6 The Adoption of Industry 4.0 Technologies

The Case of Italian Manufacturing SMEs

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CONTENTS

6.1 INTRODUCTION

The world has entered its fourth Industrial Revolution with the introduction and spread of the industrial Internet of Things (IoT) and other related technologies (Kagerman et al., 2013; Liao et al., 2017). The digital transformation is a worldwide phenomenon impacting societies, communities, organizations, and companies. Governments, policy makers, practitioners, and academics have widely acknowledged the potential impacts of the adoption of Industry 4.0 (I4.0) technologies around the world. Great expectations have been especially expressed for I4.0's impacts on manufacturing. Particularly, several governments from the old continent have underlined that a widespread adoption of I4.0 technologies could decrease the costs of production and at the same time increase the competitiveness of the manufacturing base in Europe, leading to a "Manufacturing Renaissance" (Mosconi, 2015). In 2011, the German government identified a group of technologies having the potential to shape the future of the country's manufacturing industry (Kagermann et al., 2013). Germany developed a long-term project called "Industrie 4.0" aimed at ensuring the survival of existing manufacturing systems in the long run (Kagermann et al., 2013). However, policy makers and consultants have underlined that this gradual process should be controlled and carefully guided. After this, in fact, other member states

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and advanced countries (e.g., Italy, Japan, the US) have developed measures and policies to encompass the digitalization of production processes based on devices autonomously communicating with each other along the value chain (i.e., Smit et al., 2016; Probst et al., 2017), underlining potential impacts both at micro and macro levels (Wee et al., 2016), ranging from individuals to organizations and from industries to societies (Porter & Heppelmann, 2014, 2015).

Born in the policy context, I4.0 has gained momentum around the world. In spite of this, a unique, widely accepted definition is lacking in the literature (Liao et al., 2017; Lu, 2017), even though in the manufacturing context it generally underpins a group of technologies that can facilitate inter-connection and computerization of traditional industry (Lu, 2017). Under this umbrella, Rüßmann et al. (2015) have suggested that this concept is based on nine technological pillars, namely additive manufacturing (3D printing), simulation, horizontal and vertical system integration, the industrial internet of things, the cloud, cybersecurity, robotics and augmented reality (Rüßmann et al., 2015). Each technology has different possible utilization modes, applications and functions related to desired impacts. In fact, manufacturers can implement these technologies to achieve goals in terms of increased productivity, high flexibility, reduced lead times, mass customization through small batch size production, cost reduction, high quality, or increased turnover in terms of opening new markets (Wee et al., 2016; Sauter et al., 2015; Müller et al., 2018). More broadly, Lu (2017) has suggested that I4.0 refers to manufacturing processes that are integrated, adapted, optimized, service-oriented, and interoperable, and correlated with algorithms, big data, and high technologies.

Since 2016, Italy has launched its program to boost first digitalization and then I4.0 adoption through the so-called "Piano Industria 4.0" or "Legge Calenda." In line with this, regional administrations have created policies and incentives to support digitalization and the adoption of I4.0 among all-sized companies. Despite the general interest for I4.0, there is still limited knowledge on the awareness and state of the adoption of I4.0 technologies among manufacturing SMEs. Since technology evolves quickly, small organizations often have to face new technological changes, and the recent evolution of I4.0 is supposed to pose new organizational challenges in this sense. SMEs approaching I4.0 can encounter difficulties, resource and skills constraints in the process (Kleindienst & Ramsauer, 2015; Sommer, 2015). A first aspect relates to low levels of awareness on I4.0 among SMEs, the lack of expertise (Moeuf et al., 2020) and the fact that many firms can have a negative perception of this paradigm (Sommer, 2015). Other barriers relate to privacy and data security issues, the absence of regulations, and the low level of maturity of technologies (Sommer, 2015). Another problematic issue concerns the lack of internal staff qualifications and the general absence or difficulty to shape ICT skilled employees (Sommer, 2015; Horváth & Szabó, 2019). Also, each technology can be applied to different activities of the value chain, leading to completely different impacts (Chiarvesio & Romanello, 2018). For these reasons, the process through which SMEs select and adopt I4.0 technologies may be influenced by a range of internal and external factors. Despite the widespread debate on these themes, empirical research on companies adopting I4.0 technologies is increasing but scarce (Frank et al., 2019). All this makes it interesting to understand how I4.0 is operationally carried out by SMEs, and its potential influence on innovation activities of companies. This chapter investigates this aspect, by highlighting barriers, drivers and opportunities stemming from I4.0. To this purpose, we developed a case-based studybased on in-depth interviews with managers and entrepreneurs of 18 manufacturing SMEs located in Italy.

