review report, which is completed in the last phase, contains the steps of the research in a way that the research can be reproduced at any time (Brereton *et al.*, 2007).

Figure 5: The process of systematic literature review



Source: *Own editing based on Brereton et al. (2007)*

During the literature review, we followed the steps recommended by Webster and Watson (2002) and Von Brocke et al. (2009): (1) scope definition, (2) conceptualisation of topic, (3) literature search, (4) literature analysis and synthesis and (5) research agenda. The steps of the research are presented in detail in chapter III.3.

I.4.3. Financial sector – semi-structured interviews

To answer my research questions, I conducted 13 semi-structured interviews with top executives of FinTech companies (startup / scaleup), commercial banks, the founder of a FinTech accelerator, and a FinTech legal expert.

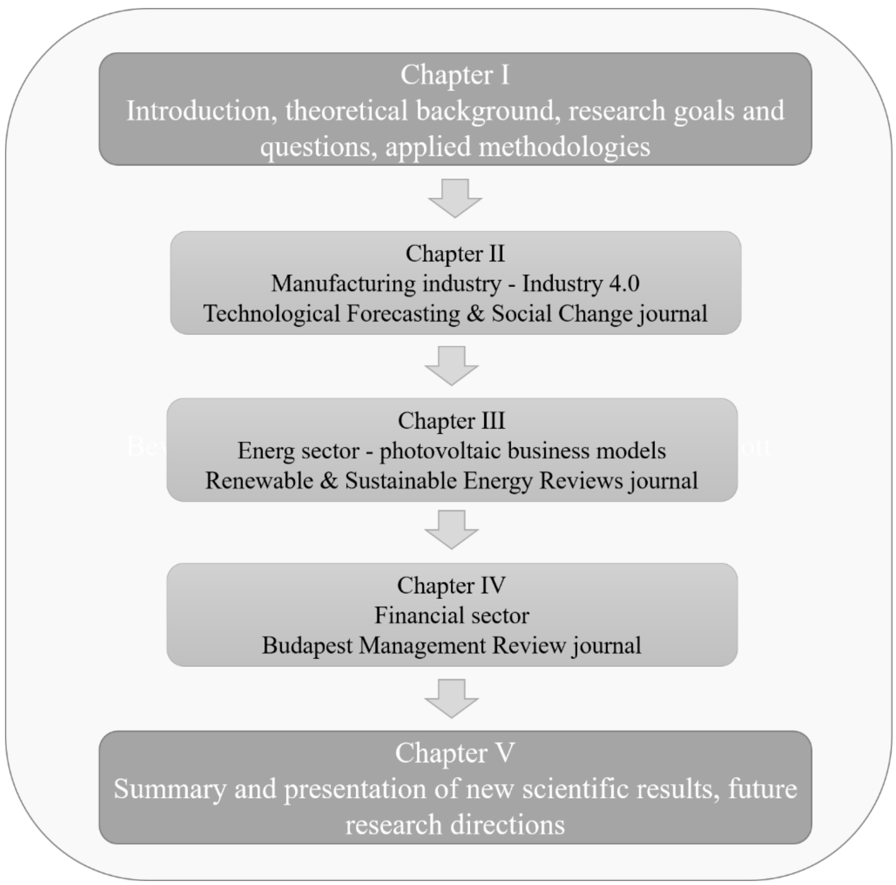
Prior to my research, I reviewed the types of interviewing that can be structured, unstructured, and semi-structured interviews. During structured interviews, the questions and their order are recorded in advance (Schober and Conrad, 2002). In unstructured interviews, neither questions nor answer categories are predefined (Minichiello, 1990). The semi-structured interview includes prepared questions based on the topics previously identified by the researcher, designed to help steer the conversation toward the areas and questions the interviewer would like answered (Qu and Dumay, 2011). According to Brinkmann (2014), compared to structured interviews, semi-structured interviews are better able to exploit the knowledge-generating potential of dialogues because they provide much more room for maneuver for both the interviewee and the researcher. In my research, I decided to conduct semi-structured interviews to have the opportunity to formulate new questions in addition to the topics I had defined in advance, as well as to develop a more informal dialogue.

During the search of the interviewees, I used snowball sampling, according to which interviewees recommended additional professional actors relevant to the research. In my research, I have sought to achieve theoretical saturation, which marks the point when there is no more new information in the data (Horváth and Mitev, 2015). Accordingly, a total of 13 semi-structured in-depth interviews were conducted with experts in the field.

I.5. Structure of the dissertation

In the introduction of my dissertation, in addition to my research area, the relevance of the research, the objectives, the main research questions as well as the applied methodologies were described. Further chapters of my doctoral dissertation are based on my already published publications. In the second chapter, I present the research in the field of manufacturing (Industry 4.0), in the third in the energy sector, and in the fourth in the financial sector. In Chapter V, in addition to the summary, the new scientific results of the dissertation are presented, and based on my results, I identify potential future research directions. The structure of the dissertation is shown in Figure 6.

Figure 6: Structure of the dissertation



Source: *Own figure*

II. Driving forces and barriers of Industry 4.0: Do multinational and small and medium-sized companies have equal opportunities?

This chapter of my dissertation was published in 2019 in the issue of September Volume 146 of the Technological Forecasting and Social Change journal, with corresponding content and form.

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Abstract

The Fourth Industrial Revolution poses significant challenges to manufacturing companies from the technological, organizational and management points of view. This paper aims to explore how top executives interpret the concept of Industry 4.0, the driving forces for introducing new technologies and the main barriers to Industry 4.0. The authors applied a qualitative case study design involving 26 semi-structured interviews with leading members of firms, including chief digital officers and chief executive officers. Company websites and annual reports were also examined to increase the reliability and validity of the results. The authors found that management desire to increase control and enable real-time performance measurement is a significant driving force behind Industry 4.0, alongside production factors. Organizational resistance at both employee and middle management levels can significantly hinder the introduction of Industry 4.0 technologies, though these technologies can also transform management functions. Multinational enterprises have higher driving forces and lower barriers to industry 4.0 than small and medium-sized companies, but these smaller companies have good opportunities, too.

Keywords: Industry 4.0; digital strategy; management functions; lean; qualitative; supply chain

II.1. Introduction of the Industry 4.0 research

The Fourth Industrial Revolution, which is currently taking place, sets a number of challenges for manufacturing companies from the technological, organizational and management points of view. With the application of new technologies and the transformation of processes, significant changes are expected in the field of work, and future production systems demand new competencies from employees. Work organization is expected to become more flexible in time and space, with workflows becoming more transparent, decentralized, and less hierarchical (Münchner Kreis, 2013; Picot and Neuburger, 2014). The exact risk of digitization is difficult to forecast, but nowadays it is becoming clear that workers in some countries are more defenseless than others. For example, in some regions, more than 25% of jobs are at high risk of automation (Segal, 2018).

In the world of future production systems, some processes are expected to be simplified, and others to become much more complex and embedded. This is likely to lead to an increase in the number of higher skilled jobs and a reduction in jobs requiring lower qualifications (Spath *et al.*, 2013; Brühl, 2015). Industry 4.0 will therefore have a significant impact on both the labour market and society. According to Kovács (2017b), the success of Industry 4.0 will be a function of both technical feasibility and the social acceptability of the whole transformation process. Vacek (2017) emphasized that if technological changes are not accompanied by significant changes in socio-economic systems, social cohesion may weaken. Industry 4.0 is therefore both a technological and socio-economic phenomenon (Szabó, Horváth and Hortoványi, 2019).

According to Hüther (2016), the likely changes may put pressure on economic policy and regulators, and the new skills and competences required by new technologies will require changes to education systems. In the context of Industry 4.0, Brettel et al. (2014) emphasized that the relocation of production activities to low-wage countries primarily affects the production of standardized mass products, but high-wage countries need to resolve the contradictions between economies of scale and scope.

In line with the expected changes, companies are becoming increasingly interested in the application of new technologies to ensure long-term competitiveness and enable them to adapt to dynamically-changing environmental conditions such as shortening product lifecycles, increasing diversity and changing consumer expectations (Spath *et al.,* 2013; Adolph, Tisch and Metternich, 2014; Lasi *et al.,* 2014; Bauer *et al.*, 2015). In spite of the increasing pressure, a number of factors can be identified that could hinder manufacturers in implementing Industry 4.0. Researchers have pointed out that the lack of skilled workforce and financial resources, standardization problems and cybersecurity issues may be particular problems (Müller and Voigt, 2016; Kiel, Arnold and Voigt, 2017; Kovács, 2017a; Nagy, 2019). However, research on this topic is still in its infancy. Only a few authors have made empirical examinations of this phenomenon and the most important driving forces and barriers to Industry 4.0 (see e.g. Basl, 2017; Müller et al., 2018; Nagy, 2019). It is also unclear how far the various driving forces and inhibiting factors will have different effects on small and medium-sized enterprises (SMEs) and multinational enterprises (MNEs).

This study aimed to explore how top executives, particularly chief executive officers (CEOs) and chief digital officers (CDOs) interpret the concept of Industry 4.0, and identify both the driving forces for introducing new, digital technologies and the main barriers and challenges to Industry 4.0. It was designed to contribute to the overall picture of the concept of Industry 4.0. We also analysed how SMEs and MNEs are affected by the driving forces and barriers identified. We carried out a qualitative exploratory study among top executives of companies. The study companies operated in different industry sectors, and were all either suppliers, users or both (dual role) of Industry 4.0 technologies.

II.2. Literature background of the Industry 4.0 research

II.2.1. Digital transformation

The traditional approach to digitization defines it as *"the use of computer and internet technology for a more efficient and effective economic value creation process"* (Reddy and Reinartz, 2017). Digitization is a phenomenon affecting all sectors, where traditional products are either replaced with digital counterparts or at least equipped with new digital features (Prem, 2015). However, digital transformation, or digitalization, goes beyond product and process improvement, to affect business models, organizational and management aspects and entire supply chain processes, creating significant challenges for companies

(Bleicher and Stanley, 2016). In other words, digital services and digitalization itself not only affect physical products, but also the nature of business, and organizational structure and strategy (Matt, Hess and Benlian, 2015; Chahal, 2016; Dremel *et al.*, 2017). Seufert and Meier (2016) suggested that to successfully complete digital transformation, companies needed to first analyse and identify consumer needs and preferences. Subsequent consumer-oriented changes within the organization should then address these needs. Berman and Bell (2011) emphasized that *"the challenge for business is how fast and how far to go on their path to digital transformation"*.

Toanca (2016) suggested that creating a digital strategy was at least as important for small and medium-sized businesses as for large ones. There is still, however, little literature on the question of how managers should approach and handle digital transformation, and implement related strategies (Hess *et al.*, 2016). Generally, and in this study in particular, Industry 4.0 refers to the digitalization of production (Erol *et al.*, 2016), so digital transformation can be considered as an overarching concept, with Industry 4.0 as a sub-concept.

II.2.2. The concept of Industry 4.0

The beginning of the original industrial revolution was at the end of the 18th century, when mechanical production facilities powered by water and steam were first used. The second industrial revolution began to unfold at the beginning of the 20th century, when mass production became possible with the use of electricity and division of labour. The third industrial revolution, which is still in progress, began in the 1970s. This is characterized by a higher level of automation of production and different work processes, achieved through the industrial application of electronics and information technology (Kagermann, Wahlster and Helbig, 2013; Shrouf, Ordieres and Miragliotta, 2014; Ghobakhloo, 2018). According to Lee et al. (2018), the fourth industrial revolution can be considered as a result of the horizontal expansion of information technology. Information and communication technologies are used in a much more extensive way than before in all spheres, including business, government and everyday life (Kovács, 2017b). Interconnectedness is a fundamental element (Aichholzer *et al.*, 2015). The concept of Industry 4.0 was introduced in 2011 by the German Industry–Science Research Alliance (Buhr, 2017).

In the fourth industrial revolution, new avenues of production are emerging through communicating objects, learning machines and autonomous robots (Valenduc and Vendramin, 2016). The term "Industry 4.0" describes the increasing digitization of the entire supply chain, which makes it possible to connect actors, objects and systems based on real-time data exchange (Spath *et al.*, 2013; Dorst *et al.*, 2015). As a result of this interconnection, products, machines and processes with artificial intelligence will be able to adapt to changing environmental factors (Hecklau *et al.*, 2016). Posada et al. (2015) and Roblek, Mesko and Krapez (2016) defined the five key elements of Industry 4.0 as: (1) digitization, optimization and customization of production; (2) automation and adaptation; (3) human–machine interaction; (4) value-added services and stores, and (5) automatic data exchange and communication. According to Zezulka et al. (2016), the term Industry 4.0 is used for three factors: (1) digitization and integration of networks, (2) digitization of products and services, and (3) new market models. These elements are mutually interconnected. Hermann, Pentek and Otto (2015) identified four main elements of Industry 4.0: cyber-physical systems, Internet of Things, Internet of Services and smart factories. Perales, Valero and García (2018) defined the main features of Industry 4.0 as virtualization, interoperability, automation, flexibility, real-time availability, service orientation and energy efficiency. The application of digital technologies in manufacturing processes is also called "smart manufacturing", "integrated industry" and "industrial internet" (Hofmann and Rüsch, 2017).

Schuh et al. (2014) defined Industry 4.0 as: *"The integration of information and communication technology into the industrial environment".* Mario, Tobias and Boris (2017) defined it as, *"…a collective term for technologies and concepts of value chain organization".* Schmidt et al. (2015) said it was*: "the embedding of smart products into digital and physical processes".* According to Thramboulidis (2015) and Lee, Bagheri and Kao (2015), the application of connected and embedded systems with software solutions makes it possible to control and monitor production through the processing and analysis of information extracted from the production process. Ghobakhloo and Modares (2018) emphasized the role of decentralization, modularity and product personalization in Industry 4.0. Overall, Industry 4.0 technologies support decision-making and therefore contribute significantly to increasing productivity (Saucedo-Martínez *et al.*, 2017; Zhong *et al.*, 2017).

II.2.3. Driving forces behind Industry 4.0

As well as understanding the concept of Industry 4.0, it is important to discuss factors that may encourage companies to move towards this approach. Ongoing changes on a global level have led to a networked society, affecting both business and private life. They have also resulted in a number of changes for manufacturing companies (Bauer *et al.*, 2015). Kaivo-oja et al. (2017) claimed that we are moving toward a ubiquitous knowledge society, in which smart and autonomous machines are inevitable. It is also important to address social challenges in many developed societies, including Western Europe. These challenges include reduced workforce numbers because of a declining population and aging society (Jankowska and Götz, 2017). They and may be addressed by developing and applying new technologies (Wang *et al.*, 2016).

Growing levels of competition have made it essential for companies to increase their innovation capacity and productivity and reduce their time-to-market (Lasi *et al.*, 2014; Bauer *et al.*, 2015). Investments in new digital technologies allow companies to improve their comparative advantage and create a decisive advantage over their competitors (Hortoványi, 2016, 2017). Change is also forced by decreasing product life cycles, changing consumer expectations and needs, and markets becoming more heterogeneous over time (Spath *et al.*, 2013; Adolph, Tisch and Metternich, 2014; BMBF, 2014; Karre *et al.*, 2017). Nagy (2019) noted that previous production systems are outdated, and no longer meet today's expectations, often causing environmental damage. By improving productivity, the quality of manufacturing can be significantly increased and waste reduced (Paritala, Manchikatla and Yarlagadda, 2016). Significant improvements can also be achieved in energy efficiency (Kovács, 2017a; Lins and Oliveira, 2017). de Sousa Jabbour et al. (2018) were the first to note that Industry 4.0 can positively affect environmentally-sustainable manufacturing, with the development of green products, manufacturing processes, and supply chain management.

Companies can therefore draw on Industry 4.0 to increase sales volumes, achieve significant cost savings (Kiel *et al.*, 2017) and provide radical micro-level performance improvements (Losonci, Takács and Demeter, 2019). Collecting and processing production data from the field also supports other benefits, e.g. faster decision-making and support for knowledge management (Cimini *et al.*, 2017; Inezari and Gressel, 2017; Uden and He, 2017). Industry 4.0 technologies help to manage production planning and scheduling, capacity utilisation, maintenance and energy management (Szalavetz, 2018).

Industry 4.0 may also lead to significant changes in existing business models, allowing new ways to create value. These changes are expected to result in the transformation of traditional value chains and create entirely new business models that enable higher levels of consumer involvement (Kagermann, Wahlster and Helbig, 2013; Ustundag and Cevikcan, 2017). Müller et al. (2018) noted that Industry 4.0 affects three elements of manufacturing SMEs: value creation, value capture and value offer. Prem (2015) suggested that as products and services become more and more digital, channels will be increasingly digitized. This may lead to changes in customer relationships and increase innovation in product and service design. Industry 4.0 can therefore be defined as a basic pillar in the future competitiveness of manufacturing companies. Firms will, however, face challenges in implementing it. Frank et al. (2019) concluded that Industry 4.0 technologies enable the servitization of manufacturing companies. However, innovative manufacturing business models should be protected by both data security methods and use of patents (Smit *et al.*, 2016). The driving forces identified from the literature on companies are shown in Table 4.

Table 4: Driving forces behind Industry 4.0 identified from the literature

Driving force	Sources
Growing competition	Bauer et al. (2015); Lasi et al. (2014)
Increased innovation capacity and productivity	Bauer et al. (2015); Lasi et al. (2014); Paritala et al. (2016)
Expectations of customers	Adolph et al. (2014); BMBF (2014); Karre et al. (2017); Nagy (2019); Spath et al. (2013)
Efforts to save energy and improve sustainability	de Sousa Jabbour et al. (2018); Kovács (2017a); Lins and Oliveira (2017); Nagy (2019); Paritala et al. (2016); Szalavetz (2018)
Financial and performance factors	Kiel et al. (2017b); Losonci et al. (2019)
Support for management activities	Cimini et al. (2017); Inezari and Gressel (2017); Szalavetz (2018); Uden and He (2017)
Opportunity for business model innovation	Frank et al. (2019); Kagermann et al. (2013); Müller et al. (2018); Prem (2015); Smit et al. (2016); Ustundag and Cevikcan (2017)

Source: *Own table*

II.2.4. Barriers to Industry 4.0 implementation

Adolph, Tisch and Metternich (2014), Erol et al. (2016), Shamim et al. (2016), Karre et al. (2017), Müller and Voigt (2017) and Kiel *et al.* (2017) all agreed that one of the major challenges to the implementation of Industry 4.0 is the lack of skilled workforce, and the requirement to retrain staff to fit changed circumstances. In the future, new ways of working are needed, which may have positive and negative effects on employees (Smit *et al.*, 2016). Changed working conditions may lead to conflicts in business organizations (Bauer *et al.*, 2015).

A number of sources (Erol et al., 2016; Kiel et al., 2017; Müller and Voigt, 2016; PwC, 2014) have suggested that shortage of financial resources is also a significant obstacle to implementation. Müller and Voigt (2016) found that low degrees of standardization, poor understanding of integration and concerns about data security could also hinder Industry 4.0 adoption. Nagy (2019) noted that standardization problems may occur in inter-organizational relationships, as well as in the tools and systems inside manufacturing companies.

Data security issues were supported by other studies (Cimini et al., 2017; Kiel et al., 2017; McKinsey & Company, 2016). These studies emphasized concerns about cybersecurity and data ownership. Weber and Studer (2016) also discussed the legal issues affecting cybersecurity. Kovács (2017) noted that the spread of new technologies meant that fears about the safe handling of private information and data were expected to intensify in the future. It is also important to highlight the role of privacy-enhancing technologies, which aim to protect individual data and privacy through technological solutions (Heurix *et al.*, 2015). However, there are a number of risks associated with these technologies. For example, de Montjoye et al. (2015) emphasized the risk of re-identification.

The development of manufacturing systems also significantly affects the risk of fragility, creating further uncertainties in the ecosystem (Kovács, 2018). Kiel et al. (2017) found that the most important inhibitory factor was the need for technological integration. Successful integration of components, tools and methods requires the development of a flexible interface, because the synchronization of different languages, technologies, and methods can lead to significant challenges (Zhou, Liu and Zhou, 2015). The reliability and stability of the systems must also be ensured, and this is a critical factor in machine-to-machine communication (Varghese and Tandur, 2014; Sung, 2018).

A study by McKinsey & Company (2016) suggests that the intensive communication required by Industry 4.0 projects, and therefore the introduction of new technologies, may be significantly affected by the difficulty of coordination across organizational units. A study from PwC (2014) found that many companies have not yet developed business cases and feasibility studies that clearly support the need to invest in the data and systems architecture required for the introduction of Industry 4.0 applications. This creates a further barrier to Industry 4.0 adoption. Similar conclusions were drawn by Basl (2017), who noted that many companies are not clear on the benefits of using Industry 4.0 technologies.

It is also essential to emphasize the role of organizational culture in transformation. This is usually not identified even though the management of organizational resistance and achieving cultural acceptance of innovations is generally a priority task during Industry 4.0 projects (Automation Alley, 2017; Kiel *et al.*, 2017; Leipzig *et al.*, 2017; Vey *et al.*, 2017). The barriers identified from the literature are shown in Table 5.

Table 5: Barriers to Industry 4.0 identified from the literature

Barrier	**Sources**
Human resources and work circumstances	Adolph et al. (2014); Bauer et al. (2015); Erol et al. (2016); Karre et al. (2017); Kiel et al. (2017b); Müller and Voigt (2017); Shamim et al. (2016); Smit et al. (2016)
Shortage of financial resources	Erol et al. (2016); Kiel et al. (2017b); Müller and Voigt (2016); PwC (2014)
Standardization problems	Müller and Voigt (2016); Nagy (2019)
Concerns about cybersecurity and data ownership issues	Cimini et al. (2017); Kiel et al. (2017b); McKinsey & Company (2016); Weber and Studer (2016)
Risk of fragility	Kovács (2018)
Technological integration	Kiel et al. (2017b); Sung (2017); Varghese and Tandur (2014); Zhou et al. (2015)
Difficulty of coordination across organizational units	McKinsey & Company (2016)
Lack of planning skills and activities	Basl (2017); PwC (2014)
Organizational resistance	Automation Alley (2017); Kiel et al. (2017b); Leipzig et al. (2017); Vey et al. (2017)

Source: *Own table*

II.2.5. SMEs versus MNEs in the context of Industry 4.0

Most companies today recognize the likely impact of Industry 4.0. However, SMEs are generally less well-prepared for the new technologies and expectations (Smit *et al.*, 2016). Many authors have pointed out that the lack of financial resources can significantly hinder SMEs in development projects (e.g. Kocsis, 2012; Mcmahon, 2001; Mittal et al., 2018). In contrast, MNEs have much greater opportunities to invest in new technologies, and therefore tend to apply more advanced manufacturing technologies than SMEs (Dangayach and Deshmukh, 2005). This suggests that MNEs have competitive advantages over SMEs.

