New value creation opportunities for Start-ups with I4.0: resources and capabilities capitalisation and effects on the Value Chain

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Abstract

Purpose of the paper: *this research aims to investigate how I4.0 enables new opportunities of value creation for start-ups using internal or external resources and capabilities related to Industry 4.0 (I4.0).*

Methodology*: we use a qualitative case study research approach, mainly because of the exploratory nature of the research and the newness of the analysed trend.*

Results*: the research points out three possible opportunities for starting new businesses: using a mix of internal and external resources/capabilities (Grafting 4.0), a combination, coordination and management of external resources and capabilities (Pollination 4.0), or internal resources and capabilities with a comprehensive 4.0 approach (Blooming 4.0). For each of them the required 4.0 technologies and the new paradigm's application are examined.*

Research limitations: *The analysed cases are all based in Italy, for a better validation it would be interesting to expand the study to other countries.*

Practical implications: *this paper may be helpful for prospective entrepreneurs that should ask themselves which kind of opportunity they could grab in consideration of the internal and external resources and competencies.*

Originality of the paper: *to the best of our knowledge this paper is amongst the first ones analysing the opportunities given by I4.0 to start new businesses.*

Key words: value creation; start-up; Industry 4.0; supply chain; business models.

1. Introduction

The increasing diffusion and adoption of I4.0 technologies has opened new challenges for all, bigger and smaller companies. It is interesting that empirical evidence suggests that some technologies at the basis of I4.0, for example big data and cloud computing (Schmidt *et al.,* 2015), are used in other fields or for other applications (Drath and Horch 2014). This goes beyond the role and the intervention of policy makers, hence it is interesting to understand how start-ups create and capture value (i.e. business models; Zott *et al.*, 2011) exploiting I4.0 technologies. Researches about this specific issue are, at the best of our knowledge, still at their infancy. From an analysis of the literature comes out an interesting aspect: chain integration. More precisely, some authors (among others: Kang *et al.*, 2016; Liao *et al.*, 2017; Wahl, 2015) enlighten that, products, things, data and even humans and not only machines are connected thanks to the paradigms of I4.0. This leads to the need of a re-examination and

reorganisation of the whole industrial processes (Hermann *et al.,* 2016) to achieve the superior benefit deriving from integration. Integration and connections are two words commonly used in I4.0. Connection is the cornerstone for new organizational structures (Fantoni *et al.* 2017), and this is true not only those of the production systems but also in the value chain, especially in manufacturing industries (Rüßmann *et al.,* 2015) as well as in agribusiness. In the first case the term Cyber Physical Systems (CPS)systems are widely used, while in the latter case the whole supply chain (SC) could be integrated with certification of food products thanks to the blockchain (Fantoni *et al.,* 2017a). Another interesting aspect related to I4.0 and value creation concerns customisation, according to which smaller volumes of tailored goods will be preferred to mass production (Rüßmann *et al.* 2015). Technologies 4.0 that can be easily integrated, e.g. Internet of Things, Additive Manufacturing (Ngo *et al.*, 2018) and Big Data, are acknowledged to be core driving forces that, thanks to interconnectivity, are able to capture advantages from synergies based on customisation (Kumar *et al.*, 2016) or to modify the SC outline (Bucy *et al.*, 2016; Zhong *et al.*, 2016). In the near future many players will rely on digitised horizontal and vertical value-chain processes (Geissbauer *et al.*, 2016), since digital SC is already considered to be the core of all the activities 4.0 implemented in the ecosystem (Schrauf and Berttram, 2016). In order to better understand the effects of I4.0 in the SC (the so called "SC4.0") it is important to examine the resources' flow both for internal and external perspectives (Kogut and Zander, 1992; Wahl, 2015) in order to understand the complicated interconnections above mentioned.

We have noticed that mainly scholars and experts, when looking to how I4.0 technologies are used in companies, focus their attention on established big and SMEs companies, while little is known about how new entrepreneurs may exploit them. Moving from entrepreneurship and innovation management research, the aim of this paper is to explore how start-ups exploit I4.0 technologies for creating new value. To do so we must analyse the aspects related to Business Models (BMs) because, as extensively discussed by many scholars, new technologies enable the emergence of new BM (Zott *et al.*, 2011, Baden-Fuller and Haefliger 2013, Teece 2017). It is indeed true that this reasoning also appears when existing technologies are applied for other purposes (Casprini *et al.*, 2014). As a matter of fact, in case of new (in the analysed sector) and distinctive external resources, which are one of the two paths analysed in this research (together with internal ones), adopted by a company, scholars have underlined the increase in efficacy and efficiency of value creation, provision, and capture (Amit and Zott, 2001; Pucci *et al.*, 2013): thus, they originate BM reconfiguration inside firms (Morris *et al.*, 2005). However, if it is widely accepted that I4.0 technologies enable new BMs and the adoption of specific BMs is associated to the possession of distinctive capabilities (Pucci *et al.*, 2017), how the internal or external resources and capabilities create or enhance value and how they affect the BMs have been hardly investigated. Therefore, to provide a first analysis of start-ups and I4.0 in the Italian context, the following main research questions are proposed:

1. What are the opportunities for start-up creation in the I4.0 context?
2. Where do the resources and capabilities originate from to foster these opportunities?
3. Do these start-ups have traditional BM or adapted/new ones?

The paper is organised as follows: In the next section an analysis of the literature is performed; then the methodology is described. Findings are reported thereafter. Practical implications are illustrated, also using a table. Conclusion and limitations are at the end.