This study contributes to the still limited literature on I4.0 from a managerial perspective. We contribute to management research by highlighting two main trajectories followed by manufacturing SMEs in adopting I4.0 technologies, particularly showing different applications to business functions and suggesting potential implications in terms of the companies' innovation activities. In fact, most existing studies on I4.0 belong to the fields of engineering and computer systems (Liao et al., 2017). However, reflections from the managerial side are desirable in light of the increasing importance of the topic.

The chapter includes seven sections, including this one. The next section describes the country background and digitalization policies of Italy. The third section describes the methodology. The following sections, respectively, illustrate I4.0 barriers, drivers, and opportunities. Conclusions follow in the last section.

6.2 COUNTRY BACKGROUND AND DIGITALIZATION POLICY IN ITALY

Italy has a long entrepreneurship tradition, with a strong manufacturing base. The digital transformation has involved manufacturing companies, with a predominance of adoption of I4.0 technologies in the metals and machinery sector (Centro Studi Confindustria, 2019). In the Italian context, the government reports show that 8.4 percent of companies have adopted at least one technology belonging to I4.0, with this propensity increasing with companies' size (18.4 percent of small companies with at least 10 employees) (Ministero dello Sviluppo Economico – MISE, 2018). However, the report of the Italian Ministry of Economic Development (MISE) (2018) clearly underlines that small companies in Italy have a lower propensity to adopt I4.0 technologies. A recent report by the Italian Institute of Statistics (ISTAT, 2020) is in line with those data: among companies with at least 10 employees, in 2020, the 82 percent of firms has adopted less than 6 among the 12 digital technologies considered, in a basket including I4.0 technologies, but also infrastructural and connectivity solutions, such as management software and or broadband and cloud); however, only the 8 percent has adopted at least two smart products or interconnected machines, robotics or big data analytics, whereas only the 4,5% uses 3D printing solutions in production.

Data can provide different interpretations when considering size and industry. As a result, at the national level, a report investigating the mechanical sector has shown that about 70 percent of companies have already adopted at least two I4.0 technologies in 2015 (Federmeccanica, 2016).

Indeed, the adoption of I4.0 technologies are at least partially a result of the Italian I4.0 national policy plan released in 2016 and aimed at boosting the investments in I4.0 by leveraging a bundle of fiscal incentives, venture capital incentives, ultrawideband spreading, I4.0 training and education support, and the commitment of institutions to increase the awareness about new technologies and their potentialities. The

TABLE 6.1
Main Guidelines of the Italian I4.0 Plan

Super amortization plans	New "Sabbadini" Law	Research and experimentation tax credit	Patent Box	Start-up and innovative SMEs	Guarantuee Fund	Digital Hub and Competence Center
Incentives for investments in software and IT systems supporting the digital and technological transformation of organizations and manufacturing processes.	Support firms requiring financial and banking support to buy new instruments and machinery, plants, tooling for manufacturing and digital technologies (hardware e software).	Tax credit (50%) on incremental investments in R&D.	Preferential taxation on income from intangible assets, including patents, brands, design, know how, software if protected by copyright.	Preferential taxation, bureaucracy simplification, insolvency law and job market facilitated.	Public guarantees (up to 80%) to support firms and practitioners with difficulties of access to credits at favorable rates.	Digital Hubs are new local entities aimed at supporting the digital transformation of companies. Competence centers are referred to specific universities (or pools of universities) to facilitate and intensify research – industry relationships.

