

The new frontiers of procurement in the digital age. Results of an empirical survey on procurement 4.0 in Italy¹

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Abstract

Purpose of the paper: *The paper presents the results of a research conducted through a university-business partnership, aimed at providing a first photo of enabling technologies in Procurement (Procurement 4.0) in Italian enterprises, both in terms of interest and cultural attitude and actual use.*

Methodology: *The research is conducted with a quantitative methodology, realized with an online questionnaire (CAWI), transmitted by the Italian Association of Procurement Managers (ADACI) via email to its members. The statistical analysis of the results is descriptive.*

Results: *The survey, with 51 recorded replies, collects a sample of innovative enterprises, with a good awareness of the role that enabling technologies can have and how strong the impact can be on business models procurement practice. These enterprises can therefore be considered as innovators able to act as a flywheel for the diffusion of enabling technologies along the supply chains they participate in.*

Research limits: *The research takes stock of a phenomenon that is still in the embryonic phase in Italy. The number of responses is therefore limited. New research will have to be carried out in order to strengthen and generalise the results, also through inferential statistical analysis.*

Practical implications: *The research provides information useful to researchers, policy-makers and practitioners to support their decision-making processes regarding a very innovative phenomenon, which is still little known in Italy.*

Originality of the paper: *Procurement 4.0 in Italy is still very little explored. The research, through a university-business partnership, provides a first original scientific contribution that will feed new research and support enterprises in this historical phase, which is crucial for the competitiveness of the Italian production system.*

Key words: enabling technologies; industry 4.0; procurement 4.0; innovation; change; Italy

1. Introduction

Enterprises and economic systems are today facing the important challenges of the fourth industrial revolution, which will deeply transform productive and economic activities.

¹ The Authors share the responsibility of the paper. Silvia Bruzzi wrote paragraphs 1, 2, 3, and 4.5 and 5; Vincenzo Genco wrote paragraphs 4.1 and 4.2; Nicola Balbi wrote paragraphs 4.3 and 4.4. Conclusions were written jointly by the Authors.

Scientific and technological innovation as well as economic-productive innovation have always been closely interconnected (Cipolla, 1989); this is evident when considering the different industrial revolutions that marked history. Think of the steam engine in the Eighteenth century and the development of the mechanical and textile industries, then electricity and the development of mass production, as well as the development of information technology in the 1970s and the introduction of programmable logic controllers (PLC) and robots that enabled the automation of industrial production processes (Vaidya, Ambad and Bhosle, 2018).

With the fourth industrial revolution based on digital technologies (Porter and Heppelmann, 2014), the production processes will be deeply influenced by Internet and by the communication opportunities between humans, machines and products in the so-called Cyber-Physical Systems (CPS)².

The new digital technologies are called Enabling Technologies (ETs) and represent the core of this revolution, baptized with the term Industry 4.0 (I4.0) in Germany by the Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung, BMBF) to stress their impact on the industrial activity of the 21st century (Schütte, 2012)³.

The disruptive impact of this technological change seems evident considering the definition of the European Commission (2009, p. 1), according to which the Enabling Technologies (or Key Enabling Technologies, KETs) “are knowledge intensive and associated with high R&D intensity, rapid innovation cycles, high capital expenditure and highly-skilled employment. They enable process, goods and service innovation throughout the economy and are of systemic relevance. They are multidisciplinary, cutting across many technology areas with a trend towards convergence and integration”.

The introduction and diffusion of these technologies in the industrial landscape is leading to the development of new economic paradigms, where the labor force is still considered irreplaceable and the ability of integration becomes a fundamental asset for the competitive advantage.

With the pervasive application of enabling technologies, enterprises will become part of hybrid integrated systems (Porter and Heppelmann, 2014), where physical and virtual elements along with information flow in integrated processes.

In this context the capacity to create value will increasingly depend on the ability to integrate business functions and processes. Enterprises need to be able to integrate processes along the different stages of the supply chain, involving all their business functions. If Operations, which are responsible for the management of the production processes, constitute the

² CPS are systems composed of physical entities (for example machines or vehicles) equipped with specific technologies, such as sensors or microprocessors and IT systems, that are capable of generating data, processing it and communicating it to other systems, also activating autonomous decision-making processes (Thoben *et al.*, 2016).

³ The Boston Consulting Group has identified nine enabling technologies: Big data and analytics, autonomous robots, simulation, vertical and horizontal integration, industrial internet of things (IIoT), cybersecurity, cloud, additive manufacturing, augmented reality (Lorenz *et al.*, 2015).

business function that will be most involved in the changes taking place, the other functions will also have to reorient themselves in order to allow the enterprise to take on the challenges. Amongst these, Procurement plays a central role and can become a driving force for innovation. Procurement, by acting on the input side and as an interface between suppliers and customers, can give a fundamental contribution to value creation, which is growing because of the increasing importance of purchasing costs, in line with the outsourcing policies adopted by firms.

With enabling technologies, Procurement seems destined to acquire an even more important role; literature refers to Procurement 4.0, in step with the term Industry 4.0, in order to highlight the need for Procurement to support the development of integrated and digital operations and supply networks.

In particular, Procurement has a fundamental role in the construction of the new hybrid integrated systems. It must ensure, through adequate suppliers' management strategies, the creation of infrastructural systems, where materials and information can safely flow across enterprises' boundaries. In line with these considerations the article aims to support this process of renewal of Procurement in Italy, where Procurement 4.0 is still in its infancy (Atti (ed.), 2018).

The research, conducted in partnership with ADACI, the association of Italian Procurement Managers, aims to take a photo, through an empirical study, of the state of the art of Procurement 4.0 in Italy; the goal is to support the decision-making processes of all the actors (firstly managers and policy-makers) and to promote the dissemination of good practices, through a better understanding of a phenomenon that is in full evolution in terms of solutions adopted and emerging difficulties/needs.

To this end, the article consists of 6 Sections. In Section 2 a literature review on Industry and Procurement 4.0 is presented in order to take stock of the state of the art and identify the theoretical and empirical gaps that the article aims to fill; then, after a brief description of the research methodology adopted (Section 3), the article describes and discusses the results of the empirical research, focusing on enabling technologies in general and, in particular, for Procurement (Sections 4 and 5). The article closes with some concluding remarks and hints for future research in this field (Section 6).