2. Literature review

Being a "planned" industrial revolution (Lasi *et al.*, 2014), the term has been given before the real revolution happened, oppositely to what happened with the previous three revolutions (Rojko, 2017). This did not prevent I4.0 from having the same impact as the previous three (Kagermann, 2015). Furthermore, Zheng *et al.* (2019) underlined the "disrupting breakthroughs" and the consequent harsh impact on production and associated processes everywhere in the world. Scholars agree in considering velocity, scope, and system impact are the distinctive features of I4.0 (Xu *et al.*, 2018). I4.0 caused a paradigm shift (Lasi *et al.*, 2014) towards decentralised production processes starting from a centralised control (Hermann *et al.*, 2016). A key aspect of I4.0 is the approach toward technologies and their application (Rojko, 2017) rather than the introduction of new technologies itself: what makes a difference is the capitalisation of the involved technologies (Baur and Wee, 2015), that represent the disruptive elements enabling the transformation from "pre-I4.0" to a completely new environment that goes far beyond this (Almada-Lobo, 2015). The effects are disruptive regardless industries and geographical location (Xu *et al.*, 2018). I4.0 sinks its roots in the integration of the traditional hardware and software (the so-called operational technology) with information technology (Thames and Schaefer, 2016) and then it allows data and information sharing at inter- and intra- organisational levels (Zheng *et al.*, 2019). Therefore, another crucial aspect of I4.0 is the exchange of information between people, machine, and resources (Hermann *et al.*, 2016) hence leading to CPS. According to Schumacher *et al.* (2016) the integration is about physical objects, humans, smart machines, production lines, and processes crosswise organisational borders. The connection of sophisticated technologies and the mixture of physical, digital, and biological domains represent a key differentiation of I4.0 and a fracture between I4.0 and "not-4.0" (Xu *et al.*, 2018).

If we consider the involved technologies and the effects of the fourth industrial revolution, it is not possible to include I4.0 in a single discipline, since it belongs to the interconnection of engineering computer science, and business administration sectors (Lasi *et al.*, 2017). Therefore, scholars from both academia and business analysed I4.0 related topics from various different points of views, e.g. (not exhaustive list): engineering, social sciences, computer sciences, production and logistics (Hermann *et al.*, 2016; Kang *et al.*, 2016; and Liao *et al.*, 2017). According to Xu *et al.* (2018), I4.0 has a disruptive effect in all the industries everywhere in the world.

The above cited literature has enlightened that there is a difference between technologies, included the enabling ones, applied without following the disruptive I4.0 paradigm and those implemented following it.

I4.0 creates a smart, networked, and agile new kind of value chain (Schumacher *et al.*, 2016). According to this reasoning, the present research analyses the exploitation of resources and capabilities specifically through an I4.0 perspective.

From 2012 to 2019 the academic literature on I4.0 grew exponentially, with scientific disciplines being the most represented in terms of publications (engineering, computer science and material sciences among the most common) and a significant portion of papers also from the "business, management and accounting" side (Muhuri *et al.*, 2019; Oztemel and Gursev, 2020). Many researches analysed I4.0 focusing on specific enabling technologies, considering their impact on processes and production of firms: 3D Printing, additive manufacturing, advanced manufacturing solutions, augmented reality, Big Data and analytics, blockchain, Cloud, Cyber-security, Horizontal/vertical integration, Industrial Internet, Internet of Things, Simulation and Smart Manufacturing (Almada-Lobo, 2015; Schumacher *et al.*, 2016; Barreto *et al.*, 2017; Fantoni *et al.*, 2017; Majeed and Rupasinghe, 2017; Witkowski, 2017; Khaqqi *et al.*, 2018). Others investigate I4.0 on specific issues or effects, also considering business and management topics: digitalisation and value creation (Kagermann, 2015; Garzoni *et al.*, 2020), e-business (Saniuk *et al.*, 2019), logistics (Hofmann, and Rüsch, 2017; Winkelhaus and Grosse, 2020), maintenance services (Macchi *et al.*, 2016), optimisation (Hsu and Yang, 2016), smart cities (Lom *et al.*, 2016), SC management (Witkowski, 2017), and the impact on the design and manufacturing processes (Tjahjono *et al.*, 2017; Ghobakhloo, 2018). Many scholars wondered how companies assimilated I4.0. Schumacher *et al.* (2016) interviewed I4.0 experts and from this analysis came out that the perception of companies of the I4.0 paradigm is about an extremely complex concept. The impact of I4.0 is different if compared to the ones of the previous three revolutions. In fact, until the third revolution the impact was on the "shop-floor", while in I4.0 it is more comprehensive, extending its influence towards other areas (Schuh *et al.*, 2014). This leads to the need for a clearer idea and an understanding of related benefits and outcomes, thus making the companies able to perceive their own I4.0 capabilities and to identify whether I4.0 represents an opportunity planning their I4.0 best strategy (Bibby and Dehe, 2018) and approach (Bienhaus and Haddud, 2018).