Source: Authors' elaboration

plan aimed at introducing more than 10 billion euros in private investments, 11.3 billion euros in private investments in R&D and innovation on I4.0 technologies and 2.6 billion euros in early stage private investments (*www.mise.gov.it/images/stories/documenti/guida_industria_40.pdf*).

Table 6.1 summarizes the guidelines of the Italian I4.0 plan, which includes direct and indirect incentives for investments in I4.0 technologies, preferential taxation policies and bureaucracy simplifications, public guarantees, and the creation of ecosystems in support of I4.0 adoption and spread.

6.3 METHODOLOGY

The aim of the research is to investigate opportunities, drivers, and barriers related to the adoption of I4.0 technologies among a sample of SMEs. In respect of the novelty of the topic, we chose an inductive qualitative research with theory-building purposes (Eisenhardt, 1989; Welch et al., 2011). Exploratory case study research is considered suitable to generate theoretical propositions upon which base future large-scale quantitative testing (Welch et al., 2011). This approach can provide insights into "why" and "how" relationships occur in a particular phenomenon (Eisenhardt, 1989; Welch et al., 2011) and can reveal mechanisms that link different phenomena together (Perren & Ram, 2004). We chose the firm as the "unit of analysis" (Perren & Ram, 2004). The cross-case analysis was carried on inductively, by focusing on "how" and "why" questions.

The sample consisted of 18 manufacturing SMEs in the metals and machinery sector located in the Italian region Friuli Venezia Giulia (FVG). The region has a tradition related to the metals and machinery district, and still hosts the metals and machinery regional cluster. This is a receptive sector to technological advances and, thus, interesting to investigate I4.0. We adopted a purposive sampling approach (Miles & Huberman, 1994) to identify companies in the sector that had already approached I4.0 technologies. The chosen firms had to fulfil to the following criteria: (1) respond to the European definition of SME in terms of turnover (less than 50 million Euro) and staff headcount (less than 250 employees) (EU Recommendation 2003/361, 2003), (2) belong to the metals and machinery sector, (3) be located in FVG region, (4) have adopted at least one of the nine I4.0 technologies described by Rüßmann et al. (2015), namely the IoT, augmented reality, big data and analytics (BDA), 3D printing, horizontal and vertical integration, cloud, simulation, robotics, and cybersecurity.

In 2017 and 2018, we conducted face-to-face in-depth interviews, based on a previously developed semi-structured questionnaire (Miles & Huberman, 1994), with entrepreneurs, CEOs and/or operation/production managers of 18 SMEs. Interviews lasted between 90 to 210 minutes, for a total of about 45 hours. Most interviews were audio-recorded and literally transcribed. Besides, we visited production factories in order to see the applications of I4.0 technologies *in loco*. We also collected and analyzed press and archival data for triangulation purposes. To support cross-case analysis, data were organized in excel tables. Table 6.2 describes the main features of sampled companies. In terms of product and processes, 11 companies manufacture machinery, plants, and cars, whereas seven firms are precision mechanics and

TABLE 6.2
Profile of Sampled Companies

Company	Product	Age	Turnover 2016 (M €)	FSTS (%)	Industry diversification	I4.0 technologies adopted
C1	Packing machines	72	20	90	Medium-Low	IoT
C2	Coffee machines	90	22	50	Low	IoT, 3D printing
C3	Beverage machines and plants	32	10	40	Medium-low	IoT, simulation, horizontal and vertical integration, cloud, BDA, robotics
C4	Programmable ovens	8	6	75	Low	IoT, cloud, BDA
C5	Ecological cars	9	2,5	85	Low	IoT, cloud, BDA
C6	Precision mechanics	38	6,5	65	High	robotics, horizontal and vertical integration, BDA
C7	Mechanical machinery	22	7	55	Medium-high	simulation, vertical integration, the IoT, cloud and BDA
C8	Precision mechanics	40	7,8	90	High	robotics, vertical and horizontal integration
C9	Precision mechanics	50	6	70	High	simulation, robotics, vertical and horizontal integration, cloud
C10	Saws	40	18	80	Low	simulation, vertical integration, robotics, BDA