2. A literature review to understand the managerial challenge coming from enabling technologies

Different definitions have been produced to describe the industrial revolution and the disruptive impact that enabling technologies can produce on production and economic systems. In particular Russmann *et al.* (2015, p. 3) highlight that "Industry 4.0 will make it possible to gather and analyze data across machines, enabling faster, more flexible and more efficient processes to produce higher-quality goods at reduced costs. This in turn will increase manufacturing productivity, shift economies, foster industrial growth, and modify the profile of the workforce - ultimately changing the competitiveness of companies and regions".

In the same way, Thoben *et al.* (2017) highlight how these technologies will lead to a passage from the paradigm of automated production of the third industrial revolution to the paradigm of intelligent production, a production that, thanks to information available in real time, succeeds in realizing products in the variations, quantities and time periods requested by customers. “The exclusive feature in I4.0 is to fulfill individual customer requirements with product variants in a very small lot size, down to one-off items. The availability of all relevant information in real time will enable manufacturing systems to meet customer requirements without waste due to reconfiguration of assembly lines or setup times through dynamic business and engineering processes” (Thoben *et al.*, 2017, p. 5)⁴.

The Authors refer to an artificial intelligence, based on the use of technologies able to endow machines with learning and decision-making skills, which allow them to independently manage production processes.

This aspect is extremely important in order to understand the impact that these technologies can have in managerial and entrepreneurial terms.

In the first place, the intelligent production paradigm modifies the man-machine relationship that developed during the previous industrial revolutions. Vaidya, Ambad and Bhosle (2018) argue that while the technological innovation that characterized the third industrial revolution acted to reduce the role of man, with intelligent production man's role is essential for managing the interconnection between machines and information systems and for guiding them in the desired direction. In this regard, Lorenz *et al.* (2015, p. 3) highlight how the adoption of enabling technologies will lead to overcoming the trade-off between productivity and employment: “manufacturers will be able to increase their competitiveness, which will enable them to expand their industrial workforce at the same time that productivity increases”. For example, the Authors estimate that in Germany the adoption of these technologies from 2015 to 2025 will lead to an overall growth in employment, despite a recomposition of the workforce to professional levels. In fact, employment with low added value will further decrease since repetitive tasks can be performed by machines and robots. However, the demand for highly skilled workers will increase (Stanton Chase, 2017; Vollmer and Machholz, 2018). Moreover, alongside high-profile technical skills, labor force will be asked to develop soft skills, such as flexibility, ability to adapt to change and openness to continuous interdisciplinary learning⁵. Brettel *et al.* (2014, p. 43) point out that “In the near future, labor work will change in content but will still remain irreplaceable, especially in view of customization resulting in an increased

⁴ Literature also refers to Smart Manufacturing, a term coined by various US agencies, such as the Department of Energy and the National Institute of Standards and Technology, to highlight the role that information technology can have in the development of intelligent and efficient operations at the level of a single production unit, factory and supply chain (Thobe *et al.*, 2017).

⁵ From this point of view, Industry 4.0 is an expression of the great socio-economic transformation that has been underway for decades and has not yet been completed, which places the enhancement of hard and soft skills at the basis of development and recognizes enterprises as primary learning environments (World Bank, 2002; Dutta *et al.*, 2014; Velo, 2007; Bruzzi e Anelli, 2014; Bruzzi, 2014).

need for coordination. Operators on the shop floor need to be skilled in decision making as the separation between device and executive work voids. Self-controlling and human systems communicate via the Internet, which alters the role of workers towards coordinators and problem-solvers in case of unforeseen events”.

Even the relationships between the enterprises that operate along the supply chain is going to change. With the pervasive application of enabling technologies, enterprises will no longer act as isolated actors, even though managed in an optimized way, but will become part of an integrated system in which processes and information will flow across business boundaries (Vaidya *et al.*, 2018). The integrated and continuous communication between the actors in the supply chain will be the core around which the integrated system will work, making it possible to reduce stockpiles and waste and increase opportunities for customization and efficient production of small lots (Russmann *et al.*, 2015).

Supply chains can thus be transformed into hybrid supply networks (Porter and Heppelmann, 2014), composed of both physical and virtual elements, powered by information and processes flows, no longer exclusively linear, between the actors that are part of the network. This integration will make it possible to achieve higher levels of efficiency and greater flexibility on the production side and responsiveness with respect to changes on the demand side. The trade-off between variety, volume and variability of demand can be overcome, with a better business performance and greater satisfaction of demand (Slack *et al.*, 2013).

The impact can be radical if technological innovation is conceived in a supply chain or network logic, that is, if it includes all the actors involved, allowing the sharing and integration of their production and decision-making processes (Evry, 2016). As with industry 4.0 operations and supply chains of many sectors and enterprises are going to be redesigned (Pfohl *et al.*, 2015) in a logic of strong integration (Russo *et al.*, 2015), the capacity to create value and to acquire a competitive advantage will increasingly depend on the ability to integrate (Porter and Heppelmann, 2014) business functions and processes.

Processes constitute the fulcrum of the fourth industrial revolution and, consistently, it is through processes that the man-machine relationship and the relationship between enterprises operating processes can innovate.

The system of organizational and inter-organizational relations is, therefore, intended to undergo profound transformations. The issue is consequently not only technical, it also takes on a strong managerial and organizational value and require a cultural shift. In order to support this transformation it will be necessary to identify new business models to which enterprises can refer.

If the fourth industrial revolution will make it possible to overcome the trade-off between man and machine, confirming the enhanced role of the man in the economic activity (Caselli, 1995; Tagliagambe and Usai, 1998), and to integrate decision-making processes across business boundaries, the impact of such changes on management may take on an historical significance: a huge cultural challenge that has probably never been experienced in this dimension.

For this reason these changes deserve the maximum attention of management scholars, first of all to understand the phenomenon and then to help guide its evolutionary process.

This emerges clearly from the debate that developed on Industry 4.0. Glas and Kleeman (2016), in a recent study based on a Content Analysis from the literature on the subject, argue that, while still lacking a universally shared definition of the term Industry 4.0, the common element in the different definitions proposed by the literature is the relevance given to the organizational and managerial dimension of innovation: technologies do not constitute the fulcrum of Industry 4.0, but rather they are an enabling element to activate profound innovations at a managerial and organizational level.

Enabling technologies in fact will impact all business functions and processes across the board; they will change not only their operations, but also their way of relating to the other functions of the same enterprises and to the functions of the other actors in the supply chain.