Other scholars, however, have argued that slack resources can be a disadvantage and lead to suboptimal organizational performance (Simon, 1957; March and Simon, 1958; Penrose, 1995; Wiseman and Bromiley, 1996; Mishina, Pollock and Porac, 2004). They suggested that resource constraints can be enabling in certain conditions like crowded, resource-poor, and small markets (Jarillo, 1989; Rao and Drazin, 2002; Katila and Shane, 2005; Hortoványi, 2012).

Kennedy and Hyland (2003) noted that manufacturing SMEs can take advantage of their operational capabilities against large multinational companies. However, their relative lack of financial resources and experience, as well as capacity constraints, can form a major drawback and limit their development opportunities. MNEs' larger resource pool and capacity mean that they have more opportunities to carry out research projects (e.g. technology research, market research).

Mittal et al. (2018) reviewed other studies to compare SMEs and MNEs along 17 dimensions and highlight their different possibilities in the context of Industry 4.0. The dimensions were financial resources, use of advanced manufacturing technologies, software umbrella, research & development, nature of product specialization, consideration of standards, organization culture/leadership flexibility, company strategy, decision-making, organizational structure, human resources engagement, exposure to human resource development, knowledge and experience of the industry, alliances with universities or research institutes, important activities, dependence on collaborative networks, and customers and suppliers. The authors concluded that SMEs possess weaker network connections and have fewer suppliers, making them much more dependent on them.

Mishra (2016) found that MNEs' manufacturing systems are more flexible, which is inevitable as competition becomes more intense. Lower manufacturing flexibility in SMEs can be traced back to lack of knowledge, low levels of support from the top management and suppliers, and fear of increased costs. This dual embeddedness means that these subsidiaries have more opportunities to use positive network effects (e.g. increasing innovation performance) (Figueiredo, 2011).

Subsidiaries of MNEs, however, are embedded in both the parent MNE's network and more local networks (Meyer, Mudambi and Narula, 2011). SMEs and MNEs therefore have different opportunities and their competitiveness is determined by several factors. It is important to examine their situation in the context of Industry 4.0 and see whether there is a difference in the driving forces and barriers of Industry 4.0 experienced by each type of company.

II.2.6. Research gaps

There are very few empirical studies on Industry 4.0, and the research sample in these papers is usually small. Studies on the driving forces and barriers of Industry 4.0 often focus only on one factor, and several studies are limited to the technological side. However, Industry 4.0 is much more complex. This study therefore aimed to understand the whole phenomenon, and analysed business, management and technological issues. Unlike previous studies, this paper pairs the driving and inhibiting factors to provide a complex interpretation of Industry 4.0. As far as we are aware, no previous papers have considered the context of MNEs and SMEs, and the results were not based on a specific ecosystem, which is essential for understanding the phenomenon. This study aimed to investigate the key actors in the Hungarian ecosystem, and we therefore tried to ensure that the sample included suppliers, users and those with both roles. Finally, in each case we interviewed the top managers of the selected companies. Details of the relevant papers, including the methodologies used, are in Appendix 1.

II.3. The applied research methodology in the examination of Industry 4.0

II.3.1. Data collection

This study explores the interpretation of Industry 4.0, and its driving forces and barriers, and analyses how SMEs and MNEs are affected by the factors identified. We used a grounded theory approach and interviews.

Grounded theory aims to develop comprehensive explanations about a given phenomenon. The method is generally used for building theories based on data that are systematically collected and analysed (Glaser and Strauss, 1967). According to Strauss and Corbin (1990), *"the objective in grounded theory studies is to explain phenomena in light of the theoretical framework that evolves during the research itself".* Grounded theory uses a systematic set of techniques to identify concepts and build theory based on qualitative data collection (Corbin, 2008). In line with the principles of grounded theory, we collected and analysed our data iteratively to reach a point of theoretical saturation.

According to Miles and Huberman (1984), *"qualitative research is conducted through an intense and/or prolonged contact with a 'field' or life situation".* The aim of qualitative research is to gather data through the perception of local actors, paying considerable attention and drawing on empathic understanding. Researchers can isolate themes and phrases, but their original form must be preserved (Szabó, 2012).

After weighing up the advantages and disadvantages of in-depth interviews and focus groups, we decided to conduct semi-structured interviews rather than focus groups. The disadvantages of focus groups include that responses are unstructured, so their coding and analysis is more difficult. Respondents may also feel that they are under social pressure and want to meet the expectations of the group, affecting their responses (Malhotra, 2010; Acocella, 2012).

We conducted semi-structured interviews with top executives including CDOs and CEOs. The interview guideline is shown in Appendix 2. The interviews were conducted in two phases between July and October 2017 and between February and May 2018. After the interviews, we wrote memos to record the most important learning points, experiences and ideas. The memos helped us to look at the data from a different perspective (Charmaz, 2003).

We aimed to select companies that varied across five aspects:

1. Role in Industry 4.0;
2. Company size;
3. Commitment;
4. Industry sector; and
5. Domestic or multinational enterprise.

We defined three roles in Industry 4.0, **providers**, or Industry 4.0 technology manufacturers, **users** of Industry 4.0 technologies, and **providers and users**, or companies that both manufacture and use Industry 4.0 technologies. We used the company size categories defined by the European Union, with firms that employed fewer than 50 people being defined as **small enterprises**, those with 50–249 employees as **medium-sized enterprises**, and those with 250 or more employees as **large enterprises**. Commitment was examined by assessing whether the company was a member of the national technology platform (participation in an alliance system).

We conducted interviews with top executives of 26 companies. The interviews lasted between 60 and 240 minutes and were all recorded and transcribed. The 26 interviews provided more than 360 pages of interview data. The detailed list of companies is in Table 6.

Table 6: Details of companies involved in interviews

Inter-viewee ID	Role in Industry 4.0	Company size	Technology platform membership	Industry sector	Domestic or MNE?
1.	Provider	Medium-sized	Yes	Machine engineer-ing	Domestic
2.	Provider	Medium-sized	Yes	Industrial automa-tion	MNE
3.	Provider	Small	No	Industrial automa-tion	MNE
4.	Provider	Small	Yes	Technical software development	Domestic
5.	Provider	Small	No	Industrial automa-tion	MNE
6.	Provider	Small	No	Industrial automa-tion, machine engi-neering	MNE
7.	Provider	Small	No	Electronics	Domestic
8.	Provider	Medium-sized	No	Technical software development	Domestic
9.	User	Medium-sized	No	Tool manufacturing	Domestic
10.	User	Small	No	Food and beverages	Domestic
11.	User	Medium-sized	Yes	Electronics	Domestic
12.	User	Medium-sized	No	Bakery	Domestic
13.	User	Medium-sized	No	Logistics and freighting	Domestic
14.	User	Large	No	Car manufacturing	MNE
15.	User	Medium-sized	No	Aluminium produc-tion	MNE
16.	Provider and user	Medium-sized	No	Machine engineer-ing	Domestic
17.	Provider and user	Large	Yes	Industrial automa-tion, drive technol-ogy building tech-nology, energy	MNE

18.	Provider and user	Small	Yes	Machine engineering, industrial automation	Domestic
19.	Provider and user	Medium-sized	Yes	Machine engineering	MNE
20.	Provider and user	Medium-sized	No	Machine engineering	Domestic
21.	Provider and user	Large	No	Industrial gas production	MNE
22.	Provider and user	Large	No	Machine engineering	Domestic
23.	Provider and user	Medium-sized	No	Machine engineering, industrial automation	MNE
24.	Provider and user	Medium-sized	No	Machine engineering	Domestic
25.	Provider and user	Medium-sized	No	Machine engineering	Domestic
26.	Provider and user	Small	No	Industrial automation	Domestic

Notes: MNE = multi-national enterprise

Source: *Own table*

Our interview guide was developed from the literature, and served as a navigation tool during the research. In line with Agee (2009), the interview guide allowed us to explore completely new, unexpected areas and therefore discover new aspects of Industry 4.0. The interview consisted of two main parts. In the first part, we discussed general issues such as the company's activities and history, the interviewee's position and experience and the company's movement towards Industry 4.0. In the second part, we examined the interpretation of digital transformation and Industry 4.0, driving forces, challenges, and other organizational and management aspects of Industry 4.0.

We did not set up hypotheses about the interviews or use any pre-defined answers in the interview questions, to avoid processing errors and bias (Solt, 1998). Based on guidelines from Patton (2002) and Golafshani (2003), we triangulated the research data by checking company websites and annual reports to increase the reliability and validity of our research. Interviewees were assured of anonymity and confidentiality, to reduce bias and increase the reliability of the results.

II.3.2. Data analysis

The data were analysed using grounded theory. After transcribing the interviews, the texts were coded using QSR NVivo software. The coding process is crucial, and its success defines the conclusiveness of the research (Gelencsér, 2003). We analysed the data using Strauss and Corbin's (1994) recommendations, building on three coding phases: open, axial and selective coding. Firstly, we applied open coding and examined the transcripts line-by-line to understand the data and identify key terms. During the axial coding, we evaluated the categories identified to create links between them and their dimensions. This phase included organizing similar concepts into groups and then creating higher-level categories (Mitev, 2012). During the selective coding phase, we defined key categories and subcategories after a systematic analysis. We ignored any categories that were not sufficiently related to the key categories and therefore could not be used in theory development. During each phase, we made notes to help us to determine the direction of the analysis and highlight the relationships.

The coding process provided nine main factors defining Industry 4.0, plus six main driving forces and five barriers to the application of new digital technologies in manufacturing processes. These were compared to previous studies to highlight items and results that had not previously been identified.

II.4. Results of the Industry 4.0 research

II.4.1. Interpretation of Industry 4.0

Several interviewees suggested that it was important to clarify the concept of Industry 4.0 to provide a uniform interpretation. Proper interpretation of the concept is required for companies to set up Industry 4.0 goals and to develop appropriate training programs. Interviewees also emphasized that digitalization and Industry 4.0 cannot be considered synonymous. Both the interviews and the literature review suggest that digitalization is the main concept, with Industry 4.0 as a sub-concept.

"The introduction of Industry 4.0 technologies first requires a common understanding." (Interviewee 17)

Interviewees also noted that the introduction of uniform standards would be necessary for the fourth industrial revolution. However, they saw positive opportunities in many areas. The conceptual interpretations formulated by the interviewees are shown in Table 7.

"Industry 4.0 is one of the greatest opportunities for performance, energy and process optimization." (Interviewee 2)

Table 7: Conceptual interpretation of Industry 4.0

Interviewee ID	Conceptual interpretation
1	Extracting information through programmed controllers that give you the ability to optimize the process. In summary: we can get information containing a useful message, which is very important for business decisions. With digitization, you can naturally extract information from the manufacturing process, and use it to improve the manufacturing process itself.
4	Continuous analysis in autonomous systems by built-in sensors and creation of predictions of possible errors and intervention needs for the system.
5	Intelligence is already at the lowest level of production.
9	Digital measurement to help reduce errors and improve the scrap ratio.
16	The digital formatting of data generated in daily activities and the digital control of machines (during manufacturing activities).
17	Industry 4.0 is a subset of digitalization.
18	Industry 4.0 is basically about efficiency gains. The development is induced by mass production. Its purpose is to reduce the human factor or to subtract it as far as possible.
19	Industry 4.0 includes manufacturing technology, products and data management.
21	The essence of Industry 4.0 is that processes within the company and between companies are increasingly intertwined, and there are artificial intelligence interfaces between each point of attachment.
22	Industry 4.0 refers to the application of new production technologies, complemented by information and communication technologies, in a common network system in which data exchange is fully autonomous.
25	Transforming the manufacturing and processing of products, enhancing their efficiency, productivity, flexibility and quality with the introduction of automation, IT and digitization systems.
26	Industry 4.0 describes an efficient organization of production processes in which devices communicate independently and work in a coordinated manner along the material stream.

Source: *Own table*

The main factors of the fourth industrial revolution are summarized in Table 8.

Table 8: The main factors and elements of Industry 4.0

Factor	**Elements**
Data collection and processing	• Data collection • Big Data • Data processing • Data analysis
Optimization of the production process	• Production optimization, using production data • Reduction of scrap percent by digital data processing • Forecasting • Application of production control systems • Increasing designability of production
Machine-to-machine communication	• Integration of systems • Sensors e.g. intelligent and vibration sensor • IO-Link • Application of cameras • Wireless technologies
Traceability of production	• Precise tracking of the production process • Unique identification of products and product components
Work without human intervention	• Work with robots • Application of collaborative robots to R&D tasks • Replacing human senses • Self-learning systems, self-regulation • Automatic movement of products and conveyors without human intervention

Preventive maintenance	• Monitoring the condition of systems • Avoiding stoppage of production • Self-monitoring systems
Visualization	• Visual display of information: human–machine interface • Pick-to-light systems • Intelligent industrial lighting systems
Augmented reality	• Linking virtual reality and reality • Supporting step-by-step processes • Maintenance including performance measurement • Quality control • Training solutions
Intelligent warehousing and logistics	• Intelligent warehouse systems • Radio frequency identification (RFID) • Intelligent logistics

Source: *Own table*

The first factor is data collection and processing. During production processes, a large amount of data is generated. By processing these data, companies can gain a lot of benefits including support in decision-making. New digital technologies can also provide a lot of information about customers (e.g. based on usage data extracted from systems placed at customer sites). Processing these data will allow companies to increase customization of products and create targeted customer programs. However, it is important to extract and process only data that are really useful. Processing of data requires a highly qualified workforce with advanced statistical and analytical capabilities.

"We use only one millionth of production information, so we need to determine the necessary data." (Interviewee 1)

The information obtained could help to optimize production processes in a number of ways. Digital data processing can significantly reduce scrap percentage and error rates. Production forecasts can be used to create an optimal production plan, increasing costeffectiveness and consumer satisfaction. Applying production control systems can determine optimal production schedules and production can be adjusted as a result of any changes. Overall, by using Industry 4.0 technologies, more predictable production can be achieved.

By integrating individual systems, using sensors, special cameras and wireless technologies, machine-to-machine communication (M2M) becomes possible. The integration of systems is feasible within one company but can also allow communication between systems in different companies across the whole supply chain. M2M applications result in significant time savings, and reduce risks and energy consumption during the production process. Industrial sensors have many areas of application. They are suitable for measuring temperature and vibration, or detecting difficult-to-see objects. IO-Link is an input/output technology that enables communication with sensors and actuators, allowing monitoring of the production process. The use of special cameras enables continuous feedback, and reduces errors and therefore the scrap ratio. Besides quality control and tracking the state of the machines, industrial cameras allow production to be documented, facilitating traceability and compliance with standards. An example of the documentation is that images of products and product components identified with unique QR codes are saved in databases. If there are consumer complaints, the images can be extracted and verified, supporting quality management. Wireless technologies speed up communication. They and other technologies allow the connection of individual workstations by the use of touch buttons and keyboards, so that employees can easily contact their supervisor if necessary. The application of these solutions therefore increases productivity and efficiency, and reduces downtime. Wireless technologies also enable tracking of employee performance, as the number and frequency of requests, and the time required to resolve them can easily be documented. These data can be incorporated into the corporate performance appraisal system. The application of Industry 4.0 technologies also helps to track production processes and products. Using unique identifiers (e.g. radio frequency identification), each component and product can be tracked.

Work without human intervention is primarily the use of collaborative robots during the production process. There are also solutions where robots are involved in research and development tasks or equipped with a camera, replacing the human eye. Self-learning systems reduce the reliance on human work by learning complex tasks, significantly affecting the future of production. This factor also involves the moving of components and products to the right place in the manufacturing process without human intervention.

The next point is preventive maintenance. The application of Industry 4.0 technologies allows the condition of systems to be monitored in real time. By analysing condition data, maintenance work can be done proactively to prevent, *inter alia*, stoppage of production. The systems themselves can also send notification of their condition and immediately notify the responsible person (e.g. the maintenance engineer) in the event of a problem.

Visualization includes both the display of data on a screen, and all systems helping the production process through visual signals. By applying human–machine interfaces, production data extracted from industrial control systems can be displayed (e.g. temperature, system status). Pick-to-light systems support operators with a light signal to gather the right components needed to produce a particular product, eliminating human errors. These systems are usually used for difficult-to-automate, monotonous tasks. Their ergonomic design reduces the joint pain of the workforce. Pick-to-light systems can also support measurement of staff performance by recording work data with sensors and cameras. The use of smart industrial lighting technologies is also very important in Industry 4.0, and can give feedback about the status of each machine using different colours.

The application of augmented reality systems supports workers in a number of ways. These technologies can help with step-by-step processes by linking virtual reality and reality. Augmented reality-supported maintenance can reduce execution times and human error rates. The technology also helps with employee performance measurement, and makes it possible to check whether each product complies with quality standards. Last but not least, augmented reality-guided training is increasingly effective.

The last factor that emerged from the interviews was intelligent logistics and warehousing. The application of intelligent warehouse solutions allows product flow to be optimized in real-time and support provided for optimal management of stock and inventory. Warehouse systems often involve radio frequency identification (RFID), using tags, readers and antennae to track products. Intelligent logistics systems deliver material to fit the loading order of the trucks and optimize shipment routes.

II.4.2. Driving forces and barriers to Industry 4.0

We identified several factors that support or inhibit the introduction of Industry 4.0. An overview is shown in Table 9.

Table 9: Driving forces and barriers of Industry 4.0

<table>
<tr><th>Driving force</th><th colspan="2">Factor</th><th>Barrier</th></tr>
<tr><td>Increasing labour shortages
Reducing human work
Allocating workforce to other areas (higher added value)</td><td colspan="2">Human resources</td><td>Lack of appropriate competences and skilled workforce
Longer learning time (training of staff)</td></tr>
<tr><td>Reducing costs e.g. human resources, inventory management and operating costs</td><td colspan="2">Financial resources and profitability</td><td>Lack of financial resources
Return and profitability
Shortcomings in tendering systems
Long evaluation period for tenders</td></tr>
<tr><td>Market competition
Follow market trends
Increasing pressure from competitors
Business model innovation</td><td>Market conditions and competitors</td><td rowspan="2">Management reality</td><td rowspan="2">Lack of a leader with appropriate skills, competencies and experience
Lack of conscious planning: defining goals, steps and needed resources</td></tr>
<tr><td>Demand for greater control (from top management)
Continuous monitoring of company performance</td><td>Management expectations</td></tr>
<tr><td>Reducing the error rate
Improving lead times (compliance with market conditions)
Improving efficiency
Ensuring reliable operation (e.g. less downtime)</td><td>Productivity and efficiency</td><td>Organizational factors</td><td>Inadequate organizational structure and process organization
Contradictory interests in different organizational units
Resistance by employees and middle management</td></tr>
</table>

		Technological and process integration, cooperation	Lack of a unified communication protocol Lack of back-end systems for integration Lack of willingness to cooperate (at the supply chain level) Lack of standards incl. technology and processes Lack of proper, common thinking Unsafe data storage systems The need for large amounts of storage capacity
Pressure from customers Improving customer satisfaction The need for quality improvement Improving flexibility	**Customer satisfaction**		

Source: *Own table*

The first group of factors is human resources. Interviewees highlighted increasing labour shortages as one of the main drivers of digital transformation:

"There are many problems on the human resources side, which mean that the workforce is going to be replaced by robots and digital technologies." (Interviewee 3)

"We will do everything we can to compensate for labour shortages by increasing efficiency." (Interviewee 11)

By expanding the use of Industry 4.0 technologies, many companies aimed to be able to allocate employees to tasks that generate higher added value:

"With the use of digital technologies, we aim to take daily, weekly routine jobs from the workers' hands. This way they can work on tasks that generate much higher added value." (Interviewee 11)

One major challenge in implementing Industry 4.0 technologies is that companies do not currently have skilled workers with the competences required in future. It may also be challenging to retrain employees, because this takes a long time, increasing costs.

The next group of factors is financial resources and profitability. Increasing digitization of production processes provides a number of financial benefits, including significant reduction in cost of human resources, inventory management and operations. However, the introduction of Industry 4.0 technologies also requires a significant amount of financial resources, which may hinder companies. Many companies were concerned about profitability and the return on investment in new technologies. Limited access to financial resources (e.g. through tenders) is also an obstacle. The interviewees suggested that the availability of financial resources may be hampered, *inter alia*, by shortcomings in tendering systems. This regulatory gap also results in the evaluation period for tenders being too long.

"Before these projects, the biggest question is whether a digitization project is really worth it. The concrete question is whether the project is financially worthwhile for the company." (Interviewee 15)

Intense market competition and pressure from competitors are additional driving forces. Companies can increase their market share and competitive advantage through innovative developments based on Industry 4.0 technologies. There are also opportunities to develop new business models and renew the value proposition, which may create many additional benefits. Providers who mainly deliver to foreign markets with more developed economies may find that digitization is an essential condition for staying in the market.

"Constant competition with competitors makes it essential for the company to be up-to-date and innovative in both its production and process management." (Interviewee 14)

"*Without digitization, we would not be competitive, we could not cooperate with most of our partners."* (Interviewee 20)

"There are small companies that have developed organically with the big foreign car manufacturers, but because they have not introduced new digital technologies, they have lagged behind." (Interviewee 11)

Expectations from management can also encourage the introduction of Industry 4.0 technologies. Top managers often want to increase control by using digital technologies. Their goal is to have continuous, real-time performance measurement. Interviewees mentioned a number of technologies that would allow data to be integrated into the enterprise performance measurement system (e.g. pick-to-light systems, smart cameras), and therefore be used for employee performance appraisal.

"It is important to me that the indicators which measure the performance of the company can be accessed and verified in real time." (Interviewee 13)

Analysing the other side of market conditions and management expectations, management reality is also a barrier. As production processes are digitized, companies need a leader with the necessary skills and experience to control Industry 4.0 projects. Interviewees suggested, however, that not having such a leader was mainly an issue in smaller businesses. Finally, during the introduction of Industry 4.0 technologies, proper planning is necessary from the very beginning of the projects, to define objectives, and the steps and resources necessary to achieve them, by time period. Industry 4.0 projects cannot succeed without conscious planning.

Another important aspect is productivity and efficiency, which covers several factors. The first is the effort to reduce error and scrap ratio. Reduction in lead times and increased production efficiency also play a prominent role. Overall, by implementing all of these factors, more reliable operations can be achieved.

"There is a strong focus on improving efficiency, especially reducing lead times, as this is a crucial success factor for us to adapt flexibly to customer needs." (Interviewee 19)

By improving productivity and enhancing quality, companies also aim to increase customer satisfaction and reduce complaints. High quality was defined by interviewees as a basic condition for participating in market competition. By increasing flexibility, companies will also be able to respond to individual customer needs more quickly.

"If our customers see that we deliver the products exactly, always on time and in the right quality, they will not choose another supplier instead of us." (Interviewee 17)

However, besides efforts to increase productivity, companies need to account for various organizational barriers. The success of Industry 4.0 technology implementation can be affected by organizational processes and structure. If corporate processes are not properly optimized and the structure is not flexible, and does not support fast flow of information or fit other requirements, the introduction of new technologies is expected to fail.