Company	Product	Age	Turnover 2016 (M €)	FSTS (%)	Industry diversification	I4.0 technologies adopted
Company 1	Mechanical machinery	14	10	95	Low	IoT, robotics, cloud
Company 2	Wheeled machinery, cobots	16	2,5	80	Medium-low	Simulation, vertical integration, the IoT, BDA
Company 3	Trailers	90	10	20	Low	Simulation, vertical integration, the IoT
Company 4	Mechanical machinery	22	15	85	Medium-high	Simulation, vertical integration
Company 5	Precision mechanics	28	14	74	Medium-low	Simulation
Company 6	Machinery and plants	54	20	90	Low	Simulation, the IoT
Company 7	Precision mechanics	46	3	10	Medium-low	Robotics, the IoT
Company 8	Precision mechanics	37	8	50	Medium-high	Robotics

Source: Authors' elaboration

components manufacturers. The firm age ranges between 8 and 90 years, whereas turnover ranges between 2.5 and 20 million euros. Most companies have high export shares.

6.4 INDUSTRY 4.0 OPPORTUNITIES

The analysis of the opportunities seized by the companies through the investment in I4.0 technologies has revealed two main patterns of adoption influencing the innovation activities of SMEs. Half of the companies adopted technologies mainly aimed at improving manufacturing processes, in line with process innovation activities. In this sense, companies followed a path that, at its maximum extent, could ideally lead to the smart factory concept. The second group of companies adopted I4.0 technologies in order to mainly achieve product innovation. In particular, the most innovative companies in this group have developed smart and connected products, fully benefiting from the Internet of Things by collecting, analyzing and interpreting data. Figure 6.1 illustrates the number of companies that have adopted each technology, as grouped per production type. Most machinery manufacturers have adopted IoT, simulation, BDA, cloud, and vertical integration, whereas components

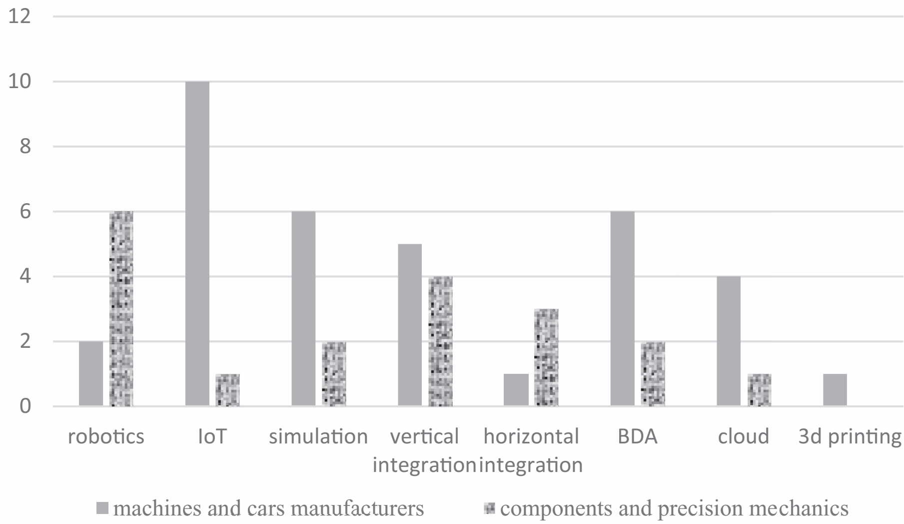

FIGURE 6.1 Number of companies adopting each technology, grouped per product features.

Source: Authors' elaboration

manufacturers tend to adopt robotics, vertical and horizontal integration. Only a few precision mechanics manufacturers use simulation, the IoT, BDA, and cloud.