Some scholars then focus their attention on innovation related issues. This may happen in terms of technologies (Ahram *et al.*, 2017; Kouhizadeh *et al.*, 2020), even if some scholars analyse innovation as a system (Reischauer, 2018; Wilkesmann and Wilkesmann, 2018). However, other scientists focus their attention on product innovation (Ancarani *et al.*, 2019; Li *et al.*, 2020) or process innovation (Sjödin *et al.*, 2018). There are researchers that study the collaboration, the (horizontal/vertical) integration topics and the effect of I4.0 on SC. Schuh *et al.* (2014), together with others (e.g.: Ilvonen *et al.*, 2018; da Silva *et al.*, 2019; Kipper *et al.*, 2020), state that collaboration, within the company and/or with other

players, has a central role in taking advantage of the I4.0 potentialities. This is supported by other scholars (Bibby and Dehe, 2018) that affirmed the revolutionary modification of the interaction of companies with suppliers and partners which reshapes the business process, too. This is in line with real time visibility (da Silva *et al.*, 2019), service integration and access to the ecosystem's information alongside the whole SC (Li Da Xu *et al.*, 2018). Collaboration, information sharing, and transparency are some of the I4.0 effects which generates disruptive changes to the entire SC and fosters, at the same time, SC progresses (Witkowski, 2017). Among these effects it is possible to include flexibility and efficiency (Ding, 2018; Dalenogare *et al.*, 2018), also because materials and resources, when smart, are not coupled entities (Almada-Lobo, 2015) making it possible to enable flexibility, integration and combination alongside SC. In fact, I4.0 has the ability to combine and blend the domains both vertically and horizontally (Ghobakhloo, 2018); therefore, in the SC companies are without borders, and they have both integrated BMs and inter organisational relationships (Halldórsson *et al.*, 2015; Ericson *et al.*, 2018). Hence, also thanks to ICT platforms, in the SC4.0 we have total coordination and control in a clear integrated ecosystem that allow co-creation and co-innovation (Schrauf and Berttram, 2016; Atti, 2018). In the SC4.0 all the players are independent but at the same time they all aim to reach a collaborative advantage for all the actors (Chen and Paulraj, 2004; Qin *et al.*, 2016). According to Kagermann (2015) these collaborations are fostering not only complexity, as previously reported, but they also require an architecture framework and a new organisation model especially for work. He is not the only one studying the new organisational and BMs linked with I4.0. Several scientists analyse the new organisational and BMs (Rüßmann *et al.*, 2015; Strange and Zucchella, 2017; Ślusarczyk, 2018). This because I4.0, as all digital technologies' progresses, is affecting how goods are designed and produced (Ślusarczyk, 2018; Grandinetti *et al.*, 2020), influencing companies also from the organisational point of view (Gölzer and Fritzsche, 2017; Prause and Atari, 2017; Horváth and Szabó, 2019; Kouhizadeh *et al.*, 2020). Hence, as stated by many scholars (among others: Rüßmann *et al.*, 2015; Gerlitz, 2016; Strange and Zucchella, 2017; Bienhaus and Haddud, 2018; Ślusarczyk, 2018; Trivelli *et al.*, 2019; Kiel *et al.*, 2017; Moeuf *et al.*, 2020), adapted (innovated) or new BMs are appearing. Indeed, academics have identified several non-traditional BMs that better fit with the needs of companies in this changing environment (Müller *et al.*, 2018). According to Ibarra *et al.* (2018), when dealing with I4.0 and BMs there are three different approaches for studying this connection: the service-oriented approach, the network-oriented approach and the user-driven approach. In fact, it is true that I4.0 entails new paradigms that ask for new managerial methods (Fettermann *et al.*, 2018). The service-oriented approach, i.e. service-oriented BM (Wiesner and Thoben, 2017; Kohtamäki *et al.*, 2019), implies changing from being product oriented to service oriented and also include all the players of the chain in a networked ecosystem. The network-oriented approach, i.e. "network-oriented" BM (Stary and Neubauer, 2017; Thuemmler and Bai, 2017), deals with vertical and horizontal integration that allow the emergence of

new actors. Instead, the user-driven approach, i.e. "user-driven" or "new value proposition" BM (Bawono and Mihardjo, 2020; Culot *et al.*, 2020), deals with advanced and flexible value propositions when customisation and user experience has a role. It is then clear that in such a complex, dynamic and sundry environment new opportunities emerge and hence there will be competition between incumbents and entrants to propose new BM (Mihardjo *et al.*, 2019) or innovate the existing ones in order to be at the cutting edge. Scholars know from decades that technological discontinuities allow the entrance of new companies (Tushman and Anderson, 1986). Furthermore, Baumol (2002) adds that entrepreneurial innovators are sources for breakthrough innovations. More recently, Hahn (2020) analysed innovation under an I4.0 light and reached to a similar statement, writing that radical changes, when adopting I4.0, are made by start-ups and not by established companies. This is supported also by Ferrás-Hernández *et al.* (2019) that affirmed the leading role of start-ups in developing winning dominant architectures when the new technologies are competence destroying. Therefore, it is not unexpected what written by Rojko (2017): most of the companies immediately implementing I4.0 were start-ups. However even if it represents a promising research, little is written in the current literature, to the best of our knowledge, about start-ups and I4.0.

3. Methodology

Due to the novelty of the phenomenon and the exploratory nature of the research question, a qualitative case study research approach is used (Eisenhardt, 1989; Eisenhardt and Graebner, 2007; Yin, 2003).

Considering the fervent environment and the potentialities, in terms of I4.0 applications and development, of the Tuscan Region in comparison to other Italian regions (Bertini, 2017; CERVED, 2019), together with the presence of renewed Universities and research centres, the three cases were identified among Tuscan start-ups. In order to choose amongst the most innovative start-ups at regional level, the sample was selected considering the most promising start-ups which had already received support from universities and/or business hubs. In particular, the three start-ups were selected since all of them were start-ups related to I4.0 with different approaches, hence allowing a good analysis according to the aim of this research. Furthermore, the three start-ups were selected for being representative of the three main areas individuated by Ibarra *et al.* (2018) when analysing I4.0 and BM: service-orientation, network-orientation and user-orientation/customisation.