Therefore, if Operations, which are responsible for the management of the production processes, constitute the business function that will be most involved in the changes taking place, the other business functions will also have to reorient themselves in order to allow enterprises to take on the challenges. Amongst these, Procurement plays a central role and can become a driving force for innovation (Nicoletti, 2018). The importance of Procurement has already been highlighted by Porter, who places it in the value chain among those activities that support the primary ones, underlining their strategic importance in order to gain competitive advantage (Porter, 1985). Procurement plays a role of supplying the enterprise, within the correct time frame, with everything that is necessary for its activities. It is, therefore, a function that, by acting on the input side and acting as an interface between suppliers and customers (Giunipero and Brand, 1996), can give a fundamental contribution to pursuit of value (Ellram and Carr 1994; Johnson and Flynn, 2015). Its contribution has also grown over time in light of the increasing importance of purchasing costs (Farmer and Day, 2002), in line with the outsourcing policies adopted by firms (Grant, 2016; Cantone, ed. 2003).

With enabling technologies, Procurement can acquire an even more important role; literature refers to Procurement 4.0, in step with the term Industry 4.0, in order to highlight the need for Procurement to support the development of integrated and digital operations and supply chains⁶.

Geissbauer *et al.* (2016) highlight how Procurement, by bonding suppliers to enterprises, constitutes the link between the various enterprises in the supply chain and the node where all information relating to suppliers and their offers is concentrated. For this reason, they are the holders of strategic know-how. Hughes and Ertel agree in this regard (2016, p. 22): "Sitting at the intersection of a company and its external

⁶ The term Procurement 4.0 also has a meaning that traces a boundary together with the already widespread e-procurement, which aims to exploit the potential of technology (lower costs and shorter times) for carrying out single purchase transactions (Ronchi *et al.*, 2010). In this regard Uygun and Ilie (2018) highlight the need for clarity, overcoming the confusion that still exists between e-procurement and the ongoing digital revolution.

suppliers, procurement can play a unique role in leveraging supplier assets and capabilities to drive innovation, actively support revenue growth and deliver competitive advantage - all while minimizing risk to a company's operations and reputation”.

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In particular, Procurement can have a fundamental role in the construction of the new hybrid integrated networks prefigured by Porter. Procurement must ensure, through correct suppliers' management strategies, the creation of an infrastructural system to support material and information flows in an efficient and agile, transparent, traceable, secure and confidential way (Mantey, 2015). In this sense, their contribution is decisive in the re-engineering of Operations according to a 4.0 logic, through the choice of innovative suppliers, defining contractual conditions and managing relations with them. Furthermore Procurement is called to contribute to the integration of the operations of all the actors of the network (suppliers and customers). The sharing of information and knowledge among all the actors is in fact essential for the network's ability to innovate and for its competitiveness. Procurement plays a decisive role in the construction of a framework that guarantees the secure management of this sharing. This is not only in relation to individual suppliers, but rather, in a network logic. The challenge of the new industrial context is, in fact, to build trust medium-long term relationships between all the actors in the network simultaneously and no longer only between two actors at a time (Bienhaus and Haddud, 2017).

In this regard, Bienhaus and Haddud highlight how the matrix of Kraljic (1983), formulated in 1983 for manufacturing enterprises and still a reference point for the decision-making procurement processes, needs to be renewed. In particular, the Authors highlight that some suppliers can assume strategic importance, for example those that provide digital inputs, despite the lower risk due to the transparency of the information flows enabled by the new technologies. Kraljic's matrix, which is too focused on commodities, should be renewed as also argued by Keith *et al.* (2016, p. 28): “The Achilles' heel of the Kraljic Matrix is that it does not recognize a new form of power - the power of highly strategic and collaborative supplier relationships”.

The challenge for Procurement is, therefore, of great importance and requires new skills. At the centre of a system of processes and relationships in full transformation, Procurement is asked to contribute to re-engineer operations, make them more agile and secure, increase the potential that comes from the relationship with suppliers and their value propositions (Pellengahr *et al.*, 2016). Risk management, security, information sharing and protection of intellectual property are some of the issues that are at the heart of the renewal of Procurement (Stephens e Valverde, 2013; Barron *et al.*, 2016)

In a 4.0 perspective, Procurement must be able to renew itself in order to be able to take advantage of the opportunities offered by the new technologies (Umbenhauer and Youger, 2018).

This is an extremely important issue for the competitiveness of the Italian production system, where Procurement 4.0 is still in its infancy.

In Italy general interest in Industry 4.0 has matured only recently.

The Industry 4.0 National Plan, aimed at supporting knowledge and dissemination of enabling technologies in the Italian production system, was launched in 2017 by the Ministry of Economic Development. In July 2018, the latter published the results of a sample survey, conducted on 23,700 enterprises between October 2017 and February 2018, showing that 86.9% of the total number of enterprises interviewed did not adopt non intend to adopt enabling technologies in the near future. On the other hand, 8.4% of enterprises use at least one enabling technology and 4.7% of enterprises are planning investments in them over the next three years (MISE, 2018). These are low values that require the adoption of adequate measures to promote the spread of a more open culture to innovation. A study by Deloitte (2018a) also highlights the persistence of a significant gap in Italy, compared with other countries, regarding the education and training of the workforce.

More specifically, the spread of digital skills in the workforce is in Italy well below the European average (29% versus 37%). Also with regard to the participation rate in training courses on 4.0 technologies, Italy records a lower value than the European average (8.3% versus 10.8%). Consistently, the robotics industry complains about an insufficient human capital to meet its need of professionals and skilled technicians⁷. The study also shows that the executives interviewed express a favorable opinion on the degree of knowledge about new technologies, although there is still considerable and widespread uncertainty about how to transform the business and organizational models of their enterprises so that the introduction of new technologies can allow the effective achievement of a competitive advantage.

This work aims to contribute to filling this gap and reducing this uncertainty by an empirical research that directly involves procurement executives and managers. Initiatives aimed at promoting attention towards enabling technologies, in the current historical phase, are extremely important in order to help the Italian production system to mature culturally and face a crucial transformation necessary for its global competitiveness. In particular, actions aimed at raising awareness with regard to the opportunities and criticalities linked to enabling technologies, can make an important contribution in this direction.