Figure 6.2 illustrates the number of technologies adopted by the companies as grouped between machinery and cars manufacturers and firms manufacturing components and precision mechanics. As shown by this figure, most machinery manufacturers have adopted more than three technologies, up to a maximum of seven, whereas components and precision mechanics manufacturers provide a different picture: three companies use three technologies, other four firms use three to five technologies.

Table 6.3 shows the clusters among the different technologies. For instance, the IoT is mostly related to BDA (6), simulation (5), cloud (4) and vertical integration (4). Besides the IoT, BDA are related to vertical integration (5) and cloud, simulation, and robotics (4). Beyond this, vertical integration is highly related to simulation (7) and robotics (5).

As far as process innovation, advanced robotics (from autonomous robots to cobots), vertical integration solutions have been adopted to increase productivity, operational efficiency and reduce wastes, both of time and materials. For example, autonomous robots are used to cover the third work shift, as they are able to work autonomously if paired with automated inventories. Simulation has an impact on the quality and effectiveness of manufacturing processes and products. Also, simulation software, when shared with customers, can help in detecting the weaknesses of the production processes (e.g., bottlenecks, breakpoints) and introduce improvements since the designing phase (before prototyping the products for the clients). Besides, simulation opens up the possibility to offer new services to clients. Horizontal and

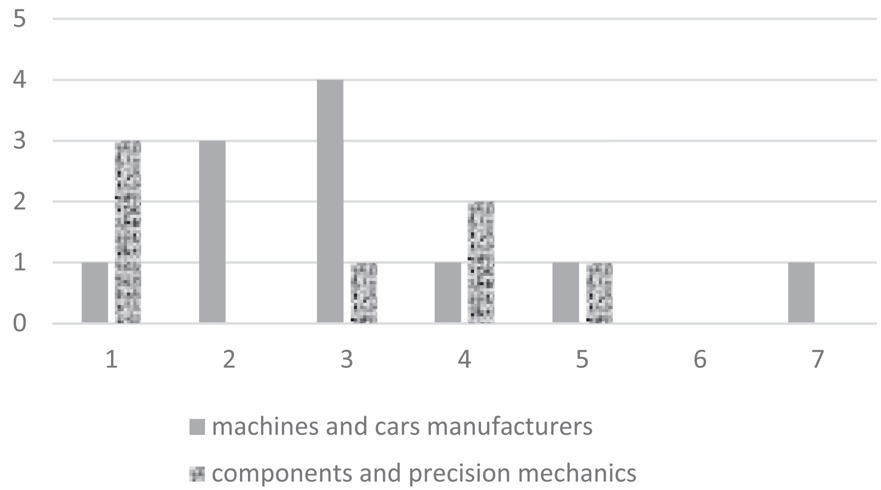

FIGURE 6.2 Number of technologies adopted by the companies split between machines and cars manufacturers and components and precision mechanics manufacturers.

Source: Authors' elaboration

TABLE 6.3
Clusters of Technologies and Total Number of Firms Adopting Each Technology (Diagonal)

Technology	IoT	BDA	Cloud	Vertical Integration	Horizontal Integration	Simulation	Robotics	3D printing
IoT	**11**							
BDA	6	**8**						
Cloud	4	4	**5**					
Vertical integration	4	5	2	**9**				
Horizontal integration	1	2	1	3	**3**			
Simulation	5	4	2	7	4	**9**		
Robotics	2	4	2	5	4	3	**8**	
3D printing	1	0	0	0	0	0	0	**1**

vertical integration are the most impactful I4.0 solutions. Vertical integration allows the interconnection of different functions within the entire organization. However, none of these companies has reached a level of total integration yet, whereas most of them are able to remotely monitor and manage their plants in real-time. More complex is horizontal integration, as it requires the involvement of actors external to the company, such as suppliers, customers and other key value chain partners and requires a certain degree of transparency; on the other hand, horizontal integration may represent an opportunity for small suppliers to strengthen relationships with their clients. Many companies operating in the highly specialized field of mechanical engineering whose clients are mostly large MNEs have already received requests of structuring for horizontal integration. However, whereas some companies have been organizing to implement this application, other firms are against a policy that gives their clients information and rights to impose their priorities on the internal organizational planning and control.

Product innovation through I4.0 mainly consists of developing smart, connected products, which include sensors enabling the data collection and, in some cases, the connection with central systems, other devices and/or the cloud. In the group following this approach, for most companies the creation of smart products has been a natural evolution of product innovation. For example, established machinery manufacturers have continuously invested in product innovation and, particularly, in related technological advances over the years. At the beginning, manufacturers introduced the inclusion of sensors that allowed to extract simple data through the USB pen drive or cables. Now, things have massively changed, with an increasing number of manufacturers producing interconnected machines or entire turnkey plants that can be often remotely real-time monitored and managed.

An important innovation in this domain reflects the increasing attention to service innovation as a component of product innovation towards a servitization logic, following the idea that the service offering should overcome the product selling. Company 3, one of the most extreme cases, still produces machines and plants, while it is transforming its business model to sell service packages, instead of single plants, through a formula that sees customers paying for the use of the machine, rather than for the machine itself. More often, smart connected products allow the offering of new services, such as remote monitoring or predictive maintenance, with strong impacts on the modes of offering post-sale assistance.

6.5 INDUSTRY 4.0 DRIVERS

It has been stated that strategy, not technology, drives digital transformation among organizations (Kane et al., 2015). In line with this statement, the cross-case analysis has revealed that companies have approached I4.0 to achieve different results consistently with the organization's characteristics and market positioning. In particular, the companies selected the technologies that better responded to their necessities related to competitive advantage sources and innovation activities. Indeed, the two patterns of adoption just highlighted that investments were directed to achieve specific objectives. Accordingly, each technology was specifically selected because it was considered suitable and coherent with the company needs and its history.

Our analysis has also allowed the identification of three main categories of drivers, which reflect three respective motivations: cost savings or improvements in performance, market needs, strategic innovation or positioning improvements.

TABLE 6.4
Drivers of I4.0 Investments Categorized by Main Objectives

Market driven investment	Cost driven investment	Strategy innovation
– Product innovation – Product quality – Customer needs – Customer satisfaction – High quality customer pre- and post-sales service – Effective and new value-added services – Customer loyalty enhancement	– Productivity and Efficiency in production – Efficiency and high quality in post-sale service – Performance increases – Quality improvement – Errors prevention	– Service innovation and business model innovation (servitization) – International competitiveness – Integration with customers – lock in effect – Sustainability – Job improvement

Source: Authors' elaboration

Table 6.4 illustrates the specific goals that companies intended to achieve through technological investments made in I4.0, split among market-driven investments, cost-driven investments, and strategy innovation.

As illustrated in Table 6.4, when considering improvements of market relationships, I.40 technologies allow innovating and increasing the product quality and, thus, better respond to customer needs, with positive returns in terms of customer satisfaction. Also, technologies allow firms to offer new services or improve existing ones. As a result, even customer loyalty can be enhanced. The IoT, in a context of product innovation, responds very often to these needs. But even BDA or simulation or process integration are consistent with these goals. For instance, simulation can be used in the design phase to develop customized products that specifically respond to specific needs of client firms, while keeping costs low.

Another driver is related to cost savings and efficiency improvements, both in the case of manufacturing processes and customer services. Technologies adopted to improve product quality, such as simulation or vertical integration, can be included in this category as this aspect not only satisfies the customer, but also reduces and prevents errors and related recovery costs. Typically, automation and process integration are consistent with these objectives. Simulation also allows efficiency improvements in production and more effective products. For example, 3D printing is considered particularly suitable to low-cost manufacture small batches of highly customized plastic workpieces that are needed during the assembly of machines (company 2).