"Many companies are not yet ready for Industry 4.0." (Interviewee 4)

Organizational resistance and inadequate management of it can also be a major obstacle. In many cases, contradictory interests among organizational units, lack of understanding of the new technology, and fear of the unknown are likely to be experienced. Organizational resistance may be seen in both lower level employees and middle managers. Employees may be frightened of losing their jobs with increasing digitization, and afraid of not having the appropriate skills to handle new technologies. Over time, the scope of activities of middle managers will also be completely transformed and their role will change to include some new tasks that may need more expertise.

"Despite the fact that new technologies are a positive change, workers still feel that as a burden and therefore resistance is inevitable. We have to invest a lot of extra energy to handle this." (Interviewee 9)

"During the digitization projects, we saw people clinging to the accustomed, and changes were cumbersome and uncertain. There must be a cultural change, which is time-consuming, and no immediate results should be expected." (Interviewee 14)

Inhibiting factors around technological, process integration and cooperation issues need to be considered when trying to increase productivity and respond to customer demands. Industry 4.0 technologies require systems integration both within and beyond the company. To ensure technological integration across the entire supply chain, it is important to develop a unified communication protocol. It is also essential to develop back-end systems with business intelligence to support the processing of large amounts of data generated during production processes. The integration of Industry 4.0 technologies across the supply chain can be hampered by a lack of willingness to cooperate and lack of standards. Lack of standards covers both the need for technology standards and also the importance of process standardization. It is also essential to develop a common way of thinking at all levels of the company.

"If there is no change in thinking, then there will be no change in the company either." (Interviewee 11)

Companies also need to build secure data storage systems to ensure data security. The increasing amounts of data may require additional data storage capacity.

II.4.3. The effect of the factors identified on SMEs and MNEs

This section discusses the different effects of the driving forces (Table 10) and barriers (Table 11) on SMEs and MNEs. For SMEs, the increasing labour shortages are crucial, because they are heavily dependent on local human resources. Many SMEs are therefore using Industry 4.0 solutions as a way to address human resource problems. MNEs have greater opportunities for recruitment, because they source talent on a global scale. If they do not find adequate human resources in a given region or country, they can move their production activities to another region.

Financial and profitability driving forces are not very important for SMEs, because they do not necessarily use new digital technologies primarily to reduce costs but to tackle other challenges (e.g. the lack of human resources). Their profitability expectations are lower and they often undertake projects with lower returns to meet personal and other management goals. For MNEs, this factor is more important, because they have higher cost reduction and profitability expectations.

SMEs are also less dependent on market conditions as driving forces. They strive to find niche markets and are less flexible than MNEs so are less able to change their operational processes. SMEs’ business model innovation aspirations are often not conscious and not handled as an opportunity but rather as a compulsion. MNEs, however, face pressure from their competitors. These companies are constantly following each other's activities and act immediately if they see new developments elsewhere. SME managers may be less aware of the monitoring and other opportunities offered by new digital technologies. In contrast, the top management of MNEs aims to monitor and control the whole operation and performance of the company in real time through the application of Industry 4.0 technologies. Productivity and efficiency factors are important for SMEs, but have a more dominant role in MNEs, which are constantly striving to improve efficiency, especially in production departments.

Customer satisfaction is crucial for SMEs. As a result, they try to fulfil all exceptional requests of their customers to ensure those clients will return. MNEs may be similarly motivated for large customers, but for smaller clients, this factor is less important.

Table 10: The level of effect of the driving forces identified on SMEs and MNEs

Driving force	SMEs	MNEs
Human resources	High	Low (locally high)
Financial resources and profitability	Medium/low	Medium/high
Market conditions and competitors	Low	High
Management expectations	Low	High
Productivity and efficiency	Medium	Medium/high
Customer satisfaction	High	Medium/high

Source: *Own table*

Human resources-related barriers are crucial for SMEs, because they often struggle to find employees with appropriate competences. MNEs recruit on a global scale, so this factor is mitigated. However, the number of artificial intelligence, big data and Industry 4.0 experts is currently low at the global level and the number of vacancies in this area is high.

Financial resources and profitability pose a high barrier for SMEs since these companies have fewer financial resources and are often unable to invest in new technologies. They mainly expect support from tenders, in which many shortcomings can be identified. For MNEs, the situation is much better because they can allocate significant amounts of financial resources to new developments and find and expend additional resources. The only questions may be around how the management tolerates uncertainty, and how much they are willing to experiment.

Management issues are also crucial for SMEs because their top management may be unable to identify the additional opportunities offered by Industry 4.0 technologies. The generation gap between employees is also a major problem. In MNEs, there are only a few managers who see through the whole supply chain and understand interdependencies.

Organizational factors are not a major barrier for SMEs. If the CEO is committed to innovative technologies, then all members of the organization will follow the CEO's lead and no or minimal organizational resistance is experienced. In MNEs, organizational resistance is much higher, especially from the middle management because they often do not want suppliers to introduce new technologies. The last barrier—technological and process integration, and cooperation—is low for SMEs, because they are not looking for technology integration at the supply chain level and instead solve emerging problems within their own organization boundaries. In contrast, this factor is a major challenge for MNEs because their primary goal is to integrate at the level of the entire network.

Table 11: The level of effect of the barriers identified on SMEs and MNEs

Barrier	**SMEs**	**MNEs**
Human resources	High	Medium
Financial resources and profitability	High	Low
Management reality	High	Medium
Organizational factors	Low	High
Technological and process integration, cooperation	Low	High

Source: *Own table*

II.5. Summary and discussion of the Industry 4.0 research

This study examined how companies interpret the concept of Industry 4.0, and the driving forces and main obstacles to introducing new, digital technologies under Industry 4.0. It also assessed the different level of effect of each of these factors on SMEs and MNEs. Discussing the interpretation of the concept, it was apparent that suppliers mostly highlighted the technology side, but users mainly focused on the management aspects of Industry 4.0. Companies with a dual role emphasized both factors equally. In line with our preliminary determination, interviewees also defined digitalization as the overarching issue, with Industry 4.0 as a sub-category. However, to drive successful adoption of Industry 4.0 technologies, companies need to create a common understanding of the change, and develop innovative forms of training that help to develop employee competences in a rapidly changing environment. In line with Kiel, Arnold, & Voigt (2017) and Ríos et al. (2017), we also suggest that manufacturing companies should actively cooperate with universities and other educational organizations to develop educational programs covering multiple fields including mathematics, engineering, programming, and data analysis and processing.

This paper identified six main driving forces and five barriers to the application of new digital technologies in manufacturing processes. Our aim was to provide a more detailed and accurate description of these than previous studies. Management expectations emerged as an important driving force behind Industry 4.0 adoption, but this is not usually discussed in the literature. Management aspiration to increase control and enable real-time performance measurement may be a significant driving force behind the introduction of Industry 4.0 technologies. By applying digital technologies, corporate managers can improve both their decision-making and employee and company performance appraisal.

Both the literature and our research results show that the fourth industrial revolution presents a number of challenges for companies. We identified a new factor not covered in previous studies: that companies' concerns about profitability and uncertainties in tendering systems can significantly hinder companies from introducing Industry 4.0 technologies. As with any change, organizational resistance can be expected to the introduction of new technologies. This may be the most powerful barrier to change, and if not properly handled, can significantly impede the successful introduction of new technologies. Organizational resistance may come from employees who are afraid of losing their jobs over time or do not have the necessary skills for new technologies, but also from middle managers. Loss of employees disrupts the social environment within the company. As the organization becomes flatter, middle managers' role will change away from managing people and towards more expert work requiring higher qualifications.

Among the emerging barriers and challenges of Industry 4.0, standardization and management and leadership aspects are also important. The introduction of new digital technologies requires technological standards and standardization. We also found that companies need a process-centred operation for the successful implementation of new technologies. They also need open-minded, creative leaders who are thinking at both organizational and whole-network levels during the development process. Another new element identified in this study is that the lack of network-level willingness to cooperate and integrate technologies at the supply chain level—one of the key elements of Industry 4.0—can significantly hinder the integration and implementation of these technologies.

MNEs and SMEs do not have equal opportunities in the area of Industry 4.0. MNEs have higher driving forces and lower barriers than SMEs across nearly every aspect. However, SMEs have advantage over MNEs, including their lower profitability expectations. Customer satisfaction is also a stronger driving force for change in smaller companies. Organizational factors are less complex in SMES, so implementing new Industry 4.0 technologies, processes and management innovations is easier. SMEs also have fewer technological dependencies, and fewer barriers to cooperation.

Besides technological and organizational changes, management functions will also be significantly transformed. *Objective setting and strategy creation* will require more steps and much more iteration in the future. An agile approach within organizations is inevitable as well as more frequent revision of objectives and strategy. To ensure *organizational function,* the proper design of structures and processes will become even more important in a rapidly changing environment. Continuous rethinking of structure and processes will be necessary, together with an approach to problem-solving that looks at both individual problems and system-level interventions. The third feature is *personal leadership*, which will also significantly change. Social support will be even more important for employees remaining in the company and organizations must take care of the social security of their staff. To support *control* as a management function, traceability will be improved and it will be possible to track employee performance in real time. Up-to-date information will mean that employees become more accountable. Individual responsibility will also increase, and the cost of measurement will be significantly reduced for well-defined activities.

The examination of organizational and management aspects of Industry 4.0 is still in its infancy. The volume of literature is limited, which leads to several new research questions. In future, researchers should explore management aspects and best practices supporting companies implementing Industry 4.0 projects. Another important issue is how changed working conditions affect workers and what challenges can be identified at the social level. It may also be useful to extend the geographical focus of Industry 4.0 research, to compare similarities and differences across regions. Finally, in line with studies by Prem (2015) and Müller and Voigt (2017), it is also necessary to study the effects of Industry 4.0 on business models.

III. Evolution of photovoltaic business models: overcoming the main barriers of distributed energy deployment

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Abstract

The use of renewable energy resources is rapidly growing around the world. However, several barriers may hinder the diffusion of distributed energy solutions. This paper aims to identify the main inhibiting factors using a literature review methodology. To overcome these barriers and adapt to changing environmental conditions, companies operating in the distributed energy market need to develop innovative business model solutions. We therefore investigated the evolution of photovoltaic business models using the Business Model Canvas to determine how the obstacles to distributed energy deployment can be addressed. Finally, we applied the Lean Canvas to show the main differences between the models analysed and describe the benefits of the community-shared model compared with the alternatives, host-owned and third-party-owned solutions.

Keywords: Business Model Canvas, business model innovation, Lean Canvas, renewable energy, solar, utility

III.1. Introduction

The global solar photovoltaic (PV) industry has undergone a major transformation in recent years, with significant growth as a result of strong demand and the continual emergence of new markets (REN21, 2016). However, according to estimates from GTM Research, global PV demand growth is expected to slow down in the next year and will reach 86 GW in 2018 (Mond, 2017). This deceleration in major markets can be traced back to policy shifts and regulatory vagueness (Attia and Parikh, 2016). This paper therefore aims to examine the main barriers—including policy and regulatory aspects—that may influence the diffusion of renewable energy solutions.

Considerable changes have been seen in photovoltaic business models, as well as significant market growth. Changing contextual conditions have led to innovative concepts designed to tackle the increased complexity. Addressing the high upfront costs of solar systems and other emerging barriers, third-party-owned (TPO) and community-shared (CS) models have an increasingly important role. The TPO model offers Power Purchase Agreement and lease solutions, while CS models allow consumers to subscribe to a defined number of panels or a portion of the generated energy in solar parks through virtual net-metering. These solutions show that innovation is important in the PV market. Managers have a decisive role in successful business model adaptation and operation. They are advised to behave like entrepreneurs, be opportunity-driven and develop inventive products and services to address unmet customer needs and emerging inhibiting factors (Hortoványi, 2012).

The United States is one of the leading countries for PV business model development, and several of its states continue to develop new renewable energy solutions. A good example is California, where the three biggest utilities (Pacific & Gas Electric, Southern California Edison, and San Diego Gas & Electric) were required to secure 600 megawatts of new community solar capacity by 2019 (Trabish, 2015). These attempts and business models could inspire countries that struggle with distributed energy (DE) deployment but are committed to renewables.

This paper uses a literature review methodology to evaluate the major barriers that may hinder the diffusion of distributed energy. We also identify and analyse the main PV business models using the Business Model Canvas (BMC), to give a full picture of the concepts and compare the identifiable models. Along the nine building blocks of the BMC, we highlight the value proposition and other core elements that distinguish each model and address consumers' problems, drawing on Osterwalder and Pigneur's (2010) definition of business models.

TPO and CS models offer a possible solution for regions with a less developed residential solar market, so this review, and the detailed presentation of the core elements of the models, may help with adoption. We also use the Lean Canvas to identify significant consumer problems and possible solutions offered by the community-shared model, and provide examples of how and to what extent business models can provide solutions to the identified barriers. Finally, we give a brief summary highlighting the value proposition of each model and some important implications for policy-makers, then note some future research issues. The paper's aim is to help policy-makers and business leaders to understand the problems that customers face in using renewables, and the main barriers to the spread of certain models, helping them to develop a proper political, regulatory and corporate background that will allow the widest possible dissemination of renewable energy resources.

The paper is organized as follows. Section III.2 describes the theoretical background. Section III.3 introduces the methodology and Section III.4 the main barrier groups, while Section III.5 sets out the business models. In Section III.6, we synthesize the business models and in Section III.7 we describe how the different business models can help overcome the identified barriers. The article ends with a summary and conclusions (Chapter III.8) as well as some future research directions in Chapter III.9.

III.2. Literature background of the research aiming to explore photovoltaic business models

III.2.1. Business models

There is no commonly accepted definition of business model, and there are many approaches in the literature. The term itself was first introduced in economics in the 1950s, with an upswing in its use in the mid-1990s, with the emergence of Internet businesses. According to Zott, Amit and Massa (2011), despite a significant increase in the number of publications on business model research, many researchers disagree on the meaning of the term.

Christensen and Johnson (2009) described four compulsory elements of business models: *key resources*, including people, technology, products, tools and brand, *key processes* such as design, manufacturing and R&D, *value proposition for customers,* for instance, price and payment and finally the *profit form*, which includes the cost structure and the revenue model. Magretta (2002), however, described the business model as nothing more than a story of how a company works. Overall, success depends on finding a good story. This referred back to Peter Drucker (Drucker, 1954), who said that a good business model answers the questions “Who are the customers?”, “What is valuable to them?” and “How can this value be provided at an appropriate cost level?”.

Casadesus-Masanell and Ricart (2011) stated that a business model is made up of decisions and consequences and defined three common features along which successful business models can be captured. Firstly, the business model must be in line with the company’s goals. Secondly, the decisions made in the design of the model must complement each other: internal consistency is essential. Thirdly, a good business model should be able to overcome threats over time. Chesbrough and Rosenbloom (2002) defined the functions of business models as articulation of value proposition, market segment identification, definition of the structure of the value chain, estimation of cost structure and profit potential, description of the position of the firm within the value network and formulation of a competitive strategy. Teece (2010) emphasized that a business model includes identifying customer needs and payment capability, responding to these needs, and creating value for them. It also encourages customers to pay for the value provided, and converts these payments into profit by properly designing and operating the various elements of the value chain.

Chatterjee (2013) suggested that the business model is about more than just making a profit by selling products and services. In his view, every business model starts with the value proposition, which is constantly evolving and so provides a competitive advantage for the organization. According to Osterwalder and Pigneur (2010), *“a business model describes the rationale of how an organization creates, delivers and captures value”*. In this paper, we have used this definition as a starting point, because it fits well with renewable energy business models.

Business model innovation is also an important issue, because it enables companies to renew their value proposition, enhance their uniqueness, acquire new markets and customers, and gain long-term sustainable competitive advantage (Zott and Amit, 2007; Amit and Zott, 2010; Eichen, Freiling and Matzler, 2015; Poetz *et al.*, 2015; Bashir and Verma, 2017; Klepakova and Wolf, 2017). Bashir and Verma (2017) suggested that business model innovation can serve as a sustainable competitive advantage, since imitating a whole new system is much more difficult than imitating a product or a service. Aspara, Hietanen and Tikkanen (2010) defined business model innovation as *"initiatives to create novel value by challenging existing industry-specific business models, roles and relations in certain geographical market areas".* Giesen *et al.* (2007) identified three main ways to innovate business models: industry model, revenue model and enterprise model innovation. Some authors have differentiated between replication and renewal of business models. Replication refers, for example, to the exploitation of opportunities offered by an existing business model in other geographic areas (Winter and Szulanski, 2001), and renewal means introducing a new business model that goes beyond the previous one (Nunes and Breene, 2011). According to Amit and Zott (2012), companies can implement business model innovation in a number of ways. These include the addition of new activities to business operations, the innovative linking of activities or changes in who performs the activity.

Several triggers of business model innovation have been identified, such as: (1) economic pressure (Amit and Zott, 2010; Eppler and Hoffmann, 2011; Stampfl, 2016), (2) product development-related issues (Stampfl, 2016), (3) price competition (Plantes and Finfrock, 2008; Eichen, Freiling and Matzler, 2015; Stampfl, 2016; Bashir and Verma, 2017), (4) customer-related issues (Stampfl, 2016), (5) strategic circumstances (Johnson, Christensen and Kagermann, 2008; Stampfl, 2016), (6) underlying conditions (Klepakova and Wolf, 2017), (7) situational triggers (Pateli and Giaglis, 2005; Wirtz, Schilke and Ullrich, 2010; Maglio and Spohrer, 2013; Klepakova and Wolf, 2017) and (8) increasing digitization (Berman, 2012; Prem, 2015; Zott and Amit, 2017).

III.2.2. The Business Model Canvas

The Business Model Canvas provides an attractive template for visualizing new or existing business models. Osterwalder and Pigneur (2010) divided the tool into four parts: customers, value proposition, infrastructure and financial aspects. The customer part covers customer relationships, customer segments and distribution channels. The value proposition includes those products and services that solve a specific problem and create value for the customers. The infrastructure section covers the architecture used for value creation, and the financial aspects highlight the connection between revenue streams and the company's cost structure.

Several articles and studies can be identified that have used the Business Model Canvas to demonstrate business models in the energy sector. Hannon et al. (2013) used it to discuss the characteristics of Energy Service Companies and Energy Utility Companies. Richter (2013a) used its building blocks to compare utility-side and customer-side renewable energy business models. Huijben and Verbong (2013) also applied the building blocks to describe the main types of PV business models in the Netherlands, as did Strupeit and Palm (2016) in the United States, Japan and Germany. Meier (2014) used the BMC framework to evaluate PV business models in emerging regions.

III.2.3. The Lean Canvas

The Lean Canvas (LC) is a business model hypothesis testing and validation tool that can be considered as a further development of the BMC (Maurya, 2012). It offers a more structured way to understand customer problems, and to build the value proposition and solution around them. It also highlights the main risks during the learning process. Its creator based the LC on the BMC but changed some fields to make it even more action-oriented.

One important addition was the Problem section. Many companies fail because they do not focus on real consumer demand, and waste time and money developing the wrong products and services. Another addition is the Solution, because once a firm understands the customers' problem, it is then in the best position to identify an appropriate solution. It is very important to measure the right elements of the operation, which can be recorded in the Key Metrics section. The fourth new part in the LC is a section on Unfair Advantage, which means obstacles preventing others entering the market.

The LC also removed some parts of the BMC, such as the Key Activities that can be derived from the Solutions. Key resources are considered similar to unfair advantages, with the distinction that a key resource can be an unfair advantage, but not all unfair advantages are key resources. These parts were also merged. Customer relationships are now captured in Channels, since all products and services must start with direct customer relationships. Companies should then identify suitable paths to reach their customers. Finally, the section on Key partners was also deleted, since the LC's creator argued that it is only essential for a few type of companies to establish good partner relationships.

III.3. Methodology of the research aiming to explore photovoltaic business models

This section describe the methodology used in this study, to ensure that it is fully understand and enable it to be reproduced in future studies. This research is based on a literature review. In line with Webster and Watson (2002) and Brocke *et al.* (2009), we used five successive steps: (1) scope definition, (2) conceptualisation of topic, (3) literature search, (4) literature analysis and synthesis and (5) research agenda.

1. The scope of this study is to identify the main barriers of distributed energy deployment and to synthesize possible business model solutions that may help in overcoming the emerging obstacles.

2. In the topic conceptualisation phase, we found that scholars discussing different business models generally used the Business Model Canvas. The main framework of our research is therefore the BMC in the business model presentation section. Barrier and business model discussion parts of papers are usually characterized by geographical breakdown such as developing and industrialized countries, so regional structuring became an essential unit in our research. This phase also helped to determine the main keywords for the literature search.

3. The literature review used the EBSCO database, as this includes the most important journals in the fields of business, management, and energy. In the first step, the search covered titles, abstracts and keywords of papers and contained combinations of the following keywords: "business model", "energy", "renewable", "alternative", "distributed", "solar", "photovoltaic", "barrier", "host-owned", "third-party", "community". In the second step, citations were examined, to broaden the existing base and get a wider overview.

4. In the fourth phase, the collected articles were divided into different groups by topic. After closer examination, papers that were not closely related to our scope were

excluded (e.g. papers about energy production modelling). Based on Palvia *et al.* (2004) and Cardenas *et al.* (2014), we then defined the following categories among the remaining papers: survey, interview, field study, case study, literature analysis, frameworks and conceptual model. Studies on barriers were also grouped by area: awareness and behavioural, financial and profitability, regulatory and institutional, technological and company resource barriers. Papers on existing business models were divided into three categories: host-owned, third-party-owned, and community-shared. There were possible overlaps between the categories as studies could cover two or more business models and/or barriers.

5. In the final step, the study classification was completed and the papers were categorized along with the specified criteria. We used the Business Model and Lean Canvases to visualize the benefits of the CS model compared to the alternatives and to help in the further development of the possible solutions.

III.4. Barriers to the diffusion of renewable energy technologies

Numerous factors and barriers can be identified that exert strong influence on the deployment of distributed energy technologies (Table 12). We identified different problem groups that contain the most important elements and factors, to develop an overall picture about the emerging obstacles in the DE market (Table 13).