For each start-up, data were collected through direct in-depth interviews and then they were triangulated with data from other sources as archival data (Gibbert *et al.*, 2008), achieving an appropriate level of internal validity (Yin, 2003). The interviews were conducted using telecommunications applications for video chat, hence having a "virtual face-to-face" interview, and they lasted between 80 and 110 minutes. Interviews were conducted between November 2017 and January 2018. All the interviewees were the

founders of the companies and two of them were also the CEOs (start-up 1&2), while one was the CIO (start-up 3). The interviews were recorded and then transcribed. For each of the three start-ups we identified how entrepreneurial opportunities arise and how the entrepreneurial team used I4.0 technologies in creating new value. Moreover, we tried to enlighten how they adapted the BM for creating such value.

In the coming sections the results of the within case analysis and the cross-case analysis are presented. For each case it is described how the idea was born, how the I4.0 technologies have been used, where they came from and if the start-up enhanced or build a new resource/capability.

4. Findings

Within case analysis

Start-up 1. The first start-up is a spin-off of a Tuscan university. This innovative start-up was born in 2015. They invented a new technology for 3D object optimisation. The whole project fits perfectly with one of the nine technologies enabling I4.0: additive manufacturing. The proposed solution came out in order to fill the gap they found about the need for more precise 3D objects in comparison to standard 3D printing results, already quite extensively used by other companies and proposed as additive manufacturing, too. More specifically, the company invented a new technology based on ABS and cellulose acetate. Other methods may be used to pursue these results, but the designed technology makes things cheaper and faster, with crucial savings in terms of time and money. The highest competitive advantage comes from the reduction of the time-to market, which can be reduced, as claimed by the founder, from two weeks to approximately to an hour. Moreover, it can count on scalability. Therefore, we can say that the proposed technology enhances an existing offering giving a significant competitive advantage to both the seller (i.e. the start-up) and the customer. Furthermore, the technology was secured by the company, which patented it. Sure enough the products they supply are very specific and do not cover the whole production chain, they provide competitive advantages to costumers by significantly optimising a process while increasing the quality of the output. The technology they provide does not enable the whole company production process to I4.0, however it accomplishes the task to introduce I4.0 in a definite level of the whole organisation. The start-up creates product optimization in I4.0 manufacturing and, at the same time, its business involves several pillars of I4.0 (cloud, web connection sensors etc.). Furthermore, everything, from technology to products, is scalable. It operates within the additive manufacturing sector, and it offers solutions for both SMEs and big companies. Products are different, but the technology and the purpose behind is identical, emphasising the adaptability and the scalability of the invention designed. The core team is composed by six people. The core team invented and designed the proprietary technological solution, which is at the basis of the offering. However, there are also several external people which help the start-up in several ways, accordingly to their

expertise. Their role can be considered as crucial for the value offered to the market as that of the founders. That is why we can consider that the start-up is efficiently combining internal and external resources and capabilities to offer a superior enhanced value to the market. For example, a patent-expert fell in love with the project and is helping the start-up with his specialised skills. Similarly, other collaborators are helping in other fields, adding value to the whole business. In total there are about ten/fifteen people sharing this passion and being, with different degrees of partnership, involved in the project. However, the start-up can also count on several partners on specific issues. The start-up believes that an excellent service/product must be delivered to the customers to succeed and to obtain, at the end of the chain, a distinguished result. Because of this, a specialised manufacturer produces the machines they designed and other technical partners oversee important but non-core activities, like e.g. certifications. The possibility to add extra features and services (e.g. virtual and augmented reality), both from the company itself or from its partners, enable a complete customisation that represent, to the founder's eyes, both a competitive advantage and a tremendous shock for the BM of their customers.

Start-up 2. The second one is a start-up born in 2014 in a technology hub of one of the Tuscan towns. It provides an app related to the food industry and was born thanks to the on-field experience of one of the founders. Being an agronomist, and keeping practicing his job meanwhile running the start-up, he recognized a gap in the market and consequently a big opportunity to create a new business, without having neither all the technical competencies nor the technologies for implementing it. The food industry had the inner desire to implement traceability for food products and the need to provide information to customers, not only about traceability but also about food origin, food safety, ingredients origin, food contact materials etc. This gap was mainly enlightened by those producers that wanted to appear as clear as possible to the customers, but also by other companies (especially those producing PDO/PGI, organic or farm-to-table food) expressed a similar need even if for pure marketing purposes. Together with other co-founders, he decided to integrate existing technologies already present in the market, sometimes used in other fields, for providing a free smartphone application that allows customers to access data stored in a database. This application also gives the possibility to share ideas, thoughts and information with the community and to directly contact the producers, hence having a SC connected in both directions. In this way the app can fulfil two main needs: information/communication and general marketing purposes. The value added by the start-up, thanks to the integration of external resources made possible by the deepen knowledge of the market by the founder, comes from the utilisation of a simple existing technology in a way that allows customers (i.e. food companies) to both complain safety rules and to exploit marketing opportunities for product differentiation at the same time. Moreover, the product offered can be considered a perfect fit of three 4.0 technologies, thus mixing cloud storage, image (i.e. label) recognition and databases.