Finally, some companies explicitly addressed I4.0 in order to innovate their business model in line with the servitization perspective. This probably represents the most innovative trend related to digital technologies adoption; however, other strategic objectives can relate to the improvement of the firm's competitiveness or even an explicit attention to sustainability as competitive advantage. In this view, it becomes interesting to consider that some new technologies can be used to improve work conditions and the quality of jobs. For example, this might be the case of automated logistics, which can be used to relieve workers from moving heavy loads.

Our analysis shows potential connections between I4.0 technologies and the drivers: e.g., the IoT leads to product innovation, whereas vertical integration is more inclined to pursue high efficiency objectives. However, the same technologies can be differently exploited by companies depending on the objectives and strategies pursued. For example, simulation can be used both in pre-sales activities, such as the design phase to improve product features and reduce wastes, and in post-sale activities to offer advanced customer services related to the use modes of products after sales. In fact, all the I4.0 technologies can have different functionalities and applications, leading to different objectives and impacts.

6.6 INDUSTRY 4.0 BARRIERS

Our analysis highlights the importance to distinguish between barriers to selection/adoption and barriers to results. As illustrated in Table 6.4, the first group refers to the factors that make it difficult to select the best technologies according to the firm' strategic development plan and to successfully implement the technologies within the company. These barriers include, for instance, the limited knowledge and awareness of I4.0 technologies functionalities and potentialities, the lack of digital competences inside the company, and the lack of sufficient financial resources to plan the investments in I4.0. The national I4.0 plan tries to address the financial issues, stimulating investments in I4.0, and the training and education problem, by favoring the creation and development of I4.0 skills at different levels of the education system, throughout Italy. However, the shortcoming of digital competences, both inside each company and outside its borders, remain a huge problem, which largely prevents companies from investing in I4.0 or – however – slowing down the selection and adoption processes. Another interesting – and relevant – aspect concerns the procedures necessary before digitizing documents, archives, and processes. The digital transformation of companies goes through a series of restructuring and knowledge codification processes that can require long timings – even months – and the involvement of several employees throughout the organization.

Table 6.5 summarizes the barriers preventing companies from adopting I4.0 technologies and the factors impeding the achievement of results (barriers to results).

The next group of barriers, instead, refers to the challenges that companies encounter during the implementation processes, with negative implications on the expected returns on investments. In this category, the most influential aspects relate to data sharing availability with clients and other stakeholders, as the implications in terms of data ownership remain largely unclear. For instance, predictive maintenance requires the access to the client's data, but this is not necessarily well considered by the client firms. In contrast, when this approach is agreed, there are strongly positive implications in terms of performance achievements for the client firm. Still, client firms are not necessarily inclined to pay additional amounts for this new service, which is – instead – taken for granted as a natural consequence of the technological evolution. In the end, technological advances and investments can lead – in some

TABLE 6.5
Barriers to Adoption and Barriers to Results

Barriers to selection/adoption	Barriers to results
– limited knowledge and awareness on I4.0 functionalities, potentialities	– selecting and adopting I4.0 technologies which are not suitable to the firm strategy can embed increased costs and efficiency reduction
– difficulties in understanding which I4.0 technology best suits the firm's manufacturing processes and organizational aspects	– misalignment between I4.0 technologies adopted, and goals expected to be achieved
– lack of the necessary financial resources to carry on a digital strategy including different I4.0 technologies, and fears to invest huge amounts in I4.0 without having the expected returns in short timings	– misleading cost estimates can entail a general increase of costs during the implementation process, postponing the expected benefits due to the adoption of I4.0 technologies
– difficulties in finding capable technological partners	– difficult relationships with technological partners: problems can lead to change partners during the process – Who owns innovations and data?
– restructuring of processes and knowledge codification are necessary before digitizing the processes and archives	– if restructuring processes and knowledge codification processes are not effectively managed, risks of amplifying the redundancies and inefficiencies in the processes
– lack of digital and managerial competences (both internally and externally) necessary to lead the processes restructuring, knowledge codification, the processes of selection/implementation of I4.0, but also to evaluate the proposals of potential technological partners.	– the lack of digital competences can lead to huge inefficiencies in the manufacturing systems
– difficult to decide which data could be shared with clients and other stakeholders, and to forecast the potential implications; privacy issues with clients related to the collection and analysis of their data.	– fears related to data sharing with clients, which could imply an increase in the pressure of clients on the suppliers' prioritization plans.

Source: Authors' elaboration

cases – to offer improved services to client firms without achieving the expected positive returns on the investments made.

6.7 CONCLUSIONS

Our analysis highlights some factors that influence the decisions about the selection and adoption of I4.0 technologies. Moreover, our results show that companies carefully select the I4.0 technologies that are more suitable to the firm strategy, usually following two different trajectories: product innovation or process innovation. As a result, benefits and challenges that stem from the adoption and implementation processes of I4.0 emerged.

Product innovation is usually more related to customer driven investments, whereas process innovation is usually driven by cost savings strategies. However, the reorganization of processes opens the way to renew relationships with customers, particularly, when simulation and horizontal integration are involved. Instead, business model innovation is usually related to both product and process innovation. This opens the way for future researches investigating the relationships existing between I4.0 technologies, business model innovation and servitization strategies, in line with recent research streams that are emerging in management literature (e.g., Müller et al., 2018, 2020; Bortoluzzi et al., 2020).

Our analysis has highlighted some drivers that can stimulate investments in I.40 technologies. Some are oriented to operational efficiency, as they aim at cost and waste reduction and productivity increases. Other drivers are more customer driven: this is the case of I4.0 technologies used to introduce new smart products, or to enlarge the offering by introducing new services. Also, it can be used to increase the customer loyalty and, in some cases, to create lock-in effects due to data sharing with key partners of the value chain. In conclusion, the most interesting experiences are characterized by an overall shift in the business model, which follows strategic drivers of the investments. In fact, some companies used I4.0 technologies to create or improve the conditions to develop a radical servitization strategy, which is a general shift to a new business model where the company sells the usage of products, instead of products themselves.

The capacity to exploit those opportunities should be considered in light of the difficulties that companies can encounter; we found that barriers can hinder the adoption of I4.0, whenever SMEs face financial constraints or lack knowledge needed to identify the right technology or support the implementation process. This is in line with the findings of Horváth and Szabò (2019), who underline that despite good opportunities, SMEs, compared to multinationals, have higher human-resources and financial resource barriers. Beside adoption, other barriers can limit the results, due to poor implementation, wrong strategies, lower than expected response from the market. More in general, our findings support the results of Moeuf et al. (2020), who highlight the lack of expertise as one of the major risks when adopting I4.0 technologies. Indeed, by studying a sample of German industrial firms, Müller et al. (2020) found that limited resources impact on the capacity to explore innovative business models instead of strategies more efficiency oriented.

Companies in the metals and machinery sector are aware of the potentialities of I4.0, even if identifying the best application of each technology consistently with the firm strategy is not that easy or trivial. For this reason, the evaluation, selection, and adoption process of I4.0 can require even some months. Companies are prudent in approaching I4.0, by selecting technologies that are coherent with two main aspects: the firm competitive strategy on the one hand, including the market positioning and customers' features, and the firm innovation strategy on the other hand, intended as the result of the historical approach and evolution of investments in innovation, technology, and R&D activities over the years. As a result, the companies adopted a "cherry picking" approach to I4.0, by selecting and adopting only the technologies that were coherent with firm innovation and competitive strategies. Moreover, technologies are implemented in a creative and various way inside the organizations to serve different purposes. So far, past research has mainly devoted to analyzing the implementation of single technologies in different contexts of application, as done in the case of 3D printing (e.g., Hannibal & Knight, 2018; Laplume et al., 2016), or in different activities of the value chains, by highlighting the different impacts depending on the value chain activity where it was applied. However, we suggest that future researches could give prominence to the interactions existing among the different I4.0 technologies and to the extent to which these interactions were able to impact on the firm's competitive advantage sources and positioning.

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