3. Research methodology

As Procurement 4.0 in Italy is still in its infancy, it was considered appropriate to proceed with a quantitative research methodology that would allow to grasp the initial dimension of the phenomenon. Therefore, a survey was conducted through an online questionnaire (CAWI detection technique - Computer Assisted Web Interviewing),

⁷ The study by Deloitte (2018a) highlights the enormous gap that separates Italy from other European countries in terms of students enrolled in Higher Technical Institutes (9,000 versus 760,000 in Germany, 529,000 in France and 400,000 in Spain), against which the Government is allocating growing resources for the adjustment of the educational offer with respect to the development of new technologies.

based on multiple-choice, numerical and open-ended questions, which was sent to the members of the Italian Association of Procurement and Supply Management (ADACI) by email (about a thousand contacts). The questionnaire was designed to satisfy different cognitive needs without making the compilation too demanding and thus risk discouraging a complete response.

The definition of the questions took place in two stages. First, some international and Italian surveys that are available in the literature were consulted [Vollmer, Machholz (2018), Deloitte (2018b), von der Gracht, Giunipero, Schueller (2016), Pellegahr, Schulte, Berg (2016), Evry Survey (2016), Ministry of Economic Development (2018), Atti (2018)]. They were consulted to better understand the aspects that are of particular interest within the debate and to obtain comparable results from the survey. Second, the questionnaire was submitted to some procurement managers, who helped make the survey more consistent with the needs of the Italian production system and to test its usability and comprehensibility.

The questionnaire was organized in two parts: 1) the first aimed at understanding the state of the art of the procurement processes, regarding both the characteristics of the supplier base and the evolution of the management of the procurement processes. The objective was, in fact, to be able to grasp the level of development of Procurement and associate with it the effective use of technologies in procurement (or at least the cultural attitude toward them). 2) The second part was dedicated to new technologies and to Procurement 4.0. In order to classify enterprises, after the initial questions aimed at understanding the knowledge and cultural attitude towards enabling technologies, the questionnaire was constructed to provide for three alternative paths: 1) a path for those who have adopted enabling technologies, and in this context have adopted Procurement 4.0 solutions (Adopters), 2) a path for those who have not adopted enabling technologies, but who intend to do so in the near future (Interested), 3) the final option, substantially leaving the questionnaire, for those who have not adopted enabling technologies and do not intend to do so in the near future.

Since the objective of the survey is to describe the population of the enterprises observed and study the behaviors/attitudes based on their responses, the statistical analysis of the proposed results is descriptive. New surveys will be carried out in the future to strengthen and generalize the results achieved so far, also through inferential statistical analysis.

The survey form was made available to ADACI members by sending an invitation to fill in the questionnaire to the membership mailing list. The questionnaire remained open for 25 days (from 10 September to 5 October 2018) and two reminders were issued. There were 51 responses recorded, of which 44 complete.

4. The results of the empirical research

4.1 Description of the respondents

Respondents are medium to large⁸ enterprises, which belong primarily to the secondary sector⁹ and are characterized by a high weight of purchases on turnover (57% between 41- 60% and 25% over 60%), a high number of active suppliers (43% over 300), who operate in Italy (100% of respondents), in Europe (EU 67%, non-EU 47%) and in Asia (47%)

In order to understand the degree of development of the procurement processes, respondents were asked to describe their procurement processes in terms of: computerization/automation and formalization degree, time dedicated to different activities (strategic/operational/emergency), presence of a system of Key Performance Indicators (KPIs) and number of KPIs used for performance evaluation, presence of supplier qualification and monitoring systems and use of e-procurement.

With reference to the first aspect, 47% of respondents stated that their procurement processes are quite computerized (computerization/automation concerns 25-49% of the processes), while 63% state that the procurement processes are very formalized (4 and 5 on the Likert scale from 1 to 5, with 1 = no formalized at all, 5 = highly formalized). Respondents use a large proportion of their time in operational activities (39 out of 100), in the resolution of emergencies (20) and in the strategic planning of procurement (20). Much less time is dedicated to the definition of new procurement strategies (11) and to monitoring/evaluation activities (10) (Tabs. 1-2).

Tab. 1: Degree of computerization/automation of procurement processes

Highly computerised (50 - 74%)	24%
Very computerised (50 - 74%)	24%
Quite computerized (25 - 49%)	47%
Little or no computerised, mainly manual (<25%)	6%

Source: Authors' elaboration

Tab. 2: Average time dedicated to the different activities (total 100)

Procurement planning	20
Daily operational management	39
Emergency resolution	20
Monitoring and evaluation	10
New purchasing strategies	11

Source: Authors' elaboration

⁸ Reference is made to the criteria established by the European Commission, in Recommendation 2003/361/EC of 6 May 2003, Commission Recommendation: definition of micro-enterprises, small enterprises and medium-sized enterprises, available from: <https://eur-lex.europa.eu/legal-content/IT/TXT/HTML/?uri=LEGISSUM:n26026&from=IT>

⁹ The percentages relative to the registry data were calculated for 44 respondents, since this information was not provided by those who did not complete the questionnaire.

In almost all cases KPIs are used for performance evaluation (in 4% of cases they are not in place, in 4% of cases the response was ‘I don’t know’¹⁰), with 47% of respondents using 3-4 KPIs. The most used KPIs are Savings (86%), followed by Reduction of purchase order cycle times (49%), Lengthening payment times (33%), Supplier’s degree of innovation (29%).

Tab. 3: The KPIs used in the procurement process

Savings	86%
Reduction of the purchase order crossing time	49%
Lengthening payment days	33%
Supplier's degree of innovation	29%
Reduction of number of suppliers	25%
Sustainability	25%

Source: Authors’ elaboration

A supplier qualification system is present in 72% of the respondents, and it is well structured in 41% of the cases. A supplier performance monitoring system is, instead, present in 76% of respondents, with a share of ‘yes, well structured’ which drops to 31%. With reference to e-procurement, 43% of respondents declare that they are using it, but only for certain categories of purchase (only 8% use it pervasively)¹¹.

The level of respondents’ satisfaction with respect to the performance of the procurement processes indicates a level of 3 for 51% and 4 for 37% (on a Likert scale from 1 - not at all, to 5 - highly). The desired interventions for improving performance are first and foremost for human resources: investments in skills and training (63%) and investments in new human resources (51%). Secondly, they concern investments in technologies: process automation actions (51%), investments in new technologies (43%) and process engineering actions (41%).