Even though the technology employed is not innovative itself the solution they designed is completely new and unique. If considered in absolute value, the diverse technologies exploited by the offering of the start-up are not new since they have been extensively used in other industries for many years. However, many of them are rather new in the market targeted by the start-up and according to the founder's experience, the proposed solution represents the only application able to integrate all the technologies in order to offer a comprehensive and useful instrument for all the players (producers, suppliers, partners and customers). The start-up is currently formed by four members and several co-workers acting as partners, which varies according to the needs. They strongly believe that specialisation is crucial to succeed in this new "environment 4.0", therefore all the technical issues about the smartphone application are carried out by a partner company specialised in software development even if the main decision and the contents in the app derive from the capabilities internally owned in the start-up. The co-workers help the founders/entrepreneurs with activities needed to offer the services they provide. This makes it possible to offer a high value service/product to consumers and to jointly operate with partners through the whole chain with mutual benefits, in terms of value creation, for all. Consumers will benefit from an integrated service where any high skilled player along the chain adds his own specialised expertise to make the product excellent. This makes it possible to fill the gap in the market offering new value to the whole chain. In term of resources and competencies the start-up, thanks to the internal knowledge of the four founders (e.g. agronomical and managerial ones), was able to recognise the gap and to consequently individuate the external partners with the requested resources and competences to offer the right product and service. To fully integrate the SC and to attract and involve users the product is free for the customers' use and it is economically sustained by participating food and wine companies and consortiums. The need to involve consortiums in this comes from the importance of the maximum participation of a high number of SC members. This makes easier and more efficient the coordination activities of any player (i.e. partners and SC companies) done by the start-up.

Start-up 3. The third start-up originates from a cross-department collaboration of researchers and professors within a Tuscan university. Its aim is to "bring the research into companies". According to this statement, the founders of this spin-off used their competences and knowledge acquired in an academic environment to design a special service/product for introducing I4.0 in outdated SMEs since the start-up offers services to convert a traditional, "old" company into a 4.0 factory. It uses PLC technology, where present, or, if needed, it adds sensors to old machineries. Then, cloud storage allows data collection which are finally analysed. Therefore, the start-up uses several I4.0 enabling technologies, as for example industrial internet, cloud, big data and analytics and advanced manufacturing solutions. Thanks to their academic experience and network and to their ability to bring academic knowledge into business, the entrepreneurial team can internally exploit new opportunities deriving

from the I4.0 development with a double role: consultant and technology provider. Additionally, due to their passion for academia, they were also able to understand the needs of the market and to tailor a business to fulfil them: many micro, small and medium enterprises (MSMEs) do not have the competencies and the knowledge to understand I4.0. Therefore, they face many difficulties to individuate and then adopt solutions, strategies, and the needed technology. This also means that SMEs are not even aware of the big opportunities they are missing. Some SMEs do not have the knowledge of I4.0. For example, accordingly to the founder's experience, they are not aware of the possibilities deriving from data analysis. Moreover, they do not know which kind of data they would like to analyse. The main reason is that they do not have any competence in these fields, and this means they do not know neither what they need nor what they are looking for. The start-up adopted an extremely efficient method to spread knowledge and awareness to entrepreneurs and managers, in which all the value is added by the members of the company. It initially offers consultancy services and assessment, thus making companies aware of technologies, opportunities and advantages. Often, when the companies understand that it is possible to have I4.0 benefits without adopting expensive and complicated software and technological solutions sold by tech multinationals, they are willing to buy the start-up's services and products. If the first step was successful and the customer is satisfied, the start-up offers several solutions, which depend on needs and size, to enable I4.0 in the company. Furthermore, this system is scalable making and it makes things faster, cheaper and highly replicable still maintaining high customisation. In this third example all the value provided to customers come from internal capabilities of the entrepreneurs and from the technological development of the start-up itself.

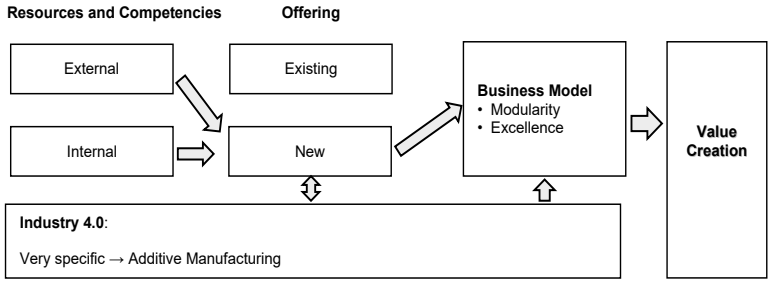
5. Cross case analysis

Comparing the three start-up cases on the basis of the origin of the prevalent resources and/or capabilities (i.e. internal or external), the type of technological offering (i.e. existing or new) together with the I4.0 technologies used and the BM adaptation needed, we identified three value creation mix granted by I4.0. With the term resource/capability 4.0 we identify any technology enabling I4.0 described in the paradigm of I4.0 (Fantoni *et al.*, 2017a) or any ability or knowledge able to take advantage of them. From the analysis of the three cases, we have identified whether the value creation's origin comes mainly from outside, from inside or is a combination of internal and external resources and capabilities and, consequently, the adaptation needed to the BM of the start-up. We named them "*Grafting 4.0*", "*Pollination 4.0*" and "*Blooming 4.0*".

In the first start-up case even if, generally speaking, 3D printing technologies were already exploited by many companies before the value proposed by the interviewed start-up, they were able to design and offer a new technological solution thanks to a perfect combination of internal and external excellent resources and competencies. Hence it was possible to

gain a significant completive advantage and to create value. Specialisation is at the basis of the value chain collaboration. The entrepreneurs believe that each player must provide a specific, yet extremely advanced, product/service adding a small however significant value to the final offering. The I4.0 technology used, i.e. additive manufacturing (Ngo *et al.*, 2018), is very specific too. This case, as well as the other two, also pointed out the need of an adapted BM. To understand why the company needs an adapted BM to fully exploit the potentiality of I4.0 we need to stress the need for excellence enlighten by the founder. Excellence is considered critical for the success of this business and it is asked not only to the start-up itself but also to all its partners. Only thanks to excellence they are able to offer superior value and to gain a competitive advantage. In order to pursue excellence each partner is in charge of a very specific task. Each task is considered as a block of the final offering. Hence, we can state that the fundamental adaptation needed to have a BM able to fully use I4.0 is modularity. Modularity is the basis for the perfect integration of internal and external resources and competencies and furthermore it allows customisation. In fact, the start-up is able to offer the perfect product/service for each customer by requesting or not the help of a specific partner (e.g. by introducing Virtual or augment reality services; Azuma, 1997; Remondino and El-Hakim, 2006), therefore by adding or not a block to the offering. Since the enhanced offering was obtained by integrating internal and external resources/capabilities, we call this phenomenon "*Grafting 4.0*".