Table 12: Overview of the main barriers and related papers

Main barriers	**Related papers**
Financial and profitability barriers	Reddy and Painuly (2004); Drury *et al.* (2012); Huijben and Verbong (2013); Richter (2013b); Davidson, Steinberg and Margolis (2015); Eleftheriadis and Anagnostopoulou (2015); Ruggiero, Varho and Rikkonen (2015); Zhang (2016); Engelken *et al.* (2016); Karakaya, Nuur and Hidalgo (2016); Strupeit and Palm (2016)
Awareness and behavioural barriers	Reddy and Painuly (2004); Edenhofer *et al.* (2011); Eleftheriadis and Anagnostopoulou (2015); Ellabban and Abu-Rub (2016); Engelken *et al.* (2016); Sen and Ganguly (2016)
Regulative and institutional barriers	Fuchs and Arentsen (2002); Monica Oliphant Research, (2012); Eleftheriadis and Anagnostopoulou, (2015); Ruggiero, Varho and Rikkonen, (2015); Comello and Reichelstein, (2016); Engelken *et al.* (2016); Karakaya, Nuur and Hidalgo (2016); Sen and Ganguly (2016); Zhang (2016)
Technological barriers	Reddy and Painuly (2004); Richter (2013b); Ruggiero, Varho and Rikkonen (2015); Engelken *et al.* (2016); Uhlir and Danecek (2016); Zhang (2016)
Company resource barriers	Reddy and Painuly (2004); Edenhofer *et al.* (2011); Richter (2013b); Engelken *et al.* (2016)

Source: *Own table*

Table 13: Overview of the identified barrier groups

Group	**Elements, main factors**
Awareness and behavioural barriers	• Lack of knowledge and information • Lack of skilled people • Misinformation regarding DE benefits • Behavioural barriers and concerns
Financial and profitability barriers	• Lack of financial resources • Profitability problems • High initial investment costs • Additional costs • Lack of available loan constructions
Regulative and institutional barriers	• Shortcomings of legal framework • Issues in feed-in-tariffs and taxation • Low electricity price • Unpredictable regulations
Technological barriers	• Grid capacity • Security of supply • System performance risks
Company resource barriers	• Lack of competence • Gaps in the product portfolio • Shortcomings in management and business skills

***Source:** Own table*

III.4.1. Financial and profitability barriers

Financial barriers such as high initial investment costs and lack of financial resources result in a long payback period in renewable technology investments, which in turn decreases the demand (Reddy and Painuly, 2004; Drury *et al.*, 2012; Eleftheriadis and Anagnostopoulou, 2015). According to utility managers in Germany, economies of scale cannot be realised in the residential customer segment because of high upfront investment costs and size of PV projects. These managers therefore do not see much future potential in the B2C area (Richter, 2013b). Low profitability of small domestic projects is therefore a strong dissuasive factor in the DE market (Ruggiero, Varho and Rikkonen, 2015).

As well as the high level of initial investments, extra cost items e.g. increased operation and maintenance costs, transaction costs associated with grid interconnection and cost of batteries also act as inhibiting financial factors (Ruggiero, Varho and Rikkonen, 2015; Engelken *et al.*, 2016; Zhang, 2016). In several countries, it is not possible to alleviate these expenses, since large parts of society are excluded from government support, and in other countries, there are no solar loan options for residential customers (Huijben and Verbong, 2013; Strupeit and Palm, 2016).

To overcome the lack of financial resources, companies operating in the DE market should develop innovative financing schemes that are adapted to customer needs and allow them to invest in renewable technologies. One possible solution could be community-shared and third-party-owned business models, as these aim to reduce or eliminate up-front costs and therefore encourage the use of renewable energy solutions for the residential market (Huijben and Verbong, 2013; Davidson, Steinberg and Margolis, 2015; Strupeit and Palm, 2016).

III.4.2. Awareness and behavioural barriers

Customer awareness and acceptance are considered essential elements in the renewable energy market, and can strongly affect demand. In developing countries in particular, the potential customer segments are unskilled because of a shortage of information about renewables (Reddy and Painuly, 2004; Engelken *et al.*, 2016; Sen and Ganguly, 2016). A poor knowledge base and misinformation about the benefits of renewable technologies, however, are not only issues in developing countries but influence the deployment of DE technologies more generally (Eleftheriadis and Anagnostopoulou, 2015). Behavioural barriers and concerns related to personal values and norms also strongly affect attitudes toward DE investments. People are usually risk-averse and do not recognize the exploitable benefits offered by renewable energy technologies alone (Edenhofer *et al.*, 2011; Ellabban and Abu-Rub, 2016; Engelken *et al.*, 2016).

We therefore conclude that market actors should take on an active role in the dissemination of information and the education of consumers. The widespread availability of information may result in higher awareness and acceptance.

III.4.3. Regulatory and institutional barriers

Most of these barriers are related to shortcomings of the legal framework, or government actions as well as energy and environmental policy (Eleftheriadis and Anagnostopoulou, 2015; Engelken *et al.*, 2016; Sen and Ganguly, 2016; Tongsopit *et al.*, 2016; Potisat *et al.*, 2017). Reductions in feed-in tariffs and the low price of electricity set by the government result in a longer payback period and increased liquidity risks for green technologies. When paired with the high initial investment costs, these form a serious barrier to the deployment of renewable technologies (Eleftheriadis and Anagnostopoulou, 2015; Comello and Reichelstein, 2016; Karakaya, Nuur and Hidalgo, 2016). Taxation also has an inhibiting influence, as it is usually imposed on the basis of installed system capacity (Monica Oliphant Research, 2012; Ruggiero, Varho and Rikkonen, 2015). Ongoing changes in feed-in tariff reductions (e.g. low buy-back rates) and high levels of taxation lead to lack of long-term planning reliability (Monica Oliphant Research, 2012; Ruggiero, Varho and Rikkonen, 2015; Zhang, 2016). Governments need to define appropriate purchase prices, eligibility period and type of incentives that fit local needs and endowments, to increase the appetite for DE investments. Dependable state activity would not only result in increased consumer investment but also attract attention from public and private investors (Fuchs and Arentsen, 2002). It can be concluded that stable political factors are essential to cost-effective system operation, and governments therefore play an important role in the deployment of DE technologies.

III.4.4. Technological barriers

Grid reliability, stability and efficiency are all critical technological issues (Uhlir and Danecek, 2016). Increasing numbers of newly built DE facilities result in a higher network load, so grid capacity must be developed to ensure reliability. Capacity constraints that were initially designed to protect the grid from collapse and overload have therefore become a substantial barrier to further investment (Ruggiero, Varho and Rikkonen, 2015; Engelken *et al.*, 2016; Zhang, 2016). In developing regions such as South America or Asia, problems in security of supply are a significant challenge for local companies (Richter, 2013b). The risk of poor system performance can exert a strong negative influence on investment activity, because residential consumers are not able to realise their initial energy targets with inefficient systems (Reddy and Painuly, 2004; Zhang, 2016).

Technology development is key in the DE market. These obstacles are not insurmountable, however, because development of unique local specialized solutions could overcome supply problems (Engelken *et al.*, 2016).

III.4.5. Company resource barriers

Lack of company competencies are seen in both industrialized and developing countries (Edenhofer *et al.*, 2011; Richter, 2013b; Engelken *et al.*, 2016). In recent years, utilities have faced significant changes in their business models and managers of these companies have identified competence shortage as a key barrier in the residential customer segment. Decades of experience in contracting with corporate customers does not really transfer to private customer segments (Richter, 2013b). Utilities also have to develop their product and service portfolio to create value for the residential segment and be competitive in the B2C market. Shortcomings in management and business skills make the situation worse in developing countries, where managers face lack of technical support, although these factors should be the keys to value creation and daily corporate operations (Reddy and Painuly, 2004; Edenhofer *et al.*, 2011; Engelken *et al.*, 2016).

III.5. Identifying basic PV business models

The papers on business models identified a new PV business model as well as the two better-known models (host-owned and third-party-owned): the spread of community-shared constructions. We examined the main characteristics of these models using the Business Model Canvas, assessing them from the perspective of the operating companies. The aim of this review is to provide an overall picture of the models and contribute to understanding of the concepts. The descriptions were divided into two, customer and infrastructure sides of the Business Model Canvas. The customer side includes value propositions, customer relationships, customer segments, channels and revenue streams, and the infrastructure side includes key partners, key activities, key resources and cost structure (Osterwalder and Pigneur, 2010). A summary of the business models examined, together with details of source papers, is in Table 14.

Table 14: Overview of the analysed business models and related papers

Business Model	Related papers
Host-owned / Customer-owned / Host-owned feed-in / Customer-sited / End-user owner	Frantzis *et al.* (2008); Schoettl and Lehmann-Ortega (2011); Huijben and Verbong (2013); Karakaya, Nuur and Hidalgo (2016); Strupeit and Palm (2016); Zhang (2016)
Third-party-owned / Third-party / Third-parties / Third-party Owner / Third-party ownership / Third party PV / Solar City model / Third-party financing / Solar energy management service model (solar EMS model)	Frantzis *et al.* (2008); Kollins, Speer and Cory (2010); Drury *et al.* (2012); Davidson and Steinberg (2013); Feldman, Friedman and Margolis (2013); Hobbs and Pierpont (2013); Huijben and Verbong (2013); Davidson, Steinberg and Margolis (2015); Brunekreeft, Buchmann and Meyer (2016); Zhang (2016); Strupeit and Palm (2016)
Community-shared / Shared solar / Community solar / Community-owned model	Coughlin *et al.* (2012); Monica Oliphant Research (2012); Huijben and Verbong (2013); Feldman *et al.* (2015); Funkhouser *et al.* (2015); Augustine and McGavisk (2016); Zhang (2016)

Source: *Own table*

III.5.1. Host-owned Business Model Canvas

The most widespread PV business model is host-owned, which is given a variety of names in the studies analysed. These include customer-owned (Huijben and Verbong, 2013; Karakaya, Nuur and Hidalgo, 2016), host-owned (Zhang, 2016), host-owned feed-in (Strupeit and Palm, 2016), customer-sited (Huijben and Verbong, 2013), and end-user owner (Frantzis *et al.*, 2008). We use the term ‘host-owned’ for consistency. In the host-owned model, the owner of the building where the PV system is installed is the main user of the energy produced. An overview of the host-owned concept is shown in Table 15.

Table 15: Host-owned Business Model Canvas

Customer side	
Value propositions	• Pre-fixed packages • Non pre-fixed packages • Possibility to install the system individually • Independence from utilities • Reduced energy bills • Competitive investment opportunity
Customer relationships	• Direct interactions, personal relationships • Word of mouth • Online contact forms
Customer segments	• Homeowners • Farmers • Small and medium-sized enterprises
Channels	• Sales representatives • Different personal channels e.g. solar walks • Company website
Revenue streams	• PV system installation • Maintenance • Reparation • Energy consulting • Sales of PV panels

Infrastructure side	
Key partners	• Producers of system components • Wholesalers of system components • Utilities • Banks
Key activities	• Turn-key solutions • Sales of PV panels • After-sales services • Customer support services • PV insurance service • Price bargaining • Supplier selection • Marketing activities
Key resources	• Human capital (e.g. expert staff) • Close knowledge of consumers • Close knowledge of local markets • Visibility of the company • Brand image
Cost structure	• Sales costs • Wages • Stock costs • Inventory holding and warehousing costs

Source: *Own table*

III.5.1.1. Customer side of the Canvas

III.5.1.1.1. Value Propositions

This section describes how companies create value for their target segments using the products and services offered. Firstly, these firms offer both pre-fixed, complex packages that contain specified elements (e.g. inverter, PV panels, cables) that cannot be modified by the customer, and non-pre-fixed packages. Non pre-set packages allow the customer to customize the system to fit their needs (Huijben and Verbong, 2013; Karakaya, Nuur and Hidalgo, 2016; Zhang, 2016). Installation is usually provided by the solar firms but some of them allow customers to arrange the installation of the system. Secondly, independence from utilities also appears in this part as customers become “prosumers” who produce their own energy and so reduce their energy bills (Sommerfeldt, Muyingo and Klintberg, 2016).

Customers can also benefit from feed-in tariffs (FiTs), which can be a significant factor in investment decisions. The rates of FiTs provide a level of return of investment (ROI) that is competitive with other investment opportunities (Couture *et al.*, 2010; Hashim and Ho, 2011; Solangi *et al.*, 2011). These tariffs can therefore greatly reduce investment risks and significantly promote the spread of renewables, so policy makers should carefully design and implement them (Couture *et al.*, 2010; Strupeit and Palm, 2016). Depending on the national regulations, residential customers may also enjoy tax benefits, get initial investment support or benefit from other special financial support programmes (Frantzis *et al.*, 2008; Nemzeti Fejlesztési Minisztérium, 2016; Zhang, 2016).

III.5.1.1.2. Customer Segments

This block defines the most important customer groups that solar PV companies aim to reach and serve via the host-owned model. The studies analysed provide only a few umbrella terms about the target groups, and no detailed sub-segments are specified. One of the main groups is households with a suitable roof and enough money to invest in DE technologies (Huijben and Verbong, 2013; Strupeit and Palm, 2016). The capacity of the installed system in the residential segment is up to approximately 10 kW_p (Dewald and Truffer, 2011). Members of this group can be characterized as early adopters who are motivated by energy independence and environmental benefits (Frantzis *et al.*, 2008). This segment usually includes pioneer customers like solar PV engineers and committed environmentalists (Zhang, 2016), but no other information is available about their lifestyles, social and family status, attitudes and further characteristics. Other customer segments for this model are farmers and small and medium-sized enterprises (Munasinghe, 1990; Strupeit and Palm, 2016).

III.5.1.1.3. Customer relationships

Customer acceptance and behavioural barriers to renewable energy technologies mean a significant challenge for DE companies. Customer relationships therefore play an essential role in building trust and long-term relationships. Many firms interact directly with customers by using personal channels (Huijben and Verbong, 2013). For instance, before creating a sales quote, a sales representative visits the customer’s house to assess the roof space, sunshine potential, and customer preferences (Huijben and Verbong, 2013; Karakaya, Nuur and Hidalgo, 2016). This section also covers online contact forms like corporate websites (Strupeit and Palm, 2016).

III.5.1.1.4. Channels

The identified channels are strongly related to customer relationships. The use of personal channels is a key area in trust-building and consumer engagement. Company sales representatives are the most essential channel elements as they make the first contact with customers (Huijben and Verbong, 2013; Karakaya, Nuur and Hidalgo, 2016). This initial interaction can determine the whole relationship with the firm and the choice of quotation. A good example of use of personal channels is Hartmann Energietechnik GmbH’s (HET) solar walks, which are held every month. During the walks, potential customers visit a number of reference houses with PV systems installed by HET (Karakaya, Nuur and Hidalgo, 2016). Another useful practice that could be followed by companies operating in the DE market, and which is an excellent pattern for multilevel marketing, is SolarCity’s Ambassador Program, where consumers can refer SolarCity to other people. If the recommended person purchases a PV system, the recommender can earn some money. Word-of-mouth communication also has a significant impact on consumers' investment decisions (Seel, Barbose and Wiser, 2014). The use of company websites and special PV magazines are also essential channels, allowing the firm to inform potential customers about their product and service portfolio (Strupeit and Palm, 2016).

III.5.1.1.5. Revenue streams

In the host-owned model, the major source of revenues comes from PV system installation. Smaller amounts of income are also available through complementary services such as maintenance and repairs (Schoettl and Lehmann-Ortega, 2011; Karakaya, Nuur and

Hidalgo, 2016; Strupeit and Palm, 2016). Companies can sometimes use their unique know-how through customized non-material value-added services such as energy consulting (Strupeit and Palm, 2016). Finally, on rare occasions, PV panels may be sold directly to end customers without any supplementary services (Frantzis *et al.*, 2008).

III.5.1.2. Infrastructure side of the Canvas

III. 5.1.2.1. Key partners

The most important key partners of solar PV companies are producers and wholesalers of system components such as inverters and solar panels. These partners usually support firms with technical, marketing and project-specific knowledge (Strupeit and Palm, 2016). It is essential to establish a stable relationship with them to ensure constant product supply and strengthen the bargaining position. Utilities also have a determinative role between the key partners as they provide permission to connect to the electrical grid. Many companies also liaise with banks offering financing services such as loans to their customers (Frantzis *et al.*, 2008; Strupeit and Palm, 2016).

III.5.1.2.2. Key activities

In line with the full-service approach, most of the companies operating in the DE market offer turn-key product solutions. This means that they design the system, arrange the permits, order the components, install the system, monitor its performance and if necessary, carry out repairs and maintenance (Schoettl and Lehmann-Ortega, 2011; Karakaya, Nuur and Hidalgo, 2016; Strupeit and Palm, 2016). Some companies also sell PV panels or offer separate after-sales services such as system performance monitoring and repairs. These firms also generally provide advice on financing, support and incentive systems, taxation, and renewable energy solutions. Customer support services have also been identified between the key activities (Frantzis *et al.*, 2008; Huijben and Verbong, 2013; Strupeit and Palm, 2016). Some market actors offer PV insurance services, reducing the investment risk and increasing customers' sense of security (Huijben and Verbong, 2013). Price bargaining and selection of suppliers are also included in this section, as PV companies procure solar system components from several producers and wholesalers (Huijben and Verbong, 2013; Strupeit and Palm, 2016). Finally, firms often use different marketing activities to increase the company's reputation and strengthen customer relationships (Frantzis *et al.*, 2008).

III.5.1.2.3. Key resources

Technical knowledge, expert staff and personal know-how are indispensable for DE companies (Huijben and Verbong, 2013; Strupeit and Palm, 2016). Firms' human capital therefore plays an important role in competitiveness and future prospects. Secondly, close knowledge of consumers and local markets, usually based on geographical proximity, is an essential resource, particularly for local companies who are in daily contact with customers and have a deeper insight into their lifestyles and preferences (Karakaya, Nuur and Hidalgo, 2016; Strupeit and Palm, 2016). Company visibility, achieved through marketing and social activities, may have a strong influence on consumer interest (Karakaya, Nuur and Hidalgo, 2016). These factors significantly contribute to brand-image building (Frantzis *et al.*, 2008).

III.5.1.2.4. Cost structure

The papers analysed did not generally provide company-side costs, but certain conclusions can be drawn based on the other parts of the Business Model Canvas. Firstly, sales representatives play an important role in customer relationships and expert staff are indispensable for efficient operations. Sales costs and wages are therefore likely to be substantial elements of general expenses. Secondly, marketing expenditure related to partnership and brand image building could also constitute a significant proportion. Stock costs such as PV system components (e.g. inverters, panels, and holding devices.), inventory-holding and warehousing costs are also likely to be significant.

III.5.2. Third-party-owned Business Model Canvas

This type of business model was given several names in the literature, including Third-party (Kollins, Speer and Cory, 2010), Third-parties (Brunekreeft, Buchmann and Meyer, 2016), Third-party owner (Frantzis *et al.*, 2008), Third-party ownership (Kollins, 2008; Bolinger, 2009; Coughlin and Cory, 2009; NREL, 2009b; Ardani and Margolis, 2010; Kollins, Speer and Cory, 2010; Hobbs and Pierpont, 2013; Corfee *et al.*, 2014; Overholm, 2015; Berger, 2016; Strupeit and Palm, 2016; Zhang, 2016), Third-party-owned (Davidson and Steinberg, 2013; Davidson, Steinberg and Margolis, 2015), Third party PV (Huijben and Verbong, 2013), Solar City model (Zhang, 2016), Third-party financing (Thumann and Woodroof, 2008; Feldman, Friedman and Margolis, 2013; Zhang, 2016), Solar services model (Eley, 2016), and Solar energy management service model (solar EMS model) (Zhang, 2016). For consistency, we use third-party-owned.

Third-party-owned business models first emerged in the United States in 2005 (Överholm, 2013), and a variety of TPO models can now be observed in many countries e.g. in the Netherlands, Denmark, China, Germany (Huijben and Verbong, 2013; Brunekreeft, Buchmann and Meyer, 2016; Strupeit and Palm, 2016; Zhang, 2016). In the United States, Sun Edison and MMA Renewable Ventures were among the first companies to apply this model, followed by many other developers (Kollins, 2008). These solar service firms usually offer Power Purchase Agreement (PPA) or lease constructions. The history of PPAs goes back much further than the TPO model, because it was originally used by utilities to buy energy from each other. The Public Utility Regulatory Policies Act (PURPA) of 1978 obliged utilities to purchase all their power from qualifying facilities. Utilities and independent generators (qualifying facilities) used PPAs for these transactions (Kollins, 2008; Kollins, Speer and Cory, 2010).

The TPO model eliminates several financial barriers such as high up-front costs for residential customers. Thanks to the many benefits provided by the model, the concept started to spread rapidly. In 2014, 72% of the residential solar systems in the United States were sold under PPA or lease constructions. However, by 2015, this rate began to decline and GTM Research predicts that by 2020, direct ownership will surpass third-party ownership in the US residential PV market (GTM Research, 2015). This downturn can be traced back to three reasons: (1) availability of many types of loan facilities, (2) lack of suppliers for the TPO model, and (3) SolarCity’s move away from this model (Mond, 2017).

This section describes the most important features common to TPO models. The Business Model Canvas can be seen in Table 16.

Table 16: Third-party-owned Business Model Canvas

Customer side	
Value propositions	• No up-front costs • Immediate energy savings • Green energy at a very competitive price • Predictable cost of electricity • Removal of maintenance tasks • Reduced technology risks • Possibility to install the system individually
Customer relationships	• Long term relationships • Personal contacts • Online contact forms
Customer segments	• Households • Farmers • Companies • Public organisations • Institutional and private investors
Channels	• Sales representatives • Conferences and events • Online and printed marketing tools • Active media relations • Company website
Revenue streams	• Power Purchase Agreements • Solar lease • State and federal incentives • Subsidies, incentives from the government • Development, monitoring and other service fees

Infrastructure side	
Key partners	• Banks, large corporations • Utilities • Producers and wholesalers of PV components • Consultants • Law firms • Insurance companies • Installation and maintenance companies
Key activities	• Provide lease or PPA • Fund management • Turn-key solutions • Operation, maintenance • Active marketing activities
Key resources	• Existing customer base • Project management software • Well-trained employees
Cost structure	• PPA and lease management costs (labour and IT) • Acquiring investors • Sales costs • Marketing costs • Stock and warehousing costs

Source: *Own table*

III.5.2.1. Customer side of the Canvas

III.5.2.1.1. Value Propositions

The financial and profitability barriers identified that high initial costs of PV systems can strongly influence demand. The biggest benefit of the TPO model is therefore that customers can use green energy without paying the upfront costs (Zhang, 2016). Electricity bill savings can be expected from the first month and customers do not have to worry about the long pay-back period (Hobbs and Pierpont, 2013). In the third-party-owned model, host customers receive a green energy supply at a very competitive price, much lower than the normal electricity price (Drury *et al.*, 2012; Zhang, 2016). The cost of electricity becomes predictable for the duration of the contract (up to 25 years), and the financing construction allows customers to avoid unpredictable price fluctuations from utility rates (NREL, 2009a; Strupeit and Palm, 2016). Strupeit and Palm (2016) also emphasized that solar service firms can provide additional benefits to consumers as they are able to handle the high transaction cost linked with the complex regulatory and policy systems.

PPA contracts place the operation and maintenance responsibility on the solar service firm and not the customer (Thumann and Woodroof, 2008; Coughlin and Cory, 2009; Ardani and Margolis, 2010; Eley, 2016). For lease agreements, the host is responsible for the upkeep but solar lease companies usually offer maintenance packages and performance guarantees, reducing the number of tasks and the risks for the customer (Kollins, Speer and Cory, 2010). Customers may also be able to install the system themselves (Huijben and Verbong, 2013).

III.5.2.1.2. Customer relationships

In the third-party-owned business model, solar service firms build long-term relationships with their customers through PPA and lease contracts. It is therefore essential to build personal contacts and strengthen relationships with the hosts through multiple channels e.g. social activities, sales representatives, customer exhibitions, and enhanced customer service (Strupeit and Palm, 2016). Use of online contact forms is also common (Huijben and Verbong, 2013).