Finally, with reference to the perception of IT risks, the survey shows that respondents have a rather low perception of risk (41% do not believe that the enterprise is exposed to risk). This data, to be correctly interpreted, must be read together with that regarding the adoption of measures to manage risk, which were adopted by 69% of respondents (Tabs. 4-5).

Tab. 4: Do you think your enterprise is exposed to IT risk?

Yes, very high	0%
Yes, high	16%
Yes, but to a limited extent	39%
No, I don't think so	41%
I don't know	4%

Source: Authors’ elaboration

¹⁰ This may be due to the fact that in a few cases the respondents are not Procurement managers nor top managers (CEO).

¹¹ E-procurement has been addressed both to understand the degree of development of the procurement processes and to avoid confusion between the topic of the survey (Procurement 4.0) and e-procurement. See what has been highlighted previously in Note 5.

Tab. 5: Have measures been taken to address IT risk?

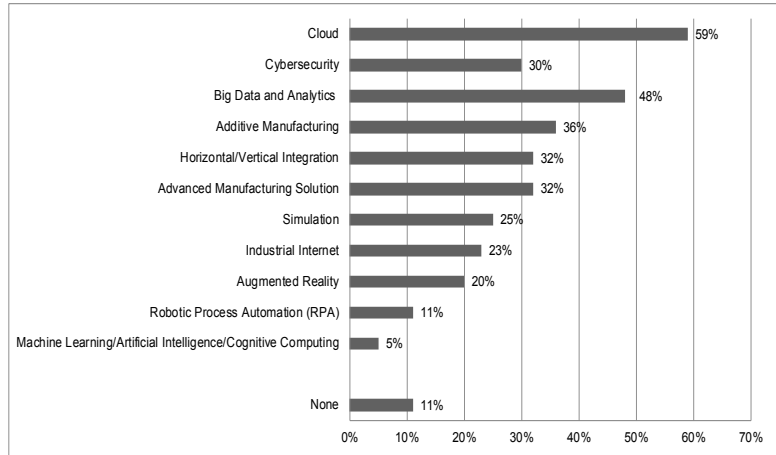
No, cyber risk is not a problem	4%
No, but we're going to do it	6%
Yes, we are organizing ourselves to implement systems and initiatives for the management of IT risk	22%
Yes, we have already implemented systems and initiatives for the management of IT risk	69%

Source: Authors' elaboration

4.2 Enabling Technologies: Knowledge and Cultural Attitude

In order to understand the cultural attitude of the interviewees with respect to enabling technologies, the survey investigated the degree of knowledge of these, as well as their expectations with respect to the impact that they will be able to generate in the future. Regarding the first aspect, we can see that the most well-known are those concerning data management, while 11% of respondents declare that they do not know about any of them. The most chosen are Cloud systems (59%) and Big Data and Analytics (48%), followed by Additive Manufacturing (36%), Horizontal/Vertical Integration and Advanced Manufacturing Solutions (32%) (Fig. 1).

Fig. 1: Knowledge of the different types of enabling technologies



Source: Authors' elaboration

With reference to the cultural attitude, the emerging widespread conviction is that enabling technologies are a radical innovation destined to change the way of doing business, as well as a rather high awareness of the impact they will have on Procurement. In the face of this, respondents believe that awareness of the impact that enabling technologies are destined to generate on business is moderate, as is the lack of awareness of the role that Procurement can have (Tab. 6).

Tab. 6: Degree of agreement/disagreement with some statements concerning enabling technologies

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	absolutely disagree				absolutely agree
ETs are a radical innovation that will change the way we do business	0%	2%	34%	32%	32%
My company is aware of the impact that these technologies may have on the way of doing business	2%	32%	34%	23%	9%
My company is aware of the role that the Procurement Department can play in the introduction/implementation of enabling technologies	9%	41%	34%	11%	5%
My Procurement Department is aware of the impact that these technologies may have on the management/activities of the office itself	7%	30%	25%	34%	5%

Source: Authors' elaboration

Considering the impact that enabling technologies will have on Procurement, it is worth emphasizing how respondents view enabling technologies as an opportunity to enhance the strategic dimension of Procurement and identify the need to develop skills for managing complex contracts and for risk management (Tab. 7).

Tab. 7: How do you think Procurement will change in the near future with the adoption of enabling technologies? (Multiple response)

It will be necessary to strengthen the skills for the management of contracts regulating the sharing of information and know-how	66%
Automation will allow more time to be spent on strategic planning and scouting for new suppliers	59%
The Procurement Department will become strategic for product innovation	52%
Supplier management will play a much more important role	52%
Expertise in risk management and mitigation will need to be strengthened	52%
The Procurement Department will become strategic for process innovation	48%
Data management will become the focus of our business	39%
I don't think the enabling technologies will impact on the operations of the Procurement Department	5%

Source: Authors' elaboration

4.3 The Adoption of Enabling Technologies

With reference to the adoption of enabling technologies, 36% of respondents stated that they are introducing them (Adopters), 34% are in an exploratory phase and 25% will deal with them in the near future. We called this part of the sample (59%) the Interested enterprises. No enterprise has introduced them and also completed the introduction process. Only 5% stated that they do not intend to introduce enabling technologies (Tab. 8).

The analysis of the results will now focus on the Adopters' responses, in order to understand the enabling technologies adopted, with a specific

focus on Procurement, on the problems encountered and on specific characteristics of these enterprises with respect to the other respondents¹².

Tab. 8: What is the penetration degree of enabling technologies in your enterprise?

We have introduced them and the implementation process has already been completed	0%
We're introducing them	36%
We are interested, but we are still in an exploratory phase/we are drawing up a feasibility study	34%
We haven't introduced them, but we'll deal with them in the near future	25%
We have not introduced them and I do not believe that they will be taken into account even in the near future	5%

Source: Authors' elaboration

Enabling technologies in Adopters are primarily in the introduction phase (69%), but in 19% of the cases are already in the consolidation phase.

The most enabling technologies used are those that relate to the intensive and integrated use of information and data: in particular, Cloud systems stand out (63%), followed by Industrial Internet (38%), Big Data and Analytics, Cybersecurity and Horizontal/Vertical Integration (all with 25% of the responses) (Tab. 9).