Fig. 1: Grafting 4.0



Source: Own elaboration

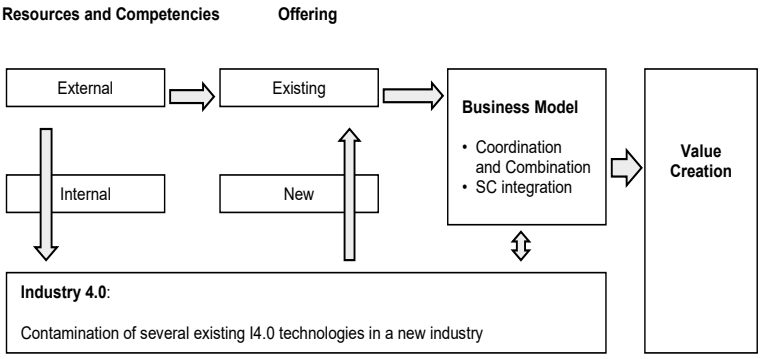
In the second case, the entrepreneurs were able to smartly combine and coordinate several existing I4.0 technologies, commonly used in other fields, to fulfil a need in the chain. Thanks to their internal knowledge and to the resources and capabilities of their partners, some of them not previously involved in the agribusiness value chain, they were able to fully exploit the potentiality of I4.0 through the combination of several technological resources and capabilities along the whole SC. The upstream and downstream integration of external resources and capabilities made possible the creation of value for all the players enhancing the offering proposed to the final customer. The integration and coordination are leaded by the owners of the start-up, that manage the work of the partners while performing their main job outside the start-up. Nobody is fully working

for the company; therefore, a crucial role is played by the partners. As written before some of them originally operated outside the agribusiness industry and thanks to the start-up have started to use their technologies and competencies in this "new" industry. Therefore, the most relevant aspect about I4.0 technologies is not linked with a specific technology itself, instead the contamination of several existing I4.0 technologies originating from other industries represents the main characteristic here.

In this second case the adaptation of the BM is affected by the need to combine and coordinate all the players. The start-up operates as an integrator of the whole SC, therefore the value added is related to the knowledge of the industry and the ability to involve and manage all the players: the start-up's partners, the start-up's customers (i.e. companies in the SC using the app) and the final consumers.

Since the start-up individuates, manages and then spreads the value brought by external partners, to offer significant benefits to both chain members and customers, we identified this phenomenon using the name "*Pollination 4.0*".

Fig. 2 Pollination 4.0



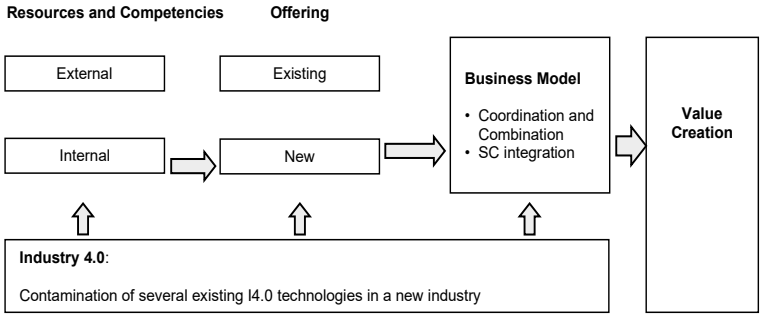
Source: Own elaboration

The third phenomenon differs from the previous two in the view of the resources and capabilities exploited. The background and the "double" role of entrepreneurs made possible the creation of new and significant value for the customers by using internal resources and competencies. Furthermore, the proposed solution enables the start-up to avoid the competition of bigger companies operating in the market of enabling MSMEs to I4.0. As a matter of fact, the offering of the start-up, as mentioned above, is double: at first it consists in a consultancy (and sometimes even dissemination) service and then the customer can demand a tailored product, designed thanks to the analysis made in the first step. According to the founders' experience this two-step, service-based, value proposition has a dual effect: attracting and convincing also the companies without any idea of the potentiality of I4.0 and furthermore understanding how to efficiently combinate the internal resources to design an excellent customised offering using scale economies. Hence the final offering gives a competitive advantage both to the start-up, being the only one to offer such services to MSMEs, and

to the customers, that will be able to exploit I4.0 and to obtain the related advantages. In term of the I4.0 paradigm, the offering of this start-up integrates several technologies and allows the introduction of I4.0 in "old style" companies. However, also I4.0 is considered in a service-oriented approach. Servitization (see among other: Vandermerwe and Rad, 1988; Lee *et al.*, 2014; Thoben *et al.*, 2017) is the crucial element, according to the founder, of this third case. It has deeply affected also the BM of the company that displays a poor interaction with partners while stresses an intense customer relationship based on a direct engagement and on a value proposition increased by critical services.

Considering the fully internal origin of the value created, we defined this phenomenon "*Blooming 4.0*".

Fig. 3: Blooming 4.0



Source: Own elaboration

6. Practical implications

I4.0 delineates new levels of organisation and control (Vaidya *et al.*, 2018), defining new paradigms, models, and principles (Ivanov *et al.*, 2019). Strandhagen *et al.* (2017) identify as key drivers of the fourth industrial revolution the combination of the so-called enabling technologies of the I4.0 paradigm.

