INDUSTRY 4.0 INVESTMENTS IN MANUFACTURING FIRMS AND INTERNATIONALIZATION

Marco Bettiol, Mauro Capestro, Valentina De Marchi, Eleonora Di Maria

Department of Economics and Management, University of Padova, Italy, 33 via del Santo, 35123, Padova

ABSTRACT

There is a growing attention on the relationship between investments in industry 4.0 technologies – specifically 3D printing – and internationalization processes. Such technologies can modify the scale and the organization of manufacturing processes, potentially pushing firms in the redefinition of their activities worldwide. At the same time, firms with manufacturing activities located in high-cost countries can benefit from industry 4.0 investments for increasing productivity. Although these relevant implications, limited attention is given to explore how manufacturing firms adopt industry 4.0 technologies in relation to their degree of internationalization. Based on an original dataset of about 1,400 Italian manufacturing firms, the paper analyzes the technological investments strategies of 200 Industry 4.0 adopters in terms of intensity of technological adoption, differences in the technological solutions used and related motivations, taking into account the location of their manufacturing activities as well as export. Results suggest that the adoption of 4.0 technologies *per se* is independent from the level of internationalization, while internationalized and domestic firms invest in different technologies. Among the four groups of firms identified (global/domestic sourcing – export/domestic market) differences in motivations arise as well as in the steps of value chains where technologies have been implemented.

Keywords: industry 4.0, internationalization, manufacturing, global sourcing, high-cost countries, 3D printing, automation

INTRODUCTION

The new waves of technologies described as "industry 4.0" (Roblek, Meško, & Krapež, 2016) has being transforming how firms configure their value chain and organize their manufacturing processes. Scholars and practitioners are putting the attention, on the one hand, on the rise of the smart factory, redesigning the efficiency of operations – i.e. thanks to new cyber-physical systems (Ustundag & Cevikcan, 2018) and, on the other hand, on new forms of interactions with markets – i.e. through Internet of Things (IoT) and big data (Manyika et al., 2015).

Within the international business debate new research is pointing out the potential transformation that the fourth industrial revolution can have on the international dimension of firms (Strange & Zucchella, 2017). Much attention is devoted to consider how especially 3D printing can affect the location of manufacturing activities with respect to final markets or the domestic context, in relation with the potentialities of product variety and high degree of customization it can offer (Ben-Ner & Siemsen, 2017; Ravi Shankar Kalva, 2015). Scholars suggest the potential positive relocation advantages (reshoring) as well as a new processes of value creation related to a more close (direct, co-located) relationship with customers – also from an innovation perspective (Bogers, Hadar, & Bilberg, 2016). However, research is far from being conclusive (Laplume, Petersen, & Pearce, 2016; Rehnberg & Ponte, 2018), suggesting different scenario could arise, also depending on the specific technology considered. Furthermore, very few empirical evidence have been developed so far, to test if and how industry 4.0 is effectively heavily impacting firms' activities and decisions, especially as far as their location choices are considered.

In this scenario we aim at understanding if and how the adoption of Industry 4.0 technologies by manufacturing firms is connected with different internationalization strategies. Those new set of technologies – and in particular Co-robots, 3D printing, Industrial IoT, and Big Data – can be very transformative in the organization of production processes both within the firm and along the supply chain (Roblek et al., 2016). The fourth industrial revolution highlights the rise of new logics in the production that potentially involves any manufacturing firm. Such possibilities might support global factories to rethink their degree or geography of internationalization (Hannibal & Knight, 2018), while domestic firms may rely on such technologies to strengthen their international competitiveness, especially in case they are located in high-cost countries (de Treville, Ketokivi, & Singhal, 2017). So both groups of firms can be motivated by investing in Industry 4.0 technologies yet it might be expected that the reasons to adopt and the way in which they are adopted differ. Against this background, we provide an analysis of the investment strategies of Industry 4.0 technologies in relation to their internationalization strategies, based on an original database on Italian manufacturing firms. Our contribution is multifold. We provide an empirical account of *what* are the Industry 4.0 technologies adopted and *why* firms are adopting industry 4.0 technologies in their activities. In doing so we are able to disentangle firms considering for their internationalization strategies, i.e. both considering their *upstream* internationalization (distinguishing firms that are engaged in global sourcing vs. domestic firms) and for the *downstream* internationalization approach (i.e. considering if they are engaging with export market rather than with domestic one). Furthermore, this analysis allows to disentangle among different technologies, e.g. 3D printing, automation, big data. The paper is organized as follow: the second section analyzes the theoretical framework by considering contributions related to the relationship between technological innovation, manufacturing activities and internationalization; the third section empirically analyzes the Industry 4.0 investments in Italian manufacturing firms; the fourth section discusses the results and offer conclusive remarks.