Tab. 9: ET adopted or in the process of adoption

Cloud	63%
Industrial Internet	38%
Horizontal/Vertical Integration	25%
Cybersecurity	25%
Big Data and Analytics	25%
Simulation	19%
Advanced Manufacturing Solution	19%
Additive Manufacturing	19%
Robotic Process Automation (RPA)	19%
Augmented Reality	13%
Machine Learning/Artificial Intelligence/Cognitive Computing	13%

Source: Authors' elaboration

Enabling technologies involve several business functions: Operations (88%) and Procurement (81%) are in first place, but we also register Logistics (69%), Accounting/management control and Supply Chain (63%). In addition, they involve the other actors in the supply chain (69%)

¹² The survey also investigated 'Interested' respondents, which, however, stated that they intend to introduce technologies for Procurement only in 15% of responses (19% said they had no intention of introducing enabling technologies for Procurement, 66% said they didn't know yet). For reasons of expository synthesis, the results of this part of the survey are not presented here, because they are considered to be of little relevance to the research and not statistically robust.

more than internal processes (31% of cases)¹³.

Procurement involvement deals primarily with the evaluation of suppliers' offers (38%) and with the choice of suppliers (31%), whereas, only in 13% of the cases Procurement is fully involved in the investment planning phase. Respondents believe that Procurement can create value by participating in decision-making processes, particularly in the management of complex contracts (indicated by 94% of respondents) and in risk mitigation (indicated by 75% of respondents).

With reference to the impact of enabling technologies, Adopters declare that the investment in enabling technologies aims to attain higher levels of efficiency (88%) and reactivity (63%) of the processes. At the level of the supply chain, enterprises aim to achieve better efficiency and to exploit the opportunity to share information among multiple actors (both 63%). The figure (63%) relating to a better predictivity is very important (Tab. 10).

With reference to difficulties, the Adopters first and foremost highlight problems in compliance with the scheduled timing and internal resistance to change (63%), but also problems of incompatibility with other actors in the supply chain (50%) and problems related to the high costs of implementation (38%) (Tab. 11).

Tab. 10: The 5 most important impacts of enabling technologies

Greater efficiency of business processes	88%
Sharing information along the SC	63%
Better predictivity	63%
Greater efficiency of the processes along the SC	63%
Greater reactivity of the processes	63%

Source: Authors' elaboration

Tab. 11: The first 5 difficulties encountered

Internal resistance to change	63%
Timing of the implementation process	63%
Incompatibility with other SC companies (suppliers and customers)	50%
Doubts about costs-benefits ratio	44%
High implementation costs	38%

Source: Authors' elaboration

4.4 The Enabling technologies for Procurement: Procurement 4.0

With reference to enabling technologies for Procurement (Procurement 4.0), 56% of Adopters are introducing them, while 13% have introduced them and already completed the implementation process. This process is very recent, since most introduced them in 2017, even if there are also enterprises that have introduced new technologies for more than three years (27%).

¹³ Enabling technologies involve first upstream actors (38%), then downstream ones (25%). The cases in which the enabling technologies act only downstream of the supply chain are instead isolated (6%).

Also here Cloud systems are confirmed as the most used technologies (64%), followed by Big Data and Analytics and Industrial Internet (both 36%) (Tab. 12).

Tab. 12: Procurement 4.0 - Technologies adopted or in the process of adoption

Cloud	64%
Industrial Internet	36%
Big Data and Analytics	36%
Cybersecurity	27%
Horizontal/Vertical Integration	27%
Robotic Process Automation (RPA)	18%
Simulation	9%
Machine Learning/Artificial Intelligence/Cognitive Computing	9%

Source: Authors' elaboration

The introduction of enabling technologies for Procurement is a process that starts mainly within the enterprise (only in 18% of cases it aims to satisfy the requests of other actors along the Supply Chain), with the aim of increasing efficiency and reducing purchase processing time (91%), simplifying processes and procedures and increasing market opportunities (64%). Very important, in 55% of the cases enabling technologies are consistent with the enterprise's propensity for innovation.

Considering the difficulties encountered by the Adopters, the timing is confirmed as the most significant criticality (64%), along with incompatibility with other enterprises' supply chains (64%). Resistance to change by other actors within the supply chain is also very important (55%) (Tabs. 13-14).

Tab. 13: Procurement 4.0 objectives for Adopters

Procurement 4.0 aims to reduce purchasing time	91%
Procurement 4.0 aims to increase efficiency in internal processes and along the SC	91%
Procurement 4.0 aims to simplify internal processes and procedures	64%
Procurement 4.0 aims to increase market opportunities	64%
Procurement 4.0 is consistent with the company's propensity for innovation	55%
Procurement 4.0 aims to reduce costs	45%
Procurement 4.0 aims to increase the quality of work	36%
Procurement 4.0 aims to meet the demand of other SC companies	18%

Source: Authors' elaboration

Tab. 14: The first 6 difficulties encountered

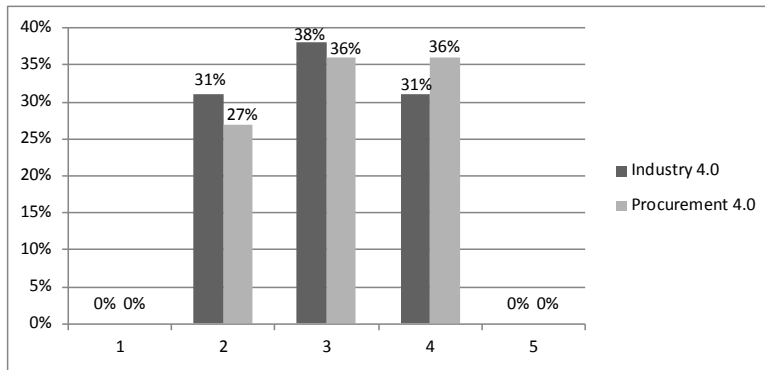
Incompatibility with other SC companies (suppliers and customers)	64%
Timing of the implementation process	64%
Resistance to change of the other companies of the SC	55%
Internal business processes unsuitable to support/benefit from enabling technologies	45%
Incompatibility with corporate culture	36%
Doubts about the security and secrecy of information and transactions	36%

Source: Authors' elaboration

The survey also attempted to investigate the degree of satisfaction expressed by Adopters, which seems quite high with regard to both Industry 4.0 technologies (69% ≥ 3 on a Lickert scale from 0 to 5) and Procurement 4.0 (72% ≥ 3 on a Lickert scale from 0 to 5) (Fig. 2).