Integration, data exchange, enhanced flexibility, efficiency, and communication are just some of the effects and benefits deriving from I4.0 (Rüßmann *et al.*, 2015; Ding, 2018, and Dalenogare *et al.*, 2018). Allowing flexibility and efficiency (Ding, 2018; Dalenogare *et al.*, 2018), I4.0 gives the possibility to accelerate processes (Xu *et al.*, 2018). I4.0 increases flexibility, also empowering the effect of lean manufacturing (Rüttimann and Stöckli, 2016), receiving an extra force not achievable otherwise (Buer *et al.*, 2018). Other significant effects of I4.0 are modularity, decentralisation, and simulation (Qin *et al.*, 2016). Even if modularity already existed in the "Traditional" concept (Koren and Shpitalni, 2010), with I4.0 it is linked with flexibility, and the 4.0 paradigm allows to overcome the rigidity of the whole context that created a barrier to fully take advantage of modularity (Pirola *et al.*, 2020). Furthermore, I4.0 does have significant effect also towards the whole SC (Pereira and Romero, 2017; Popkova *et al.*, 2019)

mainly in terms of process innovation (Lin *et al.*, 2017). There are effects also on the companies' delimitations, since I4.0 blurs their boundaries (Ilvonen *et al.*, 2018; Kohtamäki *et al.*, 2019). Pre-I4.0 companies mainly had Stiff boundaries and so manufacturing processes were not connected across boundaries (Roblek *et al.*, 2016). Thanks to I4.0 the companies in the SC have both integrated BMs and inter organisational relationships (Halldórsson *et al.*, 2015; Ericson *et al.*, 2018). In this way it is possible to use the full potential of I4.0 thanks to within and outside collaboration (Ilvonen *et al.*, 2018; da Silva *et al.*, 2019; Kipper *et al.*, 2020). Having indirect effects of technologies 4.0, i.e. effects not directly coming from the implementation of those technologies alone, is possible thanks to the fact that this is not a mere technological innovation but it is a completely new paradigm that enable additional possibilities and gives extra benefits. All those beneficial effects facilitate the rise of new opportunities for start-ups to create value by exploiting the technologies following the I4.0 paradigm. The empiric results of the case studies analysed reveal that there are three ways in which start-ups can generate new value thanks to I4.0. Start-ups can generate value by smartly mixing internal and external resources and competencies. Here start-ups take advantage of softened boundaries, modularity, and flexibility that are all beneficial effects of I4.0. In fact before I4.0, or without implementing I4.0, companies could use the same technologies but could not profit from those effects, hence not being able to generate any value and therefore to find a profitable way to start a new business. As for the grafting in botany, we mix internal resources, the "rootstock", with external ones, the "scion", generating value. In this case resources and capabilities originate both internally and externally. Since I4.0 plays a crucial role hence the label for this is "Grafting 4.0".

Another possibility for start-ups is to create value through the capitalization of communication, data exchange, and integration. Thanks to the integration of the traditional hardware and software with information technology (Thames and Schaefer, 2016) it is possible to enable data and information sharing, hence having transparency alongside the whole chain (Fatorachian and Kazemi, 2021) and enabling a holistic approach of SC. Integration makes possible the creation of a new value chain 4.0 (Schumacher *et al.*, 2016). These I4.0 effects could go together with another opportunity boosted by I4.0: technological contamination. This phenomenon is particularly visible nowadays in those sectors previously not much full of technology, i.e. "traditional sectors" not usually prone to change like agribusiness (Blasi *et al.*, 2017). In the agribusiness sector there has been a rise, during the past ten years, in the application of technologies coming from other industries. Therefore, those technologies are the "old" ones in the industry from where they originate, being quite new in the agribusiness one, and even if this phenomenon does not originate with I4.0 (Ruiz-Garcia and Lunadei, 2011; Muangprathub *et al.*, 2019), it experienced a rise thanks to the new paradigm (Zambon *et al.*, 2019; Lezoche *et al.*, 2020). The adoption in a new (i.e. where the technology was not employed before) industry of technologies extensively used in other sectors it is not something enabled by I4.0. However, integration, modularity, blurred boundaries, service-orientation and other relevant aspects strictly related

with I4.0 gave a significant boost to this phenomenon. A central role is played by the radical change in the way of thinking when the I4.0 paradigm and its potentiality are fully understood. Technology contamination, horizontal and vertical integration, and the possibility to smartly combine diverse external resources and competences are all strictly linked with the 4.0 paradigm. Without I4.0 it would not be possible to fully take advantage of them. In consideration of the value creation obtained through the management, mix, and combination of external resources to fertilise the SC as the process done with the pollen in the botanic world, the label is "*Pollination 4.0*", where "4.0" enlightens the essential role of the I4.0 paradigm. The origin of resources and capabilities in this case is external.

The third possibility that comes out from the case study analysis refers to a fully internal origin of the resources and competences. The pivotal aspect linked with I4.0 relies in this case on the ability of the start-up to interpret in the best way I4.0 and fully comprehend this new paradigm for gaining a competitive advantage by internal resources and capabilities use. Furthermore, the other critical aspect is that the start-up has a "service mindset", that allows to create a networked ecosystem with customers and partners (Ibarra *et al.*, 2018). As in botany, here we have new value, which is mainly a service, that originates from the start-up and that has a beneficial effect also for the other actors of the chain. As in the case study *start-up 3*, everything is intrinsically tied to the 4.0 paradigm. Hence, we are not referring to the mere ability to exploit internal resources, which is something that has always been done by many companies. Here we are dealing with the ability to use resources and competencies linked to the fourth industrial revolution (e.g. enabling technologies) following, in all respects, the 4.0 paradigm. This is definitely not only, as repeated several times throughout the whole paper, about using specific technologies but it is a way of thinking, understanding how to take the best from all the resources by, e.g., smartly combining and perfectly integrating them, enabling customisation and service-mind orientation. For this reason, we think about "*Blooming 4.0*".