THEORETICAL FRAMEWORK

Industry 4.0 technologies and the transformation of production

A growing number of studies disputes about the consequences of technological innovation connected to the "industry 4.0" concept on firm's activities and processes (Sauter, Bode, & Kittelberger, 2015; Schneider, 2018). At the heart of the debate there is the new emerging paradigm of the fourth industrial revolution, that promises to redefine the sources of value through the exploitation of technologies such as co-robots, additive manufacturing, Internet of Things (Io), big data, or artificial intelligence, being directly connected to manufacturing. In fact, the focus of this radical transformation is the manufacturing sphere, where production activities can be deeply modified in connection with such enabling technologies, which can be employed for both product and process management. The combination of cyber-physical systems with internet connectivity might define a new phase of industrialization (Ustundag & Cevikcan, 2018). Other authors have suggested that such technologies – and especially those connected with data management – could servitize manufacturing. More powerful and connected technological infrastructure firms could enhance their manufacturing systems up to developing Manufacturing-as-a-Service or Product-as-a-Service approaches (Ghobakhloo, 2018). In this perspective, Industry 4.0 defines a new path for the competitiveness of the manufacturing firms, especially in advanced countries such as in Europe (World Economic

Forum, 2018), which are nowadays particularly challenged by global competition and which might find in these technologies a new source of competitive advantage.

The smart factory is characterized by increased transparency in its operations activities and in the supply chain, together with more controlled and integrated production processes, in a scenario of progressively distributed, intelligent processes (Almada-Lobo, 2016). The different technologies included in the umbrella term ‘industry 4.0s’ have been suggested to support a radical change in production in different ways.

As far as robotics is concerned, new opportunities of efficient and tailored production arise; productivity increase might arise through a new organization of labor (Autor, 2015; Manyika et al., 2017). In addition to robotics, 3D printing or additive manufacturing (AM) has been viewed as the emblem of the fourth industrial revolution, due to the radical impact on production. AM is not related to economies of scale, but allows firms increasing their variety of production. Through AM, firms increase their ability to cope with the specific requirements of customers, producing tailored products – also in coordination with open innovation approach that involve customers in the product development (Petrick & Simpson, 2014; Rayna & Striukova, 2016). From this perspective, a shift can occur in terms of competitiveness from large to small firms, overcoming the advantages of size – i.e. large factories located in low-cost countries – to include instead the ability to transform market’s inputs into products – i.e. small firms with specialized and integrated competences in design and production – up to the direct production at the customer level (Anderson, 2012; Ravi Shankar Kalva, 2015).

IoT and big data technologies has been suggested to open up important opportunities to transform and customize both the products and the processes through which they are realized. Transferring data to the firm for product improvement or service deployment, products become ‘smart’, offering additional value to the customers (Manyika et al., 2015). In addition to products, also the manufacturing system as a whole can become an Industrial IoT (IIoT), impacting on the value proposition, collaboration within the networks of partners, or distribution and customers' interaction (Kiel, Arnold, & Voigt, 2017). Smart, connected products transform the entire value chain, creating new process requirement and, above all, extending the manufacturing domain: as reported by Porter & Heppelmann (2014) "manufacturing now goes beyond the production of the physical object, because a functioning smart, connected product requires a cloud-based system for operating it throughout its life" (Porter & Heppelmann, 2014: 103).

Industry 4.0 technologies and implication for internationalization strategies

The picture depicted above shows interesting business opportunities for firms to improve their competitiveness by mastering manufacturing processes within a renovated technological context. It suggests also, however, that Industry 4.0 technologies – each in its peculiar way – may impact differently on the organization of manufacturing activities.

In their recent contribution, Strange and Zucchella (2017) discuss about the implications for multinational firms (MNEs) and international business theory of the fourth industrial revolution. According to the authors, industry 4.0 technologies may deeply modify the international organization of manufacturing activities, pushing the degree of integration within the value chain and a more optimized production. In their review, they stress how different technological solutions have potentially different impacts on manufacturing processes and the structure of (global) value chains, especially considering for location decisions.

In this debate, studies focusing the relationship between Industry 4.0 and internationalization have put in particular at the core of their analysis 3D printing technologies, which may on the one hand facilitate the international reorganization of production closer to the final market, but on the other hand also supporting a new international division of labor and the rise of 3D printing supercenter. Laplume et al., (2016) in their conceptual study on 3D printing in global value chains are very open towards the impact of such technology on the organization of global activities, where some industries may be radically transformed through decentralization and dispersion of production activities, while other may be not affected. This view is also proposed by Rehnberg & Ponte, (2017), who discuss two opposite scenarios for manufacturing in global value chains: the first scenario is that of complementarity, where 3D printing radically impact on the value attached to manufacturing, moving down the "smiling curve" and push the integration (bundling) of activities, transferring the power to the actors with high degree of knowledge related to customers' need and reducing the competitive advantage of economies of scales in production; the second scenario is that of substitution, where the GVC is mainly characterized by fully 3D printed products and so the "smiling curve" moves up in relation to manufacturing, pushing production to be closer to final customers.

According to some authors (Ben-Ner & Siemsen, 2017) the shift towards the AM paradigm allows firms transforming the way they conceive and produce products to be close to their customers within a view of decentralized and localized organizations. (Hannibal & Knight, 2018) instead suggest that firms may benefit from a domestic location of production – i.e. related to country-of-origin effect – in some industries while for others may be more relevant the production close to customers, or even carried out by customers. In their deep analysis of the AM-related factors likely to affect the localization of production, Hannibal and Knight stresses a more nuanced, open view of the relationship between manufacturing processes and internationalization dynamics where innovation (i.