III.5.2.1.3. Customer segments

In the TPO model, the most important customer segment is households who cannot afford to pay the high up-front costs but would like to reduce their electricity bills and protect the environment (Huijben and Verbong, 2013; Strupeit and Palm, 2016; Zhang, 2016). According to Drury *et al.* (2012), third-party-owned constructions are attractive to younger, unqualified people who are less prosperous. Other customer segments are farmers, public organisations and companies (Drury *et al.*, 2012; Huijben and Verbong, 2013; Strupeit and Palm, 2016). Solar service firms also target public and private investors who become the technical owners of the PV systems and also benefit from PPA payments and government subsidies (Frantzis *et al.*, 2008).

III.5.2.1.4. Channels

Like the host-owned model, company sales representatives are the most important channel components in TPO business models. Solar service firms use sales representatives to inform potential customers about the benefits of third-party solutions and strengthen relationships. Solar service firms often attend conferences and events (e.g. energy industry conferences, and exhibitions for consumers), and they can broaden their network by doing so. A variety of marketing tools (both printed and online) and active media relations are usually common across channels (Frantzis *et al.*, 2008). Company websites are also used to highlight attributes of products or services and to present forms of financing (Huijben and Verbong, 2013).

III.5.2.1.5. Revenue Streams

The majority of the revenue is derived from PPA or solar lease solutions. Under a PPA contract, the host customer pays a bill calculated on the basis of generation per kWh (e.g. $/kWh) (Feldman, Friedman and Margolis, 2013; Davidson, Steinberg and Margolis, 2015; Eley, 2016; Zhang, 2016). The duration of PPAs can vary from company to company, but they are generally valid for a 10–25 year period (Frantzis *et al.*, 2008; Kollins, Speer and Cory, 2010; Feldman, Friedman and Margolis, 2013). After the expiry date, the customer can choose from three options: buying the PV system, renewing the agreement or letting the PPA provider remove the system (Kollins, Speer and Cory, 2010; Corfee *et al.*, 2014). With a solar lease, the customer does not pay for the energy produced but leases the equipment and uses the energy generated by the PV system. This means monthly rental payments (e.g. $/month) (Huijben and Verbong, 2013; Davidson, Steinberg and Margolis, 2015; Strupeit and Palm, 2016). The leasing solution is usually predominant in states in the US where PPAs are not permitted (Ardani and Margolis, 2010).

Solar service firms' other sources of income may include subsidies from the government, state and federal incentives, and incentives offered by municipalities and local utilities (Davidson and Steinberg, 2013; Hobbs and Pierpont, 2013; Sherwood, 2014). System owners can benefit from federal tax incentives—which tax-exempt units cannot—such as investment tax credit (ITC) and accelerated depreciation (Bolinger, 2009; NREL, 2009b; Berger, 2016). The ITC allows 30% of the total investment amount of PV systems to appear as a tax credit, while accelerated depreciation allows a complete depreciation during the first five years of the operation of the projects by offsetting income tax (NREL, 2009b; Corfee *et al.*, 2014). In those states in the US where the Renewable Portfolio Standard (RPS) is in force, which requires increased production of energy from renewable energy sources, solar service firms can generate additional revenue from the sale of Renewable Energy Certificates (Hurlbut, McLaren and Gelman, 2013). Last but not least, depending on the range of activities, development, monitoring and other service fees may also form part of revenue streams (Huijben and Verbong, 2013; Zhang, 2016).

III.5.2.2. Infrastructure side of the canvas

III.5.2.2.1. Key partners

Banks and other large corporations may contribute to financing project funds, by subsidizing the solar service providers' PPA and lease business models. They play a decisive role between the key partners (Frantzis *et al.*, 2008; Zhang, 2016). Like the host-owned model, relations with utilities, producers and wholesalers of PV components are also important under TPO models. Additional partners may include consultants, law firms, insurers, installers and maintenance companies (Overholm, 2015; Strupeit and Palm, 2016).

III.5.2.2.2. Key activities

There is considerable variation in key activities in the TPO model category, but several are usually common for solar service companies. The most essential key activities are lease and PPA provision (Davidson, Steinberg and Margolis, 2015; Strupeit and Palm, 2016; Zhang, 2016). Companies that offer solar leases usually arrange financing by collecting several PV projects into a fund and selling this to investors. This requires fund management functions from the service firm to manage these processes (Hobbs and Pierpont, 2013). Secondly, many companies offer turn-key solutions in the TPO model as well as the host-owned model. This implies that under the full-service concept, solar service firms install the PV systems, take the necessary permits, contact utilities to arrange interconnections and complete any applications for tax breaks and incentives (Coughlin and Cory, 2009; NREL, 2009a). In the US, these companies also usually sell Renewable Energy Certificates in several states (Hurlbut, McLaren and Gelman, 2013).

Companies often offer additional services such as performance monitoring, maintenance, and repairs (Drury *et al.*, 2012; Huijben and Verbong, 2013; Zhang, 2016). Active marketing activities are also observed, because many companies use a variety of media and other complementary channels (Frantzis *et al.*, 2008).

III.5.2.2.3. Key resources

In the third-party-owned business model, the existing customer base plays a crucial role as a key resource that allows the companies to become even better known, broadening their network. The TPO model is associated with complex project management tasks, so it is essential for solar service firms to possess software for sales, project management, and system monitoring (Strupeit and Palm, 2016). Well-trained employees with appropriate financial and technological expertise to operate this complex business model are also essential (Frantzis *et al.*, 2008; Huijben and Verbong, 2013).

III.5.2.2.4. Cost structure

Like the host-owned model, few papers listed the main costs of this model, but we can draw some inferences from other parts of the Business Model Canvas. Firstly, the majority of the expenses are likely to be related to PPA and lease construction management, including the acquisition of public and private investors through labour and IT costs. There are significant differences between the TPO and host-owned models, but some expenditure is likely to be the same, including sales, marketing, stock (components of PV systems e.g. panels, inverters) and warehousing costs.

III.5.3. Community-shared Business Model Canvas

There were a number of terms used for this category in the papers, including Shared solar (Feldman *et al.*, 2015), Community solar (Asmus, 2008; Huijben and Verbong, 2013; Konkle, 2013; Chwastyk and Sterling, 2015; Funkhouser *et al.*, 2015; Deloitte, 2016; ICF Incorporated LLC, 2016), Community-shared (Augustine, 2015; Augustine and McGavisk, 2016; Zhang, 2016), and Community-owned model (Monica Oliphant Research, 2012). We use the term 'community-shared'.

Community-shared business models are still in the early stages of development, and there were few dedicated studies. The information about this category was therefore scattered through the related literature. We have tried to provide an overall picture of the model, in the hope that this will contribute to understanding the differences between this and the host-owned and third-party-owned models.

In the United States, the first community-shared projects were completed in 2006, to enable consumers to access energy produced by the systems in solar parks or solar gardens, without installing their own photovoltaic panels (Chwastyk and Sterling, 2015). The business model can be operated and administered by several different organizations, including utilities, non-profit organizations, and solar project developers (Feldman *et al.*, 2015; Funkhouser *et al.*, 2015; Augustine and McGavisk, 2016). Customers can subscribe to these projects and own PV panels in solar farms or gardens. For community members, the CS model therefore provides a cost-effective alternative enabling them to use renewable energy through virtual net-metering. The development of information and communication technologies allows the idea to spread, and knowledge mechanisms within the operator companies can strongly determine their ability to renew the firms' value proposition and collaborate with others (Hortoványi and Ferincz, 2015).

The community-shared business model is an attractive opportunity for utilities, enabling them to realize economies of scale through larger projects (Feldman *et al.*, 2015). This type of project therefore allows utilities to innovate their business models and could also mean the introduction of a new sales channel through which they can sell additional services (Deloitte, 2016). Utilities may also be able to increase customer engagement and satisfaction (Augustine and McGavisk, 2016). Augustine (Augustine, 2015) emphasized these possibilities and drew attention to potential challenges such as poor project economics. In regions where the electricity rates are low, a CS project may not be sufficiently profitable. Before starting a new CS program, utilities therefore have to make detailed returns calculations.

An overview of the CS concept is in Table 17.

Table 17: Community-shared Business Model Canvas

Customer side	
Value propositions	• Use of green energy without hosting the PV system • Reduced electricity bill • Decreased financial barriers and costs • Flexibility
Customer relationships	• Personal relationships • Online contact forms
Customer segments	• Residential customers • Businesses • Non-profit organizations • Institutional consumers (e.g. universities, military)

Channels	• Conferences, meetings • Sales representatives • Websites
Revenue streams	• Sale of solar bonds • Tax benefits and state incentives
Infrastructure side	
Key partners	• Utilities • Subcontractors (e.g. construction company) • Producers and wholesalers
Key activities	• Subscriber management • Installation • System purchase • System operation and maintenance
Key resources	• Existing customer base • IT infrastructure • Workforce (incl. sales representatives)
Cost structure	• Initial infrastructure development • Operation and maintenance • Labour and IT costs

***Source:** Own table*

III.5.3.1. Customer side of the Business Model Canvas

III.5.3.1.1. Value propositions

Many residents are not able to host a PV system on their own roof because of three main obstacles. They may not be the owners of the building (e.g. tenants), they may live in a condominium or there may be insufficient roof space or no suitable space (e.g. shaded or old roof) to install a system. Many people worry about system performance and efficiency, or simply do not want to install a PV system on their own roof (Feldman *et al.*, 2015; ICF Incorporated LLC, 2016). In the United States, there may be other barriers to buying or leasing a private solar system, for example, that residential customers do not have a creditworthy FICO score and / or live in a state without a net energy metering policy. GTM Research therefore estimates that 77% of US households cannot install their own solar system, so could be potential customers for CS projects (Honeyman, 2015).

The community-shared model enables customers to use green energy without hosting the system through virtual net-metering, reducing their electricity bills (Center for Sustainable Energy, 2015). CS model subscribers receive a credit on their energy bills corresponding to their interest in the PV system's power generation (Augustine and McGavisk, 2016). CS also decreases the financial barriers and reduces PV system costs for customers because of group purchasing (Zhang, 2016). The contract subscriptions usually last from five to 20 years. This model therefore offers an attractive long-term saving option with low risk. Flexibility is also an essential part of the model. If consumers sell their house, they have two optional opportunities. They could sell the subscription, either with the property or separately (Monica Oliphant Research, 2012). If they do not want to sell their bonds, and they move within the service territory, the solar credits can follow them (Coughlin *et al.*, 2012). This business model also contributes to customer commitment to renewable energy sources.

III.5.3.1.2. Customer relationships

As with host-owned and third-party owned models, forming and maintaining personal relationships are essential to the successful operation of this business model. Solar service providers make long-term contracts with customers (up to 20 years), so need to make contact in various ways, such as customer exhibitions, community events and meetings as well as online channels to increase confidence and commitment (Huijben and Verbong, 2013; Konkle, 2013). Research about community-shared business models is rare, but it seems likely that firms will expand their client network by employing sales representatives.

III.5.3.1.3. Customer segments

Depending on the regulatory framework, several consumer groups may be included in the customer segments for this model. One of the main groups is residential customers facing the obstacles described in the value propositions section (e.g. renters). Businesses, commercial companies who lease their buildings, and non-profit organizations e.g. religious organizations, are also targeted by solar owners and developers (Asmus, 2008; Monica Oliphant Research, 2012; Zhang, 2016). Additional subscriber groups include institutional consumers such as local governments, universities and the military (Monica Oliphant Research, 2012; Feldman *et al.*, 2015; Zhang, 2016).

III.5.3.1.4. Channels

Community-shared business models are in an early phase of development, so continuous learning and sharing of information play an essential function in determining the deployment of these constructions. Project operators may arrange conferences, meetings, educational programmes, house parties, and community events and also use websites to share their knowledge among consumers and potential investors (Huijben and Verbong, 2013; Konkle, 2013). Sales representatives of solar service providers may also provide much of the foundation for corporate success (Konkle, 2013).

III.5.3.1.5. Revenue Streams

The CS model provides two basic forms of revenue from consumers. Firstly, customers can purchase a portion of the power produced by the solar parks or gardens, so most of the owners' revenue is derived from the sale of solar bonds (Monica Oliphant Research, 2012). The price of the shares is generally adjusted to fit government-imposed tax rates (Huijben and Verbong, 2013). Secondly, customers can pay an upfront fee to defray all the costs of the project. Some projects use a combination of the two payment options (Chwastyk and Sterling, 2015).

Depending on the regulatory framework, solar project operators in the US can also benefit from federal tax benefits and state incentives. Federal tax incentives are available for individually-owned residential system installations or for commercially-owned projects. However, community-owned systems do not fit into either of these two categories, which generates challenges in designing these projects (Coughlin *et al.*, 2012). Augustine (2015) also noted this when examining the possibilities of CS projects for public utilities and pointed out that municipalities and regulated utilities tend not to have a tax liability. When a utility wants to take advantage of tax incentives, therefore, including the renewable energy investment tax credit and accelerated depreciation, it usually has to contract with a third party entitled to receive the tax benefits (Augustine, 2015). To use federal tax reliefs in full, the entity that owns and operates the infrastructure needs to have an adequate number of community subscribers (Coughlin *et al.*, 2012).

III.5.3.2. Infrastructure side of the Business Model Canvas

III.5.3.2.1. Key partners

Firstly, the subscribers must be customers of the local utility in which the solar farm is located. Secondly, by applying virtual net-metering in CS projects, the amount of generated electricity must be synchronized with utilities' billing systems to adjust the customers' accounts suitably (Coughlin *et al.*, 2012). Solar project operators therefore need to develop close relationship with utilities. If the service providers also arrange the construction of the infrastructure, they must collaborate with additional partners such as subcontractors, producers and wholesalers (Konkle, 2013).

III.5.3.2.2. Key activities

Solar farm or solar garden owners offer different subscription options (purchasing or leasing panels, investing in systems, buying energy or capacity), so their main activity is subscriber management (Augustine, 2015; Augustine and McGavisk, 2016; Zhang, 2016). This process involves signing up customers and liaising with them. Further tasks will include consumer protection, data reporting and regulatory compliance (Chan *et al.*, 2017).

The infrastructure is usually installed by these companies, but in some cases they just take over the finished PV systems. This model places operational and maintenance responsibility on the service provider (Monica Oliphant Research, 2012).

III.5.3.2.3. Key resources

Like the third-party-owned model, the existing customer base is an essential key resource in CS models, as it enables companies to gain more clients and may lead to further investments. To manage community projects successfully, and synchronize data with utilities' systems, service providers must possess adequate IT infrastructure (Coughlin *et al.*, 2012), including suitable software solutions to monitor energy generated in real-time and manage subscriber contracts (Augustine, 2015). Another indispensable element is the workforce, including sales representatives, who contribute to network expansion and the management of complexity (Konkle, 2013).

III.5.3.2.4. Cost structure

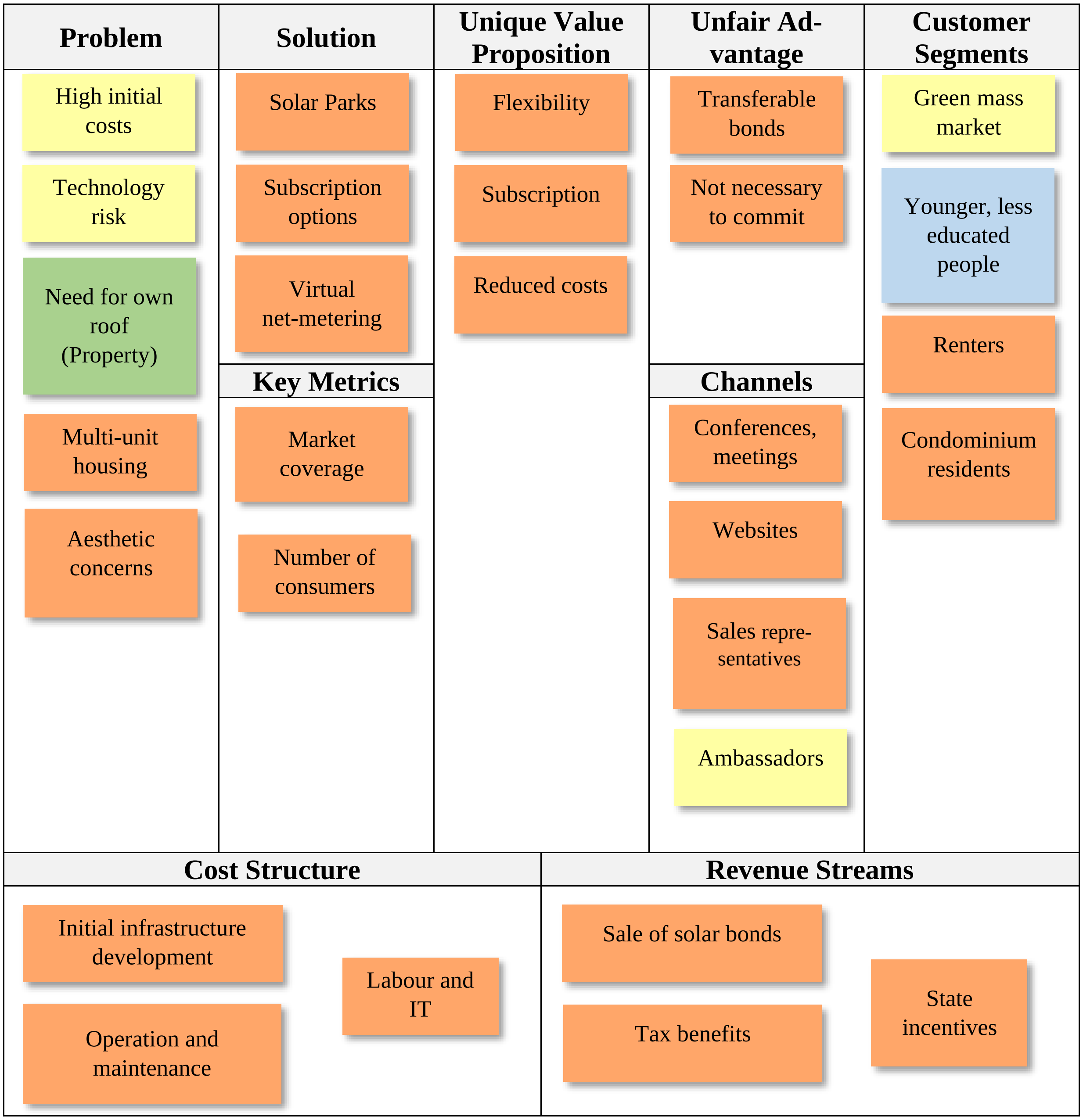
The papers included no detailed information about the CS model's cost structure, but we can draw some conclusions from the other sections, as with the previous models.

Firstly, if the initial installation investments are not funded by the community, the development of the infrastructure will have considerable costs. There are a number of examples where future subscribers pay the up-front costs, such as Briston Energy Solar (BES). BES sold shares (between £250 and £20,000) to individuals to raise money for the project. The initiative was so successful that the required amount was collected within three weeks, with 103 non-corporate contributors (Monica Oliphant Research, 2012). Secondly, a significant part of the costs are probably related to PV system operation and maintenance tasks. Subscriber management costs such as labour and IT costs are also likely to feature, because this is an essential activity of service providers. IT costs therefore play an essential role because of the management tasks, but also because of the complex software needed to harmonise the utilities' billing system with the amount of energy produced.

III.6. Synthesizing business models by applying the Lean Canvas

We used the Lean Canvas framework to identify the major differences between the three models, highlight the main reasons behind the appearance of the community-shared business model, describe its benefits in comparison with the other models and identify the problems it addresses (Figure 7).

Figure 7: Business Model Synthesis and Development in order to overcome the inhibiting factors of DE deployment (Lean Canvas)



Colour legend: yellow: Host-owned, green: Third-party-owned, blue: Host-owned and Third-party-owned, orange: Community-shared model.

Source: *Own figure*

The LC is filled in a particular order: 1. Customer segments, 2. Problem, 3. Unique Value Proposition, 4. Solution, 5. Channels, 6. Revenue Streams, 7. Cost structure, 8. Key metrics, and 9. Unfair advantage. We used yellow for the host-owned model, green for the third-party-owned model and blue for both. Contributions from the CS model are shown in orange.

Firstly, customer segments must be determined for each model to assess which groups may be attracted by the community-shared model. The main segment in the host-owned solution is the so-called “green mass market”, containing early adopters with a high level of income. In the TPO model, younger, unqualified and less affluent people are the major target groups. The community-shared model may also be attractive to early adopters and less prosperous people, since the former are usually the first users of new, innovative solutions and the latter cannot afford to pay the high initial investment costs.

Secondly, identifying the main problems of the host-owned and third-party models creates the initial phase of the analysis and can lead to appropriate solutions. The high upfront cost of the investments and a degree of technological risk are the major barriers for potential consumers of the host-owned model. Consumers also need to own a building with sufficient roof space for both the host-owned and third-party-owned models. However, many clients of solar providers do not own a property or have a suitable roof, because they are renters or live in a multi-unit house. Concerns about aesthetic issues may also be a problem.

The unique value proposition’s function is to capture customers’ attention. In the CS model, the most compelling factors are flexibility, subscription opportunities and reduced costs. As consumers do not have to pay the high upfront costs, and agreements are easily terminable or modifiable, the value is organized around these aspects.

The fourth step is to outline responses to the problems highlighted that are provided by the community-owned model. Through virtual net-metering, the CS model allows consumers to subscribe to a specified number of panels or a portion of the energy generated in solar parks. Clients receive credits on their utility bills. The solution therefore significantly reduces the barriers and provides several concessions to customers.

The fifth step is to examine the channels specified in the BMC. A solar ambassador program (from the host-owned model) could also be used successfully in community-shared business model solutions, attracting more consumers. The revenue streams and cost structures are not described here, because they were fully covered in previous sections.

Key metrics require companies to define actionable metrics, which should be organized around the value. In the initial stages, less complex indicators such as market coverage, or number of consumers, may be sufficient to lead to the fundamental engines of growth.

Finally, unfair advantage, also known as competitive advantage, describes barriers to entry for others. Unlike the host-owned and third-party-owned models, CS model customers are not required to make a firm commitment, because the model offers significant flexibility via transferable solar bonds.

III.7. Overcoming the identified barriers

This section provides some examples from the papers reviewed of how and to what extent the different PV business models help to overcome the barriers identified. In Table 18, one star is shown if the business model can partially help, and two if it can provide significant help in overcoming the barrier group. Where no star is shown, the model cannot help to overcome that barrier group.

Table 18: Possible barrier elimination opportunities

Main barriers	Host-owned	Third-party-owned	Community-shared
Financial and profitability barriers		*	**
Awareness and behavioural barriers		*	**
Regulative and institutional barriers			
Technological barriers		*	**
Company resource barriers			

Source: *Own table*

None of the models help to address company resource barriers, because they do not affect management skills. Instead, specific management tools and business model solutions are needed. However, the alternative models address several of the issues and barriers in the other groups.