Therefore, answering the first RQ, "What are the opportunities for start-up creation in the I4.0 context?", they are: "*Grafting 4.0*", "*Pollination 4.0*", and "*Blooming 4.0*".

To answer the third RQ, "Do these start-ups have traditional BM or adapted/new ones?", we use an approach similar to that of Ibarra *et al.* (2018). They both consider BM, from traditional to new, and innovation, from incremental to radical. It is fruitful to consider such approach because the three case studies also suggest the need for companies to adapt their BM for an absolute use of I4.0. According to the type of technology 4.0, the role of the company in the SC, the kind of value created and the source of the decisive resources and competencies the BM should be adapted in different ways.

The two transformations that better fit our research are about "new ecosystems and value networks" and "new BMs: smart product and services". In the first case a radical innovation of the BM is proposed. Furthermore, it may focus on the core activity, as in the case of the *start-up 3*, and/or using resources from partners, as in the case of *start-up 2*.

Therefore, there are two radical innovated BM: one linked with network-orientation, and one with service-orientation. In the first one (*start-up 2*), which can be called also "chain integration BM", the company acts as a coordinator and integrator of SC players and therefore the BM is focused in efficiently and effectively bringing together the external key partners, activities, and resources. While in the second (*start-up 3*), that can be named "service-oriented BM, confirms what has already been extensively indicated by the literature (among others, see: Vendrell-Herrero, 2017; Reim *et al.,* 2015; Bustinza *et al.,* 2015): an increasing trend towards service-orientation that consequently affects also the BM. I4.0 affects "traditional" service orientation by innovating BM (Cimini *et al.*, 2018). With I4.0 services change into smart services that, based on smart data, can generate value for both companies and customers also enabling product-service-development (Kaltenbach *et al.*, 2018). In the first start-up case there is a new disruptive innovation that needs a new BM where other actors are also involved in the process. Because of this characteristic and the need for flexibility, it is possible to name it "modular BM". In this BM, both the company and the partners are extremely specialised and the offering is composed by several modules that can be used or not accordingly to the needs. To fully answer the second RQ, it is possible to state that the studied start-ups do not have a traditional BM, since it would not allow them to fully take advantage of I4.0.

The three phenomena may be helpful for entrepreneurs in contemplating the employment of I4.0 related resources and capabilities for value creation and so for obtaining a competitive advantage. More precisely, considering the new paradigm of I4.0, managers should ask themselves whether they have internal resources or capabilities for exploiting the I4.0 paradigm and creating value (i.e. *Blooming 4.0*); if there are external resources and competencies (also not already used in their specific industry) that can be found, coordinated and managed by the company for creating values, hence acting as SC integrators (i.e. *Pollination 4.0*) and whether it is possible to combine internal and external resources and capabilities for creating value and obtaining a competitive advantage for everyone (i.e. *Grafting 4.0*).

7. Conclusions

This study represents, to the best of our knowledge, a first step in the analysis of the opportunities enabled by I4.0 for start-ups. This is particularly important considering that both public authorities, business associations and experts are continuously and increasingly recognizing the need of investing in start-ups and businesses linked to I4.0. Indeed, this is a great issue that policy makers should tackle: to boost technological rejuvenation and innovation, it is necessary to solve the lack of early capital and bet on our start-ups (Inguscio, 2018).

The present research proposes three opportunities to start new businesses thanks to I4.0. All of them consider as an essential element the full comprehension and application of the 4.0 paradigm, which enables new opportunities and/or empower existing ones. Hence, a first

opportunity comes from smartly mixing internal and external resources and competences taking advantage of modularity, blurred boundaries and flexibility. A second one comes from the smart combination and management of external resources and capabilities through full integration, communication and data exchange and technology contamination. The third one, in which all the resources and competencies are internal, deals more with the paradigm itself and a (smart) service mindset for achieving empowered benefits.

Furthermore, it is interesting to note that the usage of technologies in other fields than the one of origin, even if existing before the starting of the fourth industrial revolution, is empowered by the new paradigm and its effects, hence representing an opportunity for expanding this concept for more technologies.

Additionally, it is examined whether these start-ups should have a traditional BM or a adapted/new one. In two cases a radical innovation is proposed, while in the third one a completely new BM with the involvement of external actors, too. Hence this would lead to the need for adaptation also for their BM, as suggested from our case studies. However, the suggestion given by the interviewed start-ups to their partners about redesign the BM to the new chain is hardly followed by them, maybe because it may takes time to develop new BMs from I4.0 technologies maybe because BM are more "context-dependent" than technology (Teece, 2017).

For the managers and other entrepreneurs, reading this paper may be inspiring and could lead to further thought in their business and markets. This research enlightens some aspects that lead to start-up creation opportunities, hence they would represent a good starting point for entrepreneurs-to-be. Furthermore, it stresses the benefits deriving from an extensive comprehension of I4.0 and related benefits, not only for start-ups but also for the whole value chain.

There are several limitations in this study. Being a first study about the proposed issue, there is the need to further validate it, also using data analysis. Furthermore, it would be interesting to expand this study to companies not based in Italy. Then it would be interesting to propose a similar analysis for already established companies, both in Italy and abroad.

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