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Fig. 2: The degree of satisfaction of the Adopters



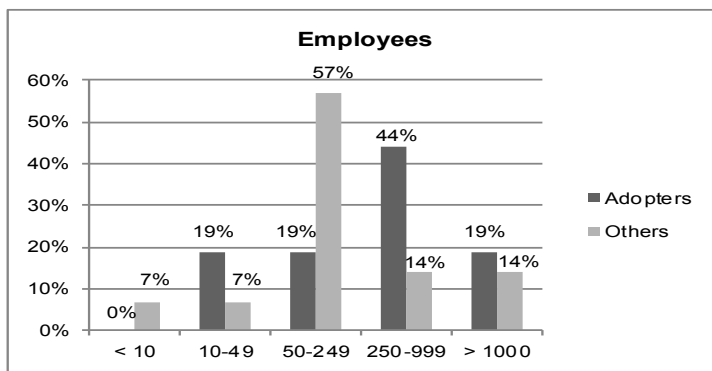
Source: the authors' elaboration

4.5 The Adopters: Specificities

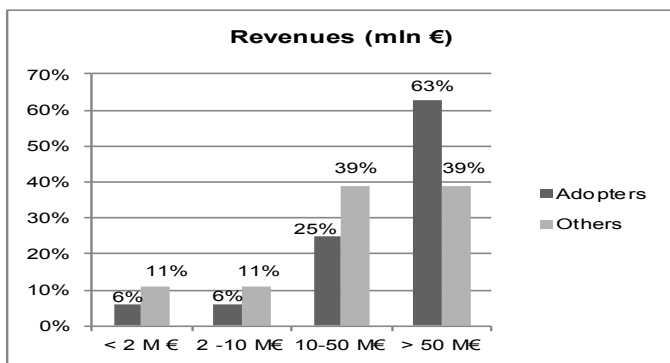
In order to see whether the Adopters have specific characteristics that would be useful for indicating a type category of innovative enterprise, the descriptive analysis of the results focused on Adopters.

The comparison between Adopters and the other enterprises shows that Adopters are on average larger, both in terms of employees and in terms of their turnover. Moreover, they have a broader range of suppliers characterized by a greater degree of internationalisation; and they have more formalized and computerized/automated procurement processes. They are more advanced in terms of supplier qualification systems, even if not in terms of supplier monitoring.

Figs. 3: Adopters' dimensions



Figs. 4: Adopters' dimensions



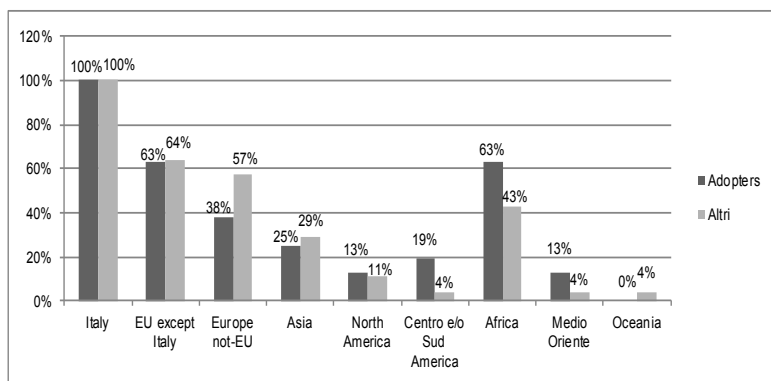
Source: Authors' elaboration

Tab. 15: The number of Adopters' active suppliers

	Adopters	Others
up to 50	6%	11%
from 51 to 300	31%	57%
more than 300	63%	32%

Source: Authors' elaboration

Fig. 5: Location of Adopters' suppliers



Source: Authors' elaboration

Tab. 16: Degree of formalization of procurement processes in Adopters

	Adopters	Others
Not at all formalised (=1)	0%	0%
2	0%	11%
3	25%	32%
4	44%	39%
Highly formalised (=5)	31%	18%

Source: Authors' elaboration

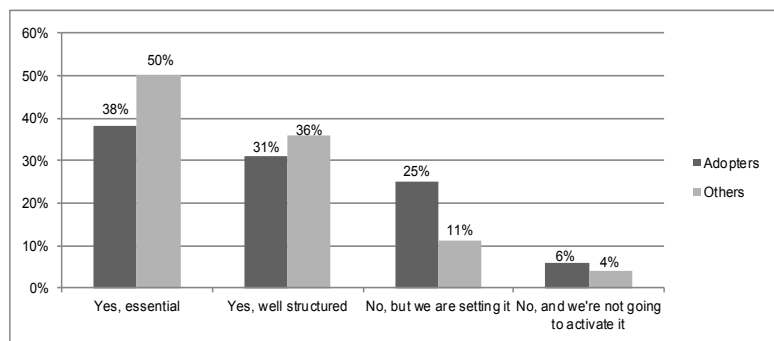
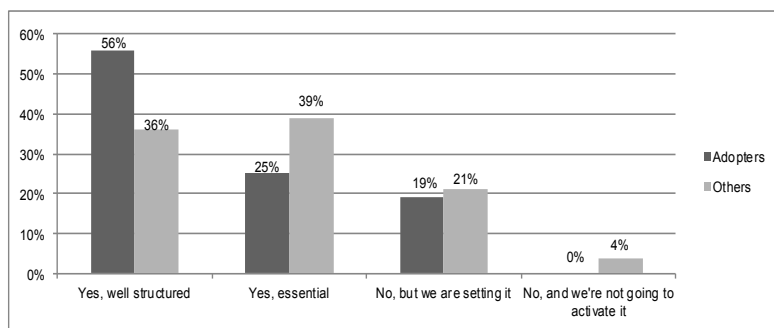
Tab. 17: Degree of computerization/automation of procurement processes in Adopters

	Adopters	Others
Little or no computerised, mainly manual (<25%)	0%	7%
Quite computerized (25 - 49%)	38%	54%
Very computerised (50 - 74%)	38%	18%
Highly computerised (50 - 74%)	25%	21%

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Source: Authors' elaboration

Figs. 6-7: Supplier qualification and monitoring systems - Adopters vs Others



Source: Authors' elaboration

With reference to the impact of enabling technologies as stated by the interviewed managers, three aspects, already emerged considering the sample as a whole, stand out. On one hand, the viewpoint emerges that automation will make it possible to dedicate more time for strategic planning and scouting for new suppliers. On the other hand, the need to enhance skills in legal matters is evident in order to be able to manage the growing complexity of contracts, and also in the management and mitigation of risks. For Adopters, data management will play a more important role in procurement activities, to a greater extent than the other respondents (44% versus 36%). Furthermore, according to the Adopters, Procurement will become strategic for product innovation (63% versus 46%).