Third-party-owned and community-shared models mean consumers do not have to meet high upfront costs, significantly reducing financial and profitability barriers. In the CS model, solar bonds can be transferable, offering more financial flexibility. In the United States, customers need a creditworthy FICO score to buy or lease a solar system, but the CS model allows them to use solar energy without such a FICO score. Overall, both the TPO and CS models can significantly reduce financial barriers, but the CS model provides more opportunities to do so.

TPO and CS actors often take on an active role in education and disseminating information, reducing awareness problems. The possession of information results in a lower risk perception and allows customers to identify the potential benefits of the different business models and the use of renewable energy sources. Karakaya, Hidalgo and Nuur (2015), drawing on

Rogers (2003), also emphasized that active communication and the activities of change agents can greatly increase the adoption of new technologies including PV systems. Work by Rai, Reeves and Margolis (2016) also confirmed this for the decision-making process of residential PV customers. Members of the community, especially in the CS model, also contribute to the reduction of acceptance difficulties because they assume a key role in knowledge transfer. The strength of the community can be exploited not only in the community-shared model, but also others, as shown by SolarCity's ambassador program.

Regulatory and institutional barriers can only be slightly overcome with the help of the existing business models. A variety of external factors may influence regulatory requirements. However, in states and regions without a net energy metering policy, the CS model may help consumers to use solar energy.

In Power Purchase Agreements (the TPO model) and community-shared projects, companies take responsibility for maintenance, reducing the technological barriers for customers. In solar leasing (the TPO model), the operating company does not always assume responsibility for maintenance, so the CS model will provide a higher degree of barrier elimination potential. The transferred responsibility means that customers do not have to worry about the risk of poor system performance.

III.8. Summary and conclusions of the research aiming to explore photovoltaic business models

We have used a literature review to highlight the most common barriers hindering the deployment of renewable energy technologies, and also identified the basic PV business models. Using Osterwalder and Pigneur's (2010) business model definition, we summarized each business model's most important value propositions, value creation, delivery and capture mechanisms in Table 19. Reduced energy bills are common to all three models, but the degree of savings may be different for each. Determining whether the investment is better under the host-owned or the TPO model very much depends on the financing solution and the amount of support available.

Table 19: Value creation, delivery and capture of PV business models

Value	Host-owned	Third-party-owned	Community-shared
Proposition	Turn-key solutions Independence from utilities Feed-in tariffs (Negative: high up-front costs) Reduced energy bills	Lower and predictable electricity price No up-front costs	Use of green energy without hosting the PV system Decreased financial barriers and costs Flexibility
	Reduced energy bills		
		No operational and maintenance responsibility[2]	
Creation	Maintenance PV insurance Energy consulting	Lease and PPA provision Fund management Performance monitoring, maintenance, and repairs	Subscriber management Program management incl. customer protection, data reporting, regulatory compliance Installation System purchase System operation and maintenance
	PV system installation		
Delivery	Solar walks Multi-level marketing Word-of-mouth marketing	Online and printed marketing tools Active media relations	Educational programmes House parties Community events
	Sales force Websites		
		Conferences, events, meetings	
Capture	Selling turn-key solutions (margin)	Power Purchase Agreements or solar lease solution fees (margin) Subsidies from the government, state and federal incentives, and incentives offered by municipalities and local utilities	Sale of solar bonds Upfront payments State incentives Tax incentives incl. renewable-energy investment tax credit and accelerated depreciation

Source: *Own table*

[2] For the TPO model, this applies to PPAs.

Overall, it can be seen that the greatest benefits can be identified for the community-owned model. The biggest advantage of the CS model is the possible economies of scale. It also allows companies to use the latest technology solutions and take into account the territorial conditions to designate the most optimal solar installation areas with the highest potential efficiency and energy output (exploiting location benefits).

We also outlined how and to what extent the different business models can help eliminate the identified barriers. The literature review showed that the spread of renewables can be significantly restricted by regulatory and institutional issues, and the identified business models provide only a limited response to these problems. Policy-makers therefore need to develop comprehensive regulatory and incentive schemes that provide multiple options to foster the spread of renewable energy sources. Financing mechanisms and innovative business models that fit local or regional circumstances could significantly increase the use of renewables.

Despite this, the community-owned model is a good opportunity for utilities to innovate their business model and increase their competitiveness. They will, however, have to take into account a number of factors during the development of CS projects. Successful implementation will require utilities to review their strategic assets and key competences (Wüstenhagen and Wuebker, 2011). They will have to invest in high productivity and high absorptive capacity to gain sustainable competitive advantage (Hortoványi, 2016). To take advantage of tax incentives, they will need to build strong and lasting partnerships with third parties who are entitled to these tax benefits. Overall, however, the community-owned model can generate significant benefits in many areas, and trends such as increasing digitization and the rise of the sharing economy are also expected to support the further development of this model (Heinrichs, 2013; Bleicher and Stanley, 2016).

III.9. Future research directions in the field of photovoltaic business models

Reduction of barriers would justify the wider diffusion of TPO and CS models, but these solutions have not yet been adopted in many countries. It may therefore be worth examining the reasons for this on a national basis. There are few studies on the community-shared model, implying a lower knowledge base. Future research in this field could close this gap and help regions and countries with easier business model adoption. The Lean Canvas summary in this review may serve as a starting point for prospective studies that accentuate the differences between the three models and help to identify and create new models. To simplify the adoption process, the investor side of PV businesses could also be examined using the Business Model Canvas and the Lean Canvas.

IV. Examination of the effect of the fintech phenomenon on traditional commercial banks

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Abstract

Innovative financial technologies bring radical changes in financial services. Customer expectations, growing demand for digital channels and new types of players in the financial sector are also pushing traditional retail banks to act. The current study explores through 13 in-depth interviews that how the different actors in the financial sector interpret the concept of FinTech and its expected impact on the operation and business model of traditional commercial banks. In addition, some regulatory challenges are identified that may hinder the innovative developments of banks and FinTech companies.

Keywords: fintech, bigtech, startup, digital transformation, innovation

IV.1. Introduction of the research in the financial sector

Nowadays, innovative digital solutions are increasingly present in the field of financial services. FinTech (Financial Technology) companies offer personalized, user-friendly financial solutions that significantly make everyday life easier for customers (Lee and Kim, 2015). However, there is no uniformly agreed definition of the interpretation of the FinTech concept, and in many cases, the approaches differ significantly. In addition to the opportunities offered by financial technologies, there are a number of risks involved. For example, cybersecurity is a major challenge, and in order to maintain and develop it, it is essential to establish cooperation between the various actors across geographical markets (Nuyens, 2019).

In parallel with the emergence of innovative FinTech solutions, in recent years many traditional commercial banks have recognized that they need to be open to digital financial services in order to remain competitive, and have also made significant improvements to their internal processes (Alt and Puschmann, 2012; Bara and Mudzingiri, 2016). Accordingly, traditional banks use different strategies to channel new solutions. However, in addition to the emergence of FinTech companies (e.g. startups), BigTech companies are playing an increasingly dominant role, with a huge customer base on the one hand, and an advantage in the field of technological developments on the other (Bank for International Settlements, 2019). The question therefore arises as to how the business model of traditional commercial banks will change in the future and to what extent they will be threatened by technology companies such as Apple or Amazon.

The purpose of this article is to explore, through in-depth interviews, how financial sector actors interpret the concept of FinTech and to examine how the phenomenon and related changes are expected to affect traditional commercial banks. In connection with the interpretation of the FinTech concept, an own FinTech definition is also defined. In addition, some regulatory challenges are identified that may be obstacles during innovative developments for both banks and FinTech companies. In order to answer the questions, 13 in-depth interviews were conducted. There is still very little research available in the field, so this article is expected to provide interesting results for both theoretical and practical professionals.

IV.2. Literature background of the research in the financial sector

IV.2.1. FinTech and the transformation of the banking sector

FinTech (Financial Technology) refers to financial innovations made possible by technology that can have a significant impact on financial markets and the provision of financial services (Kawai, 2016). According Kim *et al.* (2016), FinTech is a service sector that uses mobile-centric IT technologies to increase the efficiency of the financial system. FinTech companies primarily aim to provide consumers with products and services that are more user-friendly and efficient than the solutions currently available on the market (Dorfleitner *et al.*, 2017). With new digital technologies, a wide range of financial activities can be automated, enabling the development of new and more cost-effective solutions from lending, asset management and portfolio advice to payment systems (Vives, 2017). (For a more detailed overview of FinTech definitions, see: Horváth, 2019.)

The origin of the term FinTech can be traced back to a project called "Financial Services Technology Consortium" initiated by Citigroup in the 1990s. The aim of the project was to support the development of innovative solutions by strengthening cooperation between financial sector actors (Arner, Barberis and Buckley, 2015). However, according Arner, Barberis and Buckley (2017) the development of FinTech began about 150 years ago and the history of development can be divided into different stages. A brief description of each stage is shown in Table 20.

Table 20: The evolution of FinTech

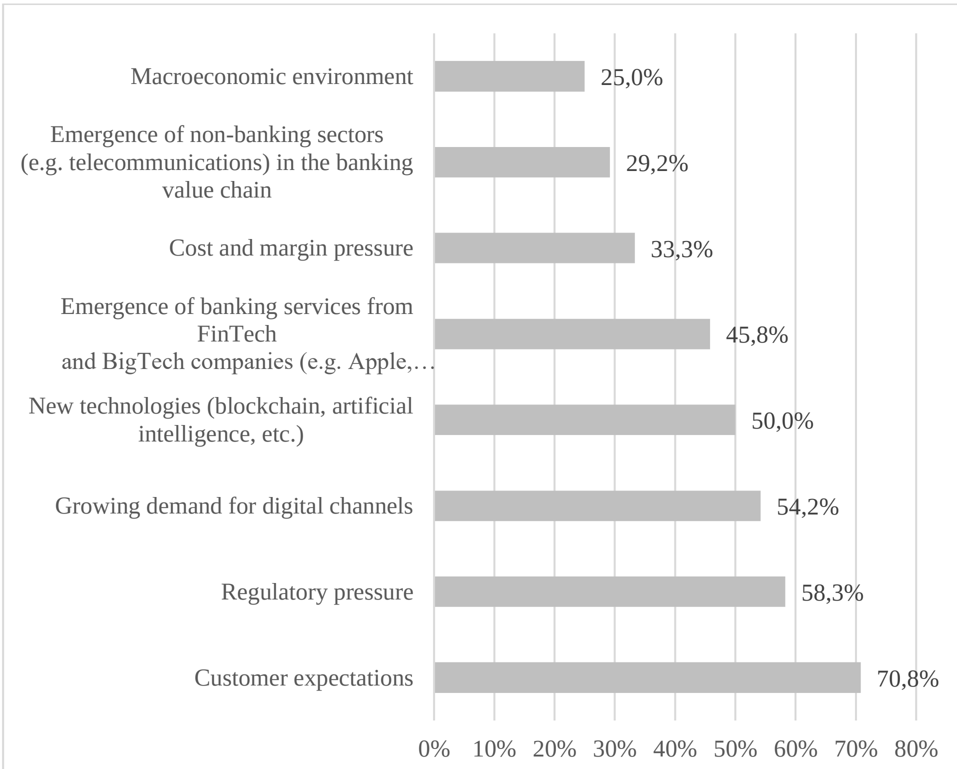
Range	Era	Short description
1866–1967	FinTech 1.0: Infrastructure	The laying of the transatlantic cable in 1866 was a huge milestone in the development of infrastructure that laid the foundations for financial globalization. Technologies such as telegraphy, as well as rail and steamboats in transport, have also made a significant contribution to cross-border financial relations. The codes used in World War II laid the foundations for encrypting financial transactions.
1968–2008	FinTech 2.0: Banks	The advent of the first handheld calculator (Texas Instruments) and ATM (Barclays) in 1967, as well as the significant development of domestic and international payment systems in the 1960s and 1970s, contributed greatly to the development of banking services. Important milestones were also the establishment of the Nasdaq (National Association of Securities Dealers Automated Quotations, 1971) and SWIFT (Society for Worldwide Interbank Financial Telecommunication, 1973).

2009–present	FinTech 3.0: Startups	After the financial crisis, a number of FinTech startups appeared on the market to serve customer needs with innovative digital financial solutions.
	FinTech 3.5: Developed and developing world	Emergence of FinTech developments in emerging markets (mainly in Africa and Asia), supported by government efforts, aimed at fostering economic growth through access to financial services.
2018–future	FinTech 4.0: BigTech companies	The growing presence of BigTech companies in the field of financial services. **GAFA:** Google, Apple, Facebook, Amazon, **BAT:** Baidu, Alibaba, Tencent.

Source: *Own editing based on Arner, Barberis and Buckley (2017)*

Statista (2018) surveyed among bank executives what factors encourage the transformation of the banking sector, of which consumer expectations proved to be the strongest factor with 70.8% (Figure 8).

Figure 8: Factors driving the transformation of the banking sector



Source: *Own editing based on Statista (2018)*

In addition to customer expectations, changes in regulations play an important role. Due to the rapid pace of innovation diffusion, regulators also need to be flexible and respond quickly to changes while continuously monitoring market developments (Nuyens, 2019). Many financial centers (e.g., London, Singapore, Hong Kong) have introduced regulations in recent years that make it much easier for FinTech startups to enter the market. In these centers regulatory sandboxes have been set up to support experimentation with new services and business models, thus facilitating market development (Puschmann, 2017). In Hungary, the Regulatory Sandbox was launched by the Hungarian National Bank in 2018, which, similarly to international examples, aims to promote the spread of FinTech innovations by providing a real test environment. In the Sandbox, applicants may be exempted from certain regulatory requirements (e.g. rules for remote customer identification, handling customer complaints, etc.) based on an individual assessment. Due to the exemption, the business potential of the given solution, the possible risks and the shortcomings of the existing regulatory environment can be assessed (Magyar Nemzeti Bank, 2017).

The European Union's second Payment Services Directive (PSD2), which entered into force on 13 January 2018, is also linked to regulatory changes (Noctor, 2018). According to PSD2, the so-called third-party service providers (account information service providers and payment initiation service providers) can access banks' account management systems through APIs, thus creating an opportunity to develop innovative financial solutions. For banks, open banking and its expected impacts require a redefinition of their position in the payment value chain and a rethinking of their future service portfolio and distribution strategy (Cortet, Rjks and Nijland, 2016). However, with regard to third party access, banks face a number of data protection challenges. According to a survey by Capgemini (2019), these challenges include compliance with data protection standards, ensuring customer online security, protection against fraud, real-time processing and transactions, recording data required by regulators, and ensuring compliance.

Based on Statista's (2018) survey, it can also be seen that in addition to the emergence of new technologies, FinTech companies (e.g. startups) can also generate significant changes in the sector. Entry barriers for FinTech startups have dropped significantly in recent years, resulting in a large number of new players entering the market (Pollari, 2016). Based on Goldstein, Jiang and Karolyi (2019), it can be said that technology simultaneously transforms financial services and creates competitors outside traditional sectors. Nowadays, in the field of financial services, more and more so-called BigTech companies (e.g. Amazon, Apple) are emerging who want to serve their customers with innovative financial solutions through their existing platforms. Examples of BigTech companies are Alibaba’s Alipay and Tencent's WeChat applications, which are leaders in mobile payment solutions in China. (Xie, Zou and Liu, 2016).

According to a report by Bank for International Settlements (2019) the business model of BigTech companies is fundamentally differentiated from the model of other players in the financial sector by two main factors:

- **Network effect:** BigTech companies have the opportunity to take advantage of the vast amount of data generated by their service network and their various platforms (e.g. e-commerce, messaging services, search engines, social media).
- **Technology:** BigTech companies have significant advantages in the latest technologies and research activities.

BigTech companies understandably pose a threat to financial institutions. In this regard, Vives (2019) emphasized that governments and regulators must take into account the impact of these companies on the banking system when drafting legislation.

In addition to FinTech startups and BigTech companies, it is important to mention the so-called challenger banks, which are typically smaller banks that rely heavily on digital customer service and innovation (Lu, 2017). An example for challenger banks is the German N26, which entered the U.S. market in 2019 as the first European challenger bank. However, it should not be overlooked that, despite the fact that banks have lost much of their reputation after the financial crisis and their customers' confidence towards them has declined, a significant proportion of customers feel safe their money at traditional banks (Eisenegger and Künstle, 2011; Boot, 2017; Winnefeld and Permantier, 2017). However, it can be seen that the emergence of new competitors and the transformation of value chains are putting constant pressure on existing players (Boot, 2017).

IV.2.2. Opportunities and risks associated with FinTech solutions

Innovative FinTech solutions present a number of opportunities and risks for customers, banks and the banking system (Bank for International Settlements, 2018). The related factors are summarized in Table 21.

Table 21: Opportunities and risks associated with innovative FinTech solutions

	Customers	Banks and the banking system
Opportunities	• Wider access to financial services • Better and more personalized banking services • Lower transaction costs and faster banking services • More substantiated financial decisions and greater control over personal finances • Raising financial awareness • Financial education of young people	• More advanced and efficient banking processes • Innovative use of data for marketing and risk management purposes • Increasing the efficiency of capital allocation • Potential positive impact on financial stability due to increased competition • RegTech (Regulatory Technology) • Reducing the circulation of counterfeit money • More effective fraud detection
Risks	• Data protection • Data security • Continuity of banking services • Inappropriate marketing practices • Exclusion of certain customer groups	• Strategic and profitability risks • Increased interconnection between financial parties • Operational risks (e.g. IT and cyber security risks) • Risks related to third party / supplier management • Money laundering, terrorist financing • Liquidity risk and volatility of bank financing sources • Lack of preparedness of the policy and regulatory environment • Threats to financial stability

Source: *Own table*

As an opportunity for customers, innovative technological solutions could provide access to financial services for segments that previously had limited or no access to them. (Salampasis and Mention, 2017). Personalized services can significantly increase customer experience and reduce the cost of banking services (Bank for International Settlements, 2018). According to Ozili (2018), with the help of the new FinTech solutions, greater control over personal finances of customers can be exercised, and based on the available data, financial decisions can be made more well-founded and faster. FinTech solutions can also help increase customers' financial awareness and provide many opportunities for young generation’s financial education (Lusardi, 2019).

In the case of banks, more efficient operation can be achieved with process optimization based on new technologies (Lee and Shin, 2018). Available data can be used in an innovative way by banks on the one hand for marketing purposes and on the other hand to improve their risk management mechanisms (Bank for International Settlements, 2018; Giudici, 2018).

Among the benefits at the level of the banking system is that innovative financial technology solutions can contribute to increasing the efficiency of capital allocation and thus to the growth of the economy (Beck *et al.*, 2016). Increased competition could have a positive impact on financial stability (Financial Stability Board, 2017), and RegTech (Regulatory Technology) solutions can provide support to both financial institutions and regulators (Bank for International Settlements, 2018). These developments can, on the one hand, help financial institutions to comply with regulations and, on the other hand, support regulators in enforcing prudential regulation more effectively and supervising financial institutions (Arner, Barberis and Buckley, 2017). Financial innovations and digital financing solutions can contribute to reducing the circulation of counterfeit money (Ozili, 2018), and innovative solutions based mainly on the use of artificial intelligence can help to detect fraud more effectively (Nicoletti, 2017).

On the risk side, there are mainly strategic, operational, cyber and data security issues. With the help of new technologies, individual actors can get even closer together, which can bring benefits to both banks and customers, but there are also a number of data and cyber security risks. The integration of new FinTech solutions may result in increasing IT interdependence between banks, FinTech companies and other market players, which involves a number of IT risks, especially if services are concentrated on one or a few dominant players (Bank for International Settlements, 2018; Lukonga, 2018). The emergence of new actors in the value chain and the provision of services can be a threat in the event that data is misused by some players. In addition, in the event of their downtime, there may be problems with the continuity of banking services. With the emergence of new players offering innovative financial solutions, banks may lose market share and reduce their profitability (Bank for International Settlements, 2018). According to the International Monetary Fund, the anonymity of cryptocurrency trading potentially leaves room for money laundering and terrorist financing (International Monetary Fund, 2018).

Examining the customer side, it becomes clear that since FinTech solutions rely primarily on Internet connection, people without Internet access may be excluded from the financial services market (Ozili, 2018). The use of aggregator platforms provides an opportunity for customers to easily switch between savings accounts or investment opportunities to achieve better returns. On the one hand, this may increase efficiency, customer loyalty and the volatility of deposits, but on the other hand, it may result in higher liquidity risk for banks (Bank for International Settlements, 2018). In addition, lack of preparedness in the policy and regulatory environment can lead to significant risks, indirectly affecting customers (Ozili, 2018).

According to the Financial Stability Board, the risks to financial stability are extremely complex and a distinction needs to be made between micro- and macro-level threats. Micro-risks include among others the liquidity mismatch that occurs when assets and liabilities have different liquidity characteristics, thus necessitating the rapid liquidation of relatively illiquid assets, thereby disrupting financial markets. According to the Council, there is a high risk of contagion at the macro level, which can be linked to the blurring of boundaries between sectors. Accordingly, the transfer of a problem experienced by a single financial institution or sector to other institutions or sectors, due to direct exposures or similarities between them, may result in a general loss of confidence in those institutions or sectors (Financial Stability Board, 2017).

In terms of risks, Nuyens (2019) highlighted three main areas where the development of cross-geographic cooperation is of paramount importance:

1. maintaining and developing cyber security;
2. the fight against money laundering and terrorist financing in order to prevent social risks;
3. maintaining the strength and security of international payment systems.

IV.2.3. Banking developments and scenarios regarding the possible future role of banks

Customer needs, which require new ways of accessing financial services, and increasing competition, in which large technology companies are becoming increasingly active alongside FinTech companies, are forcing traditional banks to develop innovative financial services in order to remain competitive. Accordingly, traditional financial institutions offer their services through an increasing number of channels (e.g., self-service branches, mobile devices, 24/7 chat bots). However, in order to keep up with the intensifying competition, they need to constantly review their current strategy and operating model (Nuyens, 2019).

Banks can implement their digitalization efforts in different ways. Tanda and Schena (2019) identified four strategies for digital developments in incumbent banks:

- **Shareholding-oriented:** acquisition of FinTech or technology companies to achieve digitalization goals;
- **Partnership-oriented:** building partnerships to develop technologically advanced products and services;
- **In-house developer:** In-bank developments through direct investment in the bank's IT infrastructure or the creation of companies focusing on their own digital developments;
- **Mixed strategy:** a combination of the strategies listed above, without favoring one over the others.

Capgemini (2019) made six suggestions for consideration regarding the operating and business model of banks:

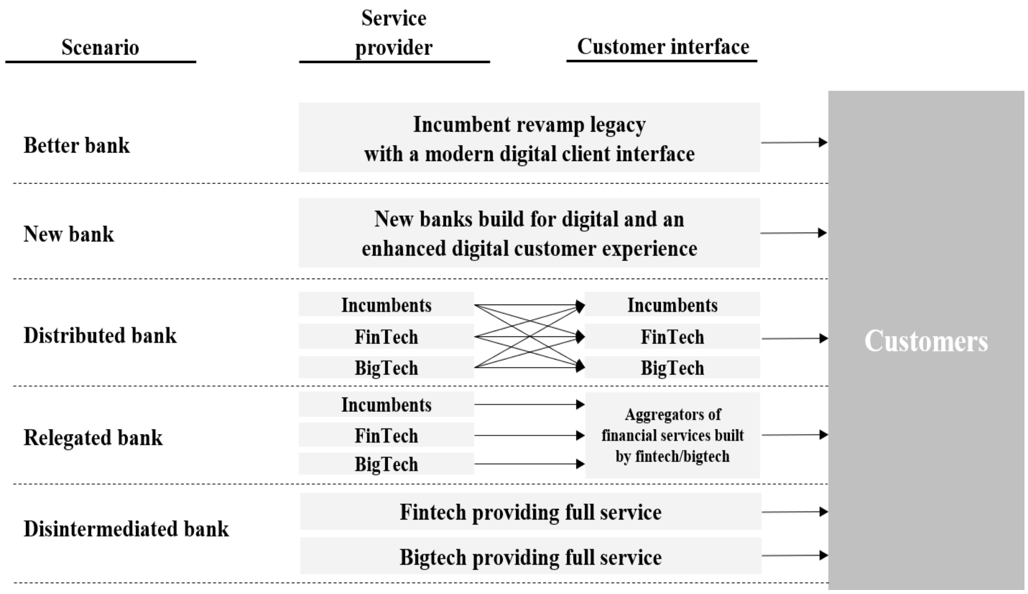
1. Increase revenues from non-banking services.
2. Expanding services through collaborations.
3. Generate revenue related to APIs using revenue sharing or usage-based models.
4. Paying increased attention to advisory services at bank branches.
5. Automation of operations to enhance the customer experience and save costs.
6. Refining technology to support change and growth in an agile way.

In connection with the cooperation recommendation, several banks have established partnerships with FinTech startups in recent years, for example through acceleration programs. We can also see domestic examples of cooperation in this way in the case of OTP and MKB Bank. Cooperation can bring significant benefits to both parties. Examples of these benefits include banks' faster response to environmental changes (Salampasis and Mention, 2017), the ability to develop location-independent solutions (Romanova and Kudinska, 2017), and strengthening customer centricity (Anagnostopoulos, 2018). Thanks to the partnership, the fundamentally high entry barriers for start-ups can be significantly reduced, and during the cooperation, they have the opportunity to take advantage of other benefits arising from the banks' social capital and larger resource base (Bunea, Kogan and Stolin, 2016; Susanne, Barberis and Telfer, 2016; Haddad and Hornuf, 2019). (For a more detailed overview of the potential benefits, see: Horváth, 2019.)

In relation to bank branches, the number of branches is likely to decrease significantly and it will be necessary to rethink the structure of branch networks. In the future, it is expected that many banks will create so-called flagship bank branches that represent the latest solutions of that bank. As a result of the standardization opportunities provided by modern information and communication technologies, banks are expected to reduce staffing in non-knowledge-intensive financial services in the medium to long term (Dapp, 2014).

Based on the Bank for International Settlements (2017) report, five different scenarios can be distinguished regarding the future role of banks (Figure 9).

Figure 9: Different scenarios for the future role of banks



Source: *Own editing based on Bank for International Settlements (2017)*

For the different scenarios, two key questions arise: (1) which actor provides the services and assumes the potential risks, and (2) which actor handles the customer relationship or interface. The scenarios are as follows:

1. **Better bank:** modernization and digitalization of incumbent actors;
2. **New bank:** replacement of incumbent players by challenger banks;
3. **Distributed bank:** the fragmentation of financial services between FinTech companies and banks;
4. **Relegated bank:** "public utility-like" operation of incumbent banks, where customer relationships are owned by new entrants (FinTech, Bigtech companies);
5. **Disintermediated bank:** incumbent banks becoming irrelevant, customers coming into direct contact with individual financial service providers e.g. through the use of distributed general ledger technology.

IV.3. The applied research methodology in the examination of the financial sector

The aim of this study is to explore how different actors in the FinTech ecosystem interpret the concept of FinTech and the impact that FinTech and related changes may have on the operation and business model of traditional commercial banks. A further aim of the research is to identify regulatory challenges that may hinder the diffusion of FinTech innovations for both banks and FinTech companies. Only a few researches are currently available on the FinTech phenomenon and its impact on traditional commercial banks, thus qualitative research has been conducted to gain a deeper understanding of the topic. The research included semi-structured interviews with senior executives of FinTech companies (startup / scaleup), commercial banks, the founder of a FinTech accelerator and a FinTech legal expert. As a result of the research, a total of 13 interviews were conducted, the list of which and a brief description of the interviewees are shown in Table 22.

Table 22: List of interviews in research in the financial sector

Interview ID	Category	Position	Short description of the interviewee
1	FinTech (startup)	Founder, Managing director	In 2014, he founded his first FinTech startup. His initiative has since grown into a FinTech company working in three different areas. In addition, he also works in the field of startup consulting and education.
2	FinTech (startup)	Founder, Managing director	He founded a FinTech startup developing financial solutions for young people in 2017. He previously worked for an international consulting firm in the FinTech field.
3	Commercial bank	Head of Innovation	He has been working for a domestic commercial bank since 2015, where he has been working on digital transformation projects since the beginning. He previously worked as a consultant, partly on banking projects.

4	Commer-cial bank	Chief Oper-ating Officer	He has been working in the banking sector for nearly 30 years in various management positions. He previously headed the financial advisory division of an international consulting firm as a partner.
5	Commer-cial bank	Head of Digital Channels	He has been working in the banking sector for almost 10 years. Currently, he leads a team of 15 people responsible for the development of the bank 's digital platforms and solutions (e.g. netbank, mobile bank, mobile payment, chatbot, etc.).
6	FinTech (startup)	Founder, Managing director	In 2018, he founded a FinTech startup dealing with factoring solutions. He previously worked for an insurance company, a FinTech startup, and as a consultant on the digitalization of financial companies.
7	FinTech accelerator	Founder, Managing director	In 2015, he founded Asia’s most successful FinTech accelerator in Hong Kong. He works at the University of Hong Kong as a FinTech researcher, and has also written his doctoral dissertation in this field, and the author of one of the best-known FinTech books. In addition, he specializes in FinTech training for senior executives in London.
8	FinTech (scaleup)	Founder, Managing director	He founded his own FinTech company in 2013, having previously worked for an asset manager. His company currently offers a number of innovative financial solutions (e.g. prepaid cards, payment solutions, digital banking platforms, etc.).
9	Commer-cial bank	Innovation manager	He has been working for a domestic commercial bank since 2018. Initially, as a community manager, he supported the operation of the bank’s FinTech accelerator program. Currently, as an innovation manager, he supports the bank's digitalization development projects at a strategic level, in addition to supporting the accelerator program.

10	FinTech legal expert	Partner, Lawyer	He has been working as a lawyer since 1997. His professional experience includes, among other things, legal support for investment firms, investment fund managers, and other money and capital market organizations, as well as conducting licensing procedures for participants in the financial intermediation system. In recent years, he has been actively involved in the legal support of FinTech startups.
11	FinTech (scaleup)	Founder, Managing director	In 2013, he founded his own FinTech company, whose innovative developments cover a wide range of financial services.
12	FinTech (startup)	Founder, Managing director	In 2017, he founded a B2B FinTech company. Their main customers are domestic commercial banks, but the company's main goal is the international expansion.
13	Commercial bank	Head of Strategic Management	He has been the Head of the Strategic Management department of a domestic commercial bank for 10 years. He previously worked for two years as a consultant for an international consulting firm, partly on banking projects.

Source: *Own table*

Prior to the interviews, an interview guideline was prepared, which included the main topics of the interview. Based on Solt (1998) and Rubin and Rubin (2011) the interview plan does not define a mandatory order of questions - as it is in fact continuous and iterative - but contains the questions to which we would like to get answers. In each case, the interviews began with an exploration of the interviewee's previous experience and his or her current role in the company and the company's main activities. Following the interpretation of FinTech's definition and key elements, the major changes and challenges in the banking sector in recent years, banks 'strategic responses to FinTech innovations, the impact of the FinTech phenomenon on banks' operations and business models, and related regulatory issues were discussed.

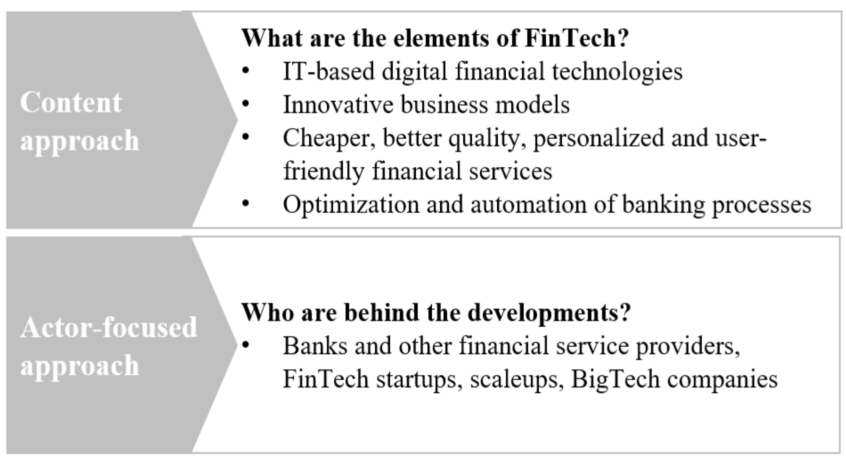
The interviews usually lasted 60 minutes and interviewees were assured of anonymity to increase reliability. After literal typing, the interviews were coded using QSR NVivo software. 112-page excerpts and 815 NVivo references were generated from the interviews. As recommended by Patton (2002), data were triangulated by checking companies' websites and other available materials (e.g. annual reports, presentations, previous available interviews).

IV.4. Results of the research in the financial sector

IV.4.1. Interpretation of the FinTech concept

In interpreting the concept and elements of FinTech, basically two perspectives were dominant. According to the first approach, the main issue is the content elements of FinTech, while according to the other approach, what matters is more about the actors behind innovative financial solutions (Figure 10).

Figure 10: Different interpretations of the FinTech concept



Source: *Own figure based on the interviews*

According to the first perspective (content approach), FinTech solutions are basically cheaper, better quality and more user-friendly innovative financial services (e.g. payment and account information solutions, robotics, etc.). An important element is personalization, serving the needs of customers at the highest possible level. The focus of FinTech solutions can be not only on renewing the value provided directly to consumers, but also on optimizing and automating internal banking and operational processes.

„FinTech products are innovative solutions to classic financial problems and a more efficient, digital alternative and replacement for classic financial products. I think it needs to be effective in two directions: outward and inward. On the one hand, the customer needs to have a better experience, on the other hand, it needs to be a much more efficient process, which also indirectly affects the customer experience. So if I don't have to wait for hours for a process to be executed, but it can run automatically in seconds, it should be reflected in the customer experience as well." (Interview 6)

According to the other approach (actor-focused approach), the question is not what FinTech means and what its main elements are, but who is behind the developments. In this sense, several interviewees defined FinTech companies (primarily startups and scaleups) as FinTech, which bring some service, product, or even operational innovation in the financial industry. This approach is close to the development history of FinTech presented in the literature section, which partly determines the milestones of evolution based on the types of actors' developments that came to the fore in the given period.

„The boundary between who we list here is very weak. This includes all financial services companies that also have technology-driven core operations and bring innovation to the market that is possible due to technology." (Interview 11)

Based on the interviews, the following definition was determined, which combines both the content and the actor-focused approach: *By the term FinTech we mean, on the one hand, personalized, innovative technological solutions and business models that make financial services more efficient and widely available, and, on the other hand, those actors who create an innovative service or product in the financial sector or implement an operational innovation.*

IV.4.2. Impact of new types of players on traditional commercial banks

The new challengers of incumbent banks offer innovative solutions in an ever-widening range of financial services, but payment services (e.g. international transfers) are currently the most dominant. The growing presence of BigTech companies was considered by several respondents to be extremely dangerous for traditional commercial banks. According to the interviewees, BigTech companies have a fundamentally larger customer base and better technology solutions than financial institutions and are usually present in more countries or even globally. A larger customer base means that they have much more customer data, allowing them to develop even more personalized products and services. It can also be said that these companies can scale their new solutions faster, such as traditional commercial banks or FinTech startups. However, the presence of BigTech companies can be seen as positive in addition to the danger in that their new solutions also encourage incumbent banks to innovate. In connection with this, it may be a question of whether BigTech companies appear to banks as a competitor or possibly as a potential partner.

„BigTechs know the customers well, while the bank handles the money. There can also be good cooperations from this and there are banks that have completely started to open in this direction." (Interview 9)

However, during the work with large technology companies, there is a risk that if banks do not innovate themselves and become too vulnerable to BigTech companies, there is a possibility that they will transform into so-called utilities. In this case, the innovative solutions are developed by the partners, and the bank only provides the infrastructure and other operational tasks to provide the services, as a result of which the partners will own the customer relationships and a significant part of the profits will go to them.

"…it is dangerous because the bank becomes a utility that produces the product that the BigTech wants. In this case, it is no longer the bank that innovates, it is not the bank that does the product development, the bank only implements it, while a significant part of the profit is pocketed by BigTech companies in an 80-20 ratio." (Interview 5)

According to the interviewees, new types of players in the financial sector are basically more successful than incumbent companies in five areas. These actors pay particular attention to (1) targeting unmet consumer needs, (2) user experience, and (3) providing data-based services. In addition, they (4) provide their services across borders and (5) enable fast registration on their platforms from anywhere in the world. In parallel with the growing presence of FinTech and BigTech companies, more and more banks have started to develop their own in-house platforms, building on user experience, similarly to the new types of players. On new or improved platforms, users can access banking and other related personalized services in an integrated manner.

" The UX / UI approach is very important because people are used to the comfort ensured by FinTech companies. Customers now expect the same experience from a bank that they get from a FinTech or Bigtech company. Customers rightly expect the bank to bring the same. We have this spirituality, that is why we started to develop." (Interview 5)

According to the respondents, challenger banks pose less threat to traditional commercial banks, but they also have the effect that many incumbent banks have started to develop innovative solutions due to the increasing presence of challenger banks.

„I don't think challenger banks pose a big threat to commercial banks. They have a large customer base, but 90% of their customers only use their account as a secondary account." (Interview 11)

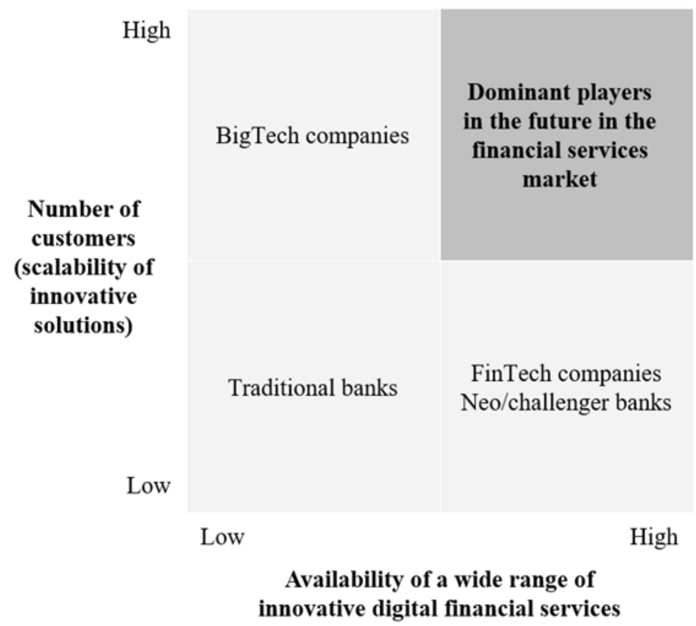
According to the interviewees, BigTech companies and challenger banks are basically an opportunity for FinTech companies operating in the B2B market, as incumbent banks usually work with them to implement their new developments.

„The presence of BigTech companies is more of an opportunity for B2B startups. That way they can provide services to banks because banks are afraid." (Interview 12)

„Banks have started to develop as a result, so overall they are making good room for the B2B sector." (Interview 11)

Overall, in the future, financial services will be dominated by players with a large customer base, enabling them to quickly scale their solutions, and providing a wide range of innovative financial services that respond to consumer concerns (Figure 11). However, when providing customer-centric, personalized solutions, it is important that each player also has in-depth banking and money market knowledge, including to perform risk management tasks related to complex financial products and to ensure regulatory compliance.

Figure 11: Key determinants of future competitiveness in the financial services market



Source: *Own figure based on the interviews*

IV.4.3. Expected changes in the case of traditional commercial banks

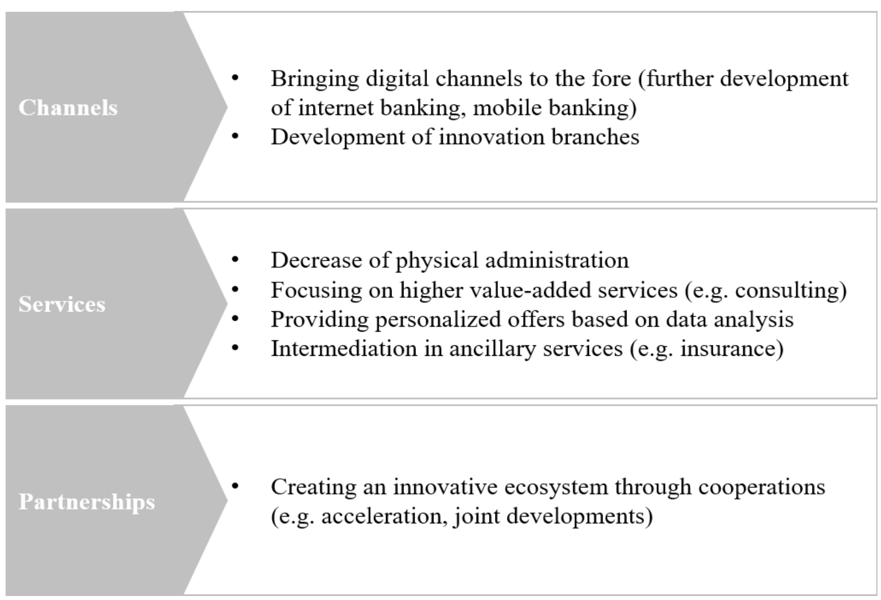
In my research, all interviewees agreed that the post-crisis period, the recovery from the crisis significantly slowed down and pushed the developments of banks into the background. After the crisis, banks had to comply with a lot of regulations and capital requirements, while more and more FinTech solutions appeared on the market in the meantime. At the domestic level, tackling the problems surrounding foreign currency loans was also a significant challenge. Due to this situation, domestic banks were later able to react to the changed market conditions, but in recent years digitalization, organizational development and other projects have been launched at all players, focusing on the implementation of innovative solutions. However, it can be seen that due to limited resources, many banks currently focus primarily on ensuring regulatory compliance (e.g. PSD2-related developments) and their longer-term plans include higher value-added FinTech developments (e.g. robotics consulting).

"In the last 8-10 years, the focus has been more on recovering from the whole crisis, so banks have not been able to sacrifice a huge amount of money on innovation, so there have been large lags at the banking sector level." (Interview 5)

"While in one part of the world banks were working to fix their IT architectures, in Hungary for 3-4 years, all available resources of all banks were concerned with the need to deal with foreign currency loan problems." (Interview 4)

Based on the expectations of the respondents, the classic commercial banking business model (deposit collection, lending, payment services) will not fundamentally change, but developments are expected mainly in channels, focus and quality of services, and partnerships (Figure 12).

Figure 12: Expected changes for traditional commercial banks



Source: *Own figure based on the interviews*

In the future, innovative digital channels will become increasingly important for traditional commercial banks. However, the opacity of banking systems poses a significant challenge in the integration of new solutions. It can be a huge risk factor in the digitization process if, for example, the bank database structure is not uniform.

New digital solutions are emerging for both retail and corporate customers, but due to the nature of services, a slower transformation is expected in the corporate segment. In the case of individually negotiated constructions and project loans, personal negotiation is expected to continue to be a priority, and FinTech solutions will appear as a kind of convenience function, e.g. in the field of data provision or credit monitoring.

According to the interviewees, the number of bank branches will not decrease drastically in the coming years, but rather their role will change. Physical administration is expected to decline in the future and branches will function as a kind of community space where higher value-added services with high expertise, such as financial advice, come to the fore. According to the respondents, there is a need for the availability of personal administration, especially among the elderly, and the current regulations do not even allow for the full online administration of certain products (e.g. mortgage loans).

"It's been a while to hear that banks are moving towards advisory, higher value-added investment services, which have a serious knowledge factor that is not like payment services, so you don't just have to operate a system." (Interview 4)

„Finance has two sides: on the one hand, there are less complex, utility-like services where simple digital processes are needed, and on the other side there are more valuable, more serious financial decisions e.g. buying a home, unexpected things, investments. Personal counseling is still needed in these areas and cannot be digitalized end-to-end." (Interview 13)

During the discussion on the future role of commercial banks, several interviewees emphasized the importance of developing a platform strategy that focuses on cooperation with FinTech companies. At the domestic level, we can see several examples where banks target FinTech startups or scaleups through incubation, acceleration programs or other channels in order to gather innovative ideas and accelerate their developments.

"I think banks need to move in the direction of platform strategy. They have the license, they have the knowledge, all the skills they need. They channel well-functioning successful startups into their ecosystem, allowing them to serve a very wide spectrum at a very high level. In addition to being able to get into this with their expertise, they can help and shape the products." (Interview 6)

In terms of organizational capacity, the focus will be on expanding IT resources (mainly IT development) in the future. The growing development needs predict that banks will not operate primarily as financial institutions specializing in risk management, but will transform into quasi-technology development companies. However, despite the digitalization initiatives of the top management of banks, it is expected that it will be a long time before the drive for innovation appears in the whole organization. Achieving the strategic goals of digitalization is likely to require a complete organizational culture change.

„The functions must be rewritten first in the mindset. If we had previously asked what type of organization the bank is, we have so far said that it is a financial organization that specializes in risk management. However, in the long run - like FinTech companies - IT will be the dominant." (Interview 13)

IV.4.4. Regulatory and other challenges

The research revealed that both traditional commercial banks and FinTech companies face several regulatory challenges. This article is not intended to take a position on the side of any actor. The perspectives of each interviewee are presented below, based on the research conducted to understand the topic.

In many cases, banks have been criticized for being inferior to FinTech companies' solutions, especially in terms of pricing. However, traditional banks are subject to a lot of regulations and additional burdens that FinTech companies do not have to comply with, thus making banks' financial services more expensive. Examples of these additional requirements are the transaction fee for electronic transfers at the domestic level, the deposit insurance payable to the National Deposit Insurance Fund, which protects the savings of bank depositors, or the regulations for bank customer service (personal and telephone). Electronic money issuers and payment service providers are not normally subject to these rules, nor are they members of the Deposit Guarantee Scheme in their home country. Thus, it can be seen that the primary goal of the additional regulations for domestic banks (e.g. deposit insurance, customer service) is to protect customers, which would need to be incorporated into the regulations for FinTech companies as well.

„Many FinTech companies, for example, have operations in England. They have the opportunity to enter a lot of countries without having to comply with any national regulations, without having to pay local taxes. EU banks are the most regulated in the world, but as an English company, there are plenty of rules that apply to an EU bank but FinTech companies can avoid." (Interview 13)

During the research, it became clear that the principle of the same service and the same regulation does not currently apply to traditional banks and FinTech companies, thus creating a competitive disadvantage for banks. According to the respondents, it is necessary to draw the attention of customers (as the Hungarian National Bank recently issued a warning on Revolut, Transferwiser and Paypal) to the problems related to solutions of FinTech companies and to make the differences transparent. Based on the opinions of the interviewees, it would be necessary to align the regulations for banks and FinTech companies, for example by developing a licensing structure at the European level that sets the same conditions for the same type of services.

„The number one basic principle of banks is the assumption of risk, according to which the customer will definitely have access to his/her deposit. This is step 0 that a deposit management company needs to know… Customers need to be educated about what the differences are." (Interview 13)

In addition to the regulatory challenges of traditional commercial banks, the perspective of FinTech companies has also come under scrutiny. In my research, it was revealed that the interviewees generally assessed the attitude and initiatives of the Hungarian National Bank towards FinTech as positive, but in practice they identified several areas for improvement. In the case of the Regulatory Sandbox, for example, a significant challenge arises that FinTech startups can only apply for the test environment if they have already signed a contract with a licensed financial service provider who assumes responsibility towards the Hungarian National Bank. This requirement is extremely difficult for startups to meet due to the early phase. Based on the opinions of the interviewees, there would also be a need for active and detailed communication on which companies turned to the Hungarian National Bank, with what problems and how they were solved.

In connection with the license application of third-party service providers (TPP), a challenge arose, for example, that if a foreign company wanted to obtain a TPP license in Hungary, it is currently only possible to do so in Hungarian. In addition, the difficulty of complying with the cloud recommendation issued by the Hungarian National Bank was identified as an additional limiting factor.

Thus, it can be seen that innovative initiatives in many cases encounter obstacles, which can also be found in Hungary's FinTech Strategy:

„The spread of fintech and insurtech solutions is hindered by the shortcomings of the domestic legal environment. International best practices go beyond the current Hungarian regulations, so despite the fact that the supervision proactively helps the spread of fintech solutions with the means at its disposal (briefings, Innovation Hub, Regulatrory Sandbox, instant payment, education, lectures, conferences, workshops, etc.), the domestic players are at a significant disadvantage in the international competition." (Digitális Jólét Nonprofit Kft, 2019).

According to the interviewees, a significant part of the restrictions mentioned in the FinTech Strategy can be related to the regulations in force (ministerial decree, laws). Domestic regulations and the conditions set out in them make it extremely difficult, among other things, for innovative FinTech companies to set up a company in Hungary, so there are many examples of these companies being registered for example in Malta or Estonia, due to favorable conditions there. According to the interviewees, it would be necessary to assess at the national level where the European Union directives regulating the financial sector allow for deviations and to determine the directions where the regulators apply deviations at the domestic level. As a further proposal, there would be a need to establish a legislative organization at the level of the Ministry of Finance, which on the one hand has an active dialogue with Hungarian FinTech startups, and on the other hand, can effectively take action against the Hungarian National Bank.

According to the respondents, the proposed measures could significantly help the activities of Hungarian startups, the faster spread of innovations, thus reforming the financial sector and making the everyday lives of people living in the region easier.

In addition to the proposals listed, there is also a need to improve customers' financial awareness and financial literacy through educational activities, as incomplete knowledge is also a barrier to the application and diffusion of new technologies. In addition to the lack of knowledge related to financial literacy, the lack of knowledge related to digital security (e.g. widespread sharing of personal data) has been highlighted, which allows for a lot of fraud and abuse.

IV.5. Summary of research results in the financial sector

The intensifying digital transformation in the financial sector is leading to profound changes in customer relationships and the nature of products and services provided to customers. New entrants (Fintech and BigTech companies) are putting significant pressure on traditional financial institutions through innovative business models and the use of advanced technologies. As a result of these factors, the question arises as to how the role and business model of traditional commercial banks will evolve in the future and what strategies they will use to maintain their competitiveness.

The present research examined (1) the interpretation of the FinTech concept, (2) the impact of Fintech solutions and new types of players on traditional commercial banks and examined (3) regulatory challenges that may be barriers to innovation both for banks and FinTech companies.

Two approaches to the interpretation of the FinTech concept have been explored. In one sense, it is necessary to examine the content elements of FinTech, while in the other approach, the main question is what type of actors are behind the phenomenon. Based on the interviews, my own FinTech definition was also defined, which combines the two points of view: *By the term FinTech we mean, on the one hand, personalized, innovative technological solutions and business models that make financial services more efficient and widely available, and, on the other hand, those actors who create an innovative service or product in the financial sector or implement an operational innovation.*

It was also identified that the growing presence of BigTech companies in financial services is a major challenge for banks. These companies have a huge customer base, rely heavily on the capabilities offered by BigData and artificial intelligence in their services, and customers' confidence towards them is also growing. However, the presence of BigTechs for traditional commercial banks can be assessed as positive in that in this way incumbent banks are also increasingly striving to develop innovative financial services.

In recent years, several domestic commercial banks have embarked on digitalization developments, but their resources are currently significantly tied up in regulatory compliance projects (e.g. PSD2). Regarding the services of traditional commercial banks, the focus is expected to shift towards higher value-added services in the future. Domestic banks typically implement their digital aspirations through in-house developments and partnerships (e.g. startup acceleration program).

The use of innovative financial technologies provides an opportunity to target new customer segments, develop faster and more personalized banking services, or even improve internal banking processes. However, the integration of new solutions can be significantly hampered by challenges related to IT systems. In addition, despite the digitalization initiatives of the top management of the banks, it is expected that it will be a long time before the drive for innovation appears throughout the organization. Achieving the strategic goals of digitalization will presumably require a complete change in organizational culture. Typically protracted, bureaucratic processes (e.g., sales, decision-making, administration) and organizational resistance, as with any change, are significant barriers to innovation. It can thus be seen that banks definitely need to develop their resilience and agility in order to keep up with new players in the financial sector. It is also an important direction that incumbent banks will have to build more and more on the opportunities offered by artificial intelligence in the future.

Regarding the relevant regulations, it was revealed that both banks and FinTech companies face a number of challenges. In the case of services provided by banks and FinTech companies, the principle of the same service and the same regulation does not currently apply. Banks are subject to several regulations that FinTech companies do not have to comply with, making banks' financial services more expensive. According to the interviewees, it would be necessary to develop a licensing structure at European level that sets the same conditions for the same type of services. In the case of FinTech companies, despite the positive domestic initiatives, a number of factors can hinder the spread of innovative solutions and the entry of domestic players into the international market. In order to mitigate the existing problems, it would be necessary to review where and to what extent the existing European Union directives and regulations allow derogations. In addition, the financial education of customers, which focuses on the development of financial awareness, data security knowledge and financial culture, should be given priority, thus supporting the development and promotion of the use of new technologies.

V. Summary of the results of the dissertation, presentation of new scientific results

In my research, I aimed to examine the business model innovation opportunities provided by digital transformation. In my dissertation I examined three areas, the manufacturing industry, the energy sector, and the financial sector. The role of the examined industries is significant both domestically and globally and are expected to face significant transformations. Incorporating new digital technologies into organizational operations and business models poses several challenges. However, successful business model innovation can even lead to complete renewal and significant positive consequences for market players.

The ever-increasing digital transformation offers companies many opportunities, thereby accelerating changes in different industries. The changes that take place in this way could lead to a complete reorganization of the current competitive environment, which will force players in all industries to act.

In my dissertation, I reviewed the theoretical background of business model innovation and digital transformation, and I linked the two areas. Based on the analyzed literature, it has become clear that the causes of business model innovation can be linked to three main phenomena, (1) the decline of an established industry, (2) the emergence of a new industry, or (3) technological changes. In addition to the consequences of profitability and cost reduction, companies that renew their business model can gain new customers, target new markets, increase their company's attractiveness to existing and future employees, prevent their competitors from copying their products and services, and create a much more sustainable model overall.

Thanks to digital technologies, companies can get an even more complete picture of their customers' habits, as well as completely renew their value proposition and offer much more customized solutions, e.g. through the provision of data-driven services. In the future, digital channels will become more and more important, through which one of the goals of companies is to focus on direct interactions with customers. However, it is important to highlight that the digital transformation of business models results not only in the transformation of certain elements of the business model but also in the transformation of value chains.

After reviewing the theoretical background of business model innovation and digital transformation, I examined three main areas. First, in connection with Industry 4.0, I examined manufacturing companies. The integration of information and communication technologies in production processes results in a radical transformation of production systems. Based on the 26 interviews conducted during the research, the following results were revealed:

- The research explored how company executives interpret the conception of Industry 4.0, what are the key components of the concept, and what factors can motivate and inhibit manufacturing companies in adopting new digital technologies. During the examination of the components of the Industry 4.0 concept, nine main factors were identified, the key elements of which include data collection and processing, the possibility of optimization and traceability of production processes, and activities performed without human intervention. Relying on all these factors, thanks to new digital technologies, manufacturing companies can significantly renew their value proposition and business model.
- In the study of the driving forces of Industry 4.0, six main factors, while in the case of barriers, five main factors were identified. It has become apparent that in addition to tracking market trends and serving customer needs, the introduction of new technologies is often driven by the company's top management's efforts to ensure real-time performance measurement and increased control, thereby supporting decision-making. However, it was found that profitability concerns, human resource-related barriers, organizational resistance, and the lack of willingness to cooperate among supply chain actors can significantly hinder the implementation of Industry 4.0 solutions.
- The research also revealed that MNEs have higher driving forces and lower barriers than SMEs in relation to Industry 4.0, however, SMEs also have good opportunities.
- It was also found that with the use of Industry 4.0 technologies, management functions will also transform significantly in the future. *Objective setting and strategy*

creation will require more iteration in the future, while in the case of the *organizational function* the continuous rethinking of structures and processes will become more crucial. Regarding *personal leadership*, social support for employees who remain in the company becomes even more important, and in terms of *control*, new technologies make it possible to monitor performance in real-time.

In the second article of my dissertation, I focused on the field of energy. In the energy sector, in line with climate protection objectives and increasingly conscious customer behavior, renewable resources are playing an increasingly important role nowadays, which also involves the renewal of business models. The main results of the paper are summarized below:

- Our research on the topic has identified factors that may hinder the spread of renewable energy sources. As a result, five main problem groups have been identified, which are as follows: financial and profitability, awareness and behavioural, regulatory and institutional, technological and company resource barriers.
- This was followed by a review of globally identifiable photovoltaic business models and how each model could contribute to reducing the identified barriers. Of the three identified models (host-owned, third-party-owned, community-shared), the community-shared model is expected to play a significant role in the future. During the construction of solar parks under a community-shared model, service providers are relying heavily on innovative digital technologies that allow customers to use green energy without owning a solar system and even an own property. This solution has the potential to bring several benefits to both customers and companies, and the increasingly intense digital transformation and sharing economy are also expected to support the further development of the model.
- It can also be seen that innovative business models can provide several renewal opportunities for traditional utilities in addition to reducing the barriers to the spread of decentralized energy production. However, in their business model innovation efforts, utilities need to review their key competencies, strategic tools, and partnerships.

As a third area, I examined the financial sector, where significant changes have also taken place in recent years. In my article, I was among the first in Hungary to explore how financial sector actors interpret the concept of FinTech, the impact of new types of actors on traditional commercial banks, and what changes are expected in the business model of banks. In addition, I have identified some regulatory challenges. I consider the following as the main results of my research:

- There are basically two approaches to the interpretation of the FinTech concept: content-focused and actor-focused. While the content approach seeks answers to what the elements of FinTech are, the actor-focused approach concentrates on the companies behind the developments.
- New types of players in the financial sector (FinTech and BigTech companies) pose a threat on the one hand and an opportunity for traditional commercial banks on the other. These players typically provide cheaper, more user-friendly services, which may jeopardize the competitiveness of incumbent players, but may also encourage traditional banks to renew their services, even through cooperation opportunities.
- In relation to the traditional commercial banking business model, I identified that significant changes are expected in three main areas in the future: channels, services, and partnerships. In the case of channels, digital platforms are coming to the fore, while in the field of services, there is an increasing emphasis on personalized, data-driven services that allow customers to exercise more control over their personal finances and support more conscious financial planning. In parallel with the transformation of channels and services, the role of bank branches may be questionable, in connection with it can be said that the branches will certainly not disappear in the short term but will play a role of community space as physical administration declines. In the case of partnerships, it will be important for all actors to develop a platform strategy in which banks work with different types of companies to implement digitalization developments tailored to customer needs.
- It has also been identified that the revision of the regulatory environment and the development of financial culture are essential for the faster spread of financial innovation.

Overall, business model innovation can have several positive consequences for all companies. However, it should be emphasized, that business model innovation alone is no longer sufficient, and digital transformation is emerging as a mandatory element. As far as possible, it is important that individual actors, and in particular incumbent companies, accomplish digital transformation as soon as possible by removing barriers, thereby renewing their value proposition and the overall business model. In the case, if these companies recognize the need for change too late or are unable to successfully address emerging challenges, their competitiveness is expected to decline, and they are likely to disappear over time and their place can be easily taken by other actors who are still growing but have greater flexibility and entrepreneurial willingness.

Based on the three areas examined in my dissertation, it has become clear that partnerships along the entire supply chain are becoming increasingly essential for the successful implementation of business model innovation enabled by digital technologies, where the parties can work together to create a mutually beneficial situation and thereby realize the benefits of business model innovation more quickly. In my research, I have identified that in business model innovation endeavors, it becomes increasingly important for incumbent actors to strive to create an innovative ecosystem where developments are implemented jointly with other companies. In this type of cooperation, vertical relationships (supplier-buyer) are the most typical, but nowadays there are more and more examples of diagonal alliances. In the case of diagonal alliances, companies start cooperating with each other, which are neither in a supplier-buyer relationship nor competing but operate in different industries. These types of cooperations provide an opportunity for incumbents (e.g. traditional utilities, commercial banks) to enter new markets to adapt to changing competitive conditions, thereby seeking to increase their customer base and create new revenue channels. However, despite the positive examples, the different types of partnerships at the domestic level are still significantly hindered by the lack of willingness to cooperate, which based on my research, can be linked mainly to the lack of trust.

In my dissertation, it was also identified that the spread of new technologies, and thus business model innovation, can in many cases be hindered by regulatory challenges. To overcome this, regulators should strive to create a regulatory environment for all sectors that creates similar conditions for the different actors and at the same time enables the faster spread of new types of technologies and services, which can be beneficial both for the economy and customers.

V.1. Future research directions based on the three examined areas

In my doctoral research, I examined business model innovation opportunities, challenges, and other related organizational and management aspects related to digital transformation in different fields. Based on the research results, several possible future research directions were identified in each of the three areas I examined, which are summarized in Table 23.

Table 23: Potential future research directions in the three examined areas

Area	Research directions
Manufacturing industry	• Exploring management aspects and best practices that support manufacturing companies in Industry 4.0 projects • Exploring the impact of changed working conditions on employees, identifying societal challenges • Extending the geographical focus of the present research, comparing similarities and differences between regions • Further study the impact of Industry 4.0 on business models
Energy sector	• Exploration of the reasons behind the moderate use of the third-party-owned and community-shared models (e.g. through the comparison of different countries) • Exploration of further features of the community-shared model to support adaptation • Investigation of the investor side of photovoltaic business models with Business Model Canvas and Lean Canvas
Financial sector	• Examining FinTech business models, FinTech-related additional benefits and potential challenges • Exploring opportunities for cooperation between traditional and new types of actors in the financial sector • Examining the role of regulators and central banks, identifying additional regulatory challenges and solutions • Investigation of the possibilities of developing the financial culture through the application of technological solutions

Source: *Own table*

In addition to the possible future research directions presented in the table, it can be said that digital transformation is likely to result in similar changes in all industries. The research methodologies used in the dissertation can be well applied in other areas to explore expected changes and business model innovation opportunities. Simultaneously with the accelerated technological development, in addition to incumbent companies, more and more new types of players are appearing in each industry, and as a result, the examination of the renewal efforts of different types of players is emerging as a potential research area.

In the areas examined in the dissertation, the number of previous research was limited, as a result of which qualitative research methodologies provided a good opportunity to explore the topics. In order to validate the results presented in the dissertation, it is worthwhile to conduct a larger sample of questionnaire research in the future, during which, among other things, the differences between different regions and countries and the best practices applied by companies can be compared.

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VIII. Appendix

Appendix 1: Papers about the driving forces and barriers to Industry 4.0 with details of the methodologies used in each

Author(s)	Applied methodology
Adolph et al. (2014)	Literature review
Automation Alley (2017)	Survey of 150 senior technology executives and 150 senior manufacturing executives
Basl (2017)	Quantitative Survey 25 companies (mainly top management)
Bauer et al. (2015)	Literature review / expert opinion
BMBF (2014)	Expert report
Cimini et al. (2017)	Literature review
de Sousa Jabbour et al. (2018)	Literature review
Erol *et al.* (2016)	Literature review, Case study (Learning Factory)
Frank et al. (2019)	Literature review / conceptual paper
Inezari and Gressel (2017)	Literature review and analysis of knowledge management and data analysis systems
Kagermann et al. (2013)	Expert report
Karre et al. (2017)	Literature review and one case study (LeanLab)
Kiel et al. (2017b)	46 semi-structured interviews with managers
Kovács (2017a)	Literature review
Kovács (2018)	Literature review / conceptual paper
Lasi et al. (2014)	Literature review / conceptual paper
Leipzig et al. (2017)	Literature review and one case study
Lins and Oliveira (2017)	Policy survey (more than 300 policies have been studied)

Losonci et al. (2019)	Analysis of financial indicators of companies and the Industry 4.0 maturity of different sectors
McKinsey&Company (2016)	Survey with 300 manufacturing experts
Müller and Voigt (2016)	68 interviews with CEOs, CTOs and heads of different departments
Müller et al. (2018)	68 interviews with CEOs, CTOs and heads of different departments
Nagy (2019)	4 semi-structured interviews
Paritala et al. (2016)	Literature review
Prem (2015)	Literature review (based on former case studies)
PwC (2014)	Survey of 235 German industrial companies
Smit et al. (2016)	Analytical study based on relevant statistical data and information
Spath et al. (2013)	Analytical study based on relevant statistical data and information
Sung (2018)	Literature review
Szalavetz (2018)	16 in-depth interviews with CEOs and CTOs
Uden and He (2017)	One case study
Ustundag and Cevikcan (2017)	Literature review
Varghese and Tandur (2014)	Literature review
Vey et al. (2017)	Literature review
Weber and Studer (2016)	Literature review, analysis of two legal instruments
Zhou et al. (2015)	Literature review / conceptual paper

Appendix 2: Interview guideline in the Industry 4.0 research

1. **Introduction**

- Interviewee introduction (How long have you been working at the company? Where did you work before? What is your position, responsibility? Past and present tasks?)
- General information about the company (history, scope of activities, number of employees, number of business units)
- What challenges has the company faced in the past 5 years? (e.g. financial, labour qualification, labour shortage etc.)

2. **Digitization, Industry 4.0 (if there is)**

- How would you define the term: digitalization? What are the main elements of it? How does digitalization appear in the company? What does Industry 4.0 mean?
- *How can the company be defined when adopting innovations (or digitalization)? (innovator, early adopters, early majority, late majority, lagging behind)* ***based on impression***

2.1 If the company is deliberately committed to digitalization

- What were the key driving forces and motivations of digital transformation / industry 4.0? (E.g. pressure from competitors, customer demand)
- If there are industry 4.0 technologies within the company, how did the introduction of new technologies happen? How long did the introduction of new technologies take? How conscious was the planning? How did it happen?

2.1.1 Introduction process, levels, other details of digital transformation / Industry 4.0

- How much did employees get involved during the formation of the new system? In which areas had the employees the opportunity to share their ideas?
- What is involved in Digitization/Industry 4.0 (e.g. company level / mainly products / products and services)

- If the digitalization completed, where did the company acquire the required knowledge? (What did they see at suppliers / buyers / competitors) Did you cooperate with external experts (e.g. consultants, software developers)?
- What obstacles did you encounter during the introduction?
- What kind of digital platforms are there to customers? (e.g. what kind of e-commerce appears) Which area is affected? (e.g. billing, etc.)
- What kind of changes are expected in the company's operation thanks to digitalization / Industry 4.0?

2.1.2 The role of structure and organizational sectors in Digital Transformation / Industry 4.0

- Who is responsible for managing the digitalization / Industry 4.0 project? In what job position the responsible person works? Does the Chief Digital Officer (CDO) position appear within the company or who is responsible for digitalization and other technological innovations (CEO, CIO, etc.)?
- What are the key capabilities needed to fill this position? (Some examples: IT skills, change management skills, inspirational abilities, management of organizational resistance)
- Is there a separate education-development department within the company? If not, which department is responsible for training? What type of trainings did they have regarding digitalization / industry 4.0? How did the staff's training take place? Who held these trainings?
- Is (or was) there a need to form/develop new competencies within the company? If yes, how will (or did) you obtain them? (e.g. using existing resources, developing partnerships, acquiring knowledge through acquisitions, outsourcing digital competencies) Which department is responsible for this? (e.g. HR, education development)
- How would you define the role of the HR department during the digitalization / Industry 4.0 project? In which processes has the HR department been involved? (e.g. the prominent role of HR department in organizational acceptance, cultural related issues, management of organizational resistance)

- Was there a need to create new positions within the company, did the previous ones transformed and if yes, how? Are former employees able to carry out the new tasks or is it necessary to either expand the workforce or replace them completely or partially?
- What structural changes did occur because of digitalization / Industry 4.0?
- Is the company planning to integrate new business units into the existing corporate structure or set up separate business units responsible for digitalization / Industry 4.0?
- What structure / organizational solution do you think is best suited to support the transformation? (e.g. matrix, flat organizational hierarchy, project teams, decentralization)
- What kind of changes are expected in the company's operation? What kind of changes has been happened so far?

2.1.3 Financial aspects

- How strong was the financial pressure on the current business? Was profitability adequate or this is why digitalization /Industry 4.0 has become necessary?
- What is the source of the digital transformation / Industry 4.0 funding?
- What kind of savings did the company realize? To what extent? What are the company’s expectations?

2.2 If the company is currently not committed to digitalization

- Are there plans to introduce new digital platforms within the company or the supply chain? Explicate it (which departments are working together, whom are you planning to cooperate)
- Why have not been introduced these kinds of tools/technologies?

2.3 Both types

- How important is the role of IT department in achieving strategic goals? (Does the department have only a supportive role or a strategic role too?)
- When deciding on a technological innovation, who makes the final decision? In the current company structure who will take part in a possible future digital transformation project?