Tab. 18: How do you think Procurement will change in the near future with the adoption of enabling technologies? (Multiple response)

	Adopters	Others
Data management will become the focus of our business	44%	36%
The Procurement Department will become strategic for process innovation	38%	54%
Expertise in risk management and mitigation will need to be strengthened	69%	46%
Supplier management will play a much more important role	50%	54%
The Procurement Department will become strategic for product innovation	63%	46%
Automation will allow more time to be spent on strategic planning and scouting for new suppliers	81%	46%
It will be necessary to strengthen the skills for the management of contracts regulating the sharing of information and know-how	75%	57%
I don't think the enabling technologies will impact on the operations of the Procurement Department	6%	4%

Source: Authors' elaboration

5. Discussion of the results

The survey made it possible to identify a sample of enterprises that are very keen to actively participate in the digital transformation processes that are under way. Enterprises that have adopted or are adopting enabling technologies (Adopters) and enterprises that intend to do so in the near future (Interested) represent 95% of the respondents; this is an extremely high figure when compared to those presented by the MISE research (2018), in which only 8.4% of enterprises use at least one technology and 4.7% plan to make investments in enabling technologies in the next three years. However, since the rate of participation in our research is low, despite the fact that the survey was carried out by the Italian Association of Procurement and Supply Management (ADACI), it is likely that in our survey a non-response should be considered as an expression of disinterest and, therefore, of non-engagement in the activation of enabling technologies.

Therefore, if the sample of respondents cannot be considered to be representative of Italian enterprises and since the results of the research do not lend themselves to generalization, the results allow us to examine the features and choices of very interesting enterprises from the point of view of the ongoing digital transformation.

The study demonstrates a good knowledge of the enabling technologies, a full awareness of the challenges they offer and a good level of satisfaction in the results achieved through investments in technologies. The results show a high cultural maturity of the respondents, who express a widespread belief that technologies are a radical innovation intended to change the way of doing business and the way of managing procurement processes. In addition, enabling technologies are seen as an opportunity to enhance the strategic dimension of Procurement. Also the attitudes towards the information technology risk, which appears to be substantially under control thanks to the adoption of appropriate measures, highlights the enterprises' awareness of the risks associated with the digital revolution.

Moreover, respondents believe that enterprises' awareness of the impact of enabling technologies is moderate, just as the awareness within the enterprises of the role that Procurement can assume is scarce. This appears to be confirmed also by the fact that one of the main difficulties expressed by respondents concerns the internal resistance to change. This attitude appears to be in line with the results of a German study, which still showed a certain resistance and a certain skepticism on the part of managers regarding the opportunities that Industry 4.0 can offer to enterprises and to Procurement in particular (Glas and Kleeman, 2016).

The same role assumed by the Adopters' Procurement function in investment in enabling technologies tends to remain anchored to traditional tasks: the evaluation of suppliers' offers in 38% of the cases and the choice of suppliers in 31%, while only 13% of the responses indicate that Procurement is already involved in the investment planning phase.

In view of this, respondents hope for greater involvement of Procurement in the conviction that it can contribute to creating value in various areas, including some that in the current global competitive framework play a decisive role, such as the management of complex contracts and risk mitigation.

Respondents show a marked propensity for innovation, not only from a technological point of view, but also from a managerial point of view. The introduction of technologies takes on a pervasive nature, involving transversally different business functions and different actors in the supply chain, increasing communication flows and sharing. From this initial evidence, respondents appear to be active in the construction of integrated hybrid networks, in which, as anticipated by the literature, traditional physical elements are integrated with digital ones. The most highly adopted technology is, in fact, Clouds, which allows enterprises to share data and information, therefore, offering a fundamental infrastructure for process sharing and integration.

The role of innovators is confirmed by the fact that, regarding the adoption of specific technologies for Procurement, respondents state that the enabling technologies are consistent with the propensity of the enterprise to innovation (55% of the cases), while there is only a low percentage (18%) of enterprises adopting enabling technologies to satisfy the demands of other enterprises in the supply chain. This is a complex process, which will require much time, considering that the problems of incompatibility with other actors in the supply chain and their resistance to change are among the main difficulties highlighted by respondents.

These considerations suggest that the panel of enterprises identified in the research can be considered an interesting reference point for understanding and advancing this ongoing process. Indeed, this study has demonstrated that these enterprises have specific characteristics: they are larger and have a larger and more internationalised active supplier base than the other participants; their procurement processes appear to be more advanced in terms of formalization, computerization/automation and qualification of suppliers.

These characteristics suggest, within the limitations of the analyzed data, that Adopters can be considered as innovators capable of leading

6. Conclusions

This research constitutes the first step in a wider body of research that aims to support enterprises in the complex adoption of enabling technologies during this crucial transformation phase for the Italian competitiveness within a global framework. Since Procurement plays a central role in the introduction and implementation of technologies, as well as in creating and managing innovative relationships with suppliers, a particular focus on Procurement in the field of research on Industry 4.0 would appear to be fundamental.

The research aims to provide useful information for decision-makers, primarily for managers and policy-makers. The article highlights the strong cultural dimension of the fourth industrial revolution, which requires a strong involvement of all the actors.

This first phase, based on a quantitative research methodology and on a statistical analysis of descriptive data, has made it possible to involve the enterprises that are most attentive to a phenomenon in its infancy and, for this reason, it suffers from a lack of participation.

On the other hand, the fact of having identified a panel of innovative enterprises that can play a role in driving innovation will allow to deepen the experiences already documented and to produce an awareness-raising effect towards other enterprises.

In order to nourish the know-how created up to this point, the research will continue in two directions: on one hand the results obtained will be studied in depth with qualitative research, through case studies, in order to better understand the phenomenon. The objective is to verify whether Adopters are actually playing a role in driving innovation within their supply chains and how this role is developing. It will be interesting to see whether hybrid and integrated supply networks are actually developing in Italy, in which sectors and in which geographical areas. On the other hand, we will try to broaden the sample of enterprises with new quantitative research that will make it possible to statistically strengthen the results gathered in this phase, also through an inferential analysis. The hope is that these activities, conducted through a solid university-business partnership, will nourish an action of cultural fertilization within the Italian production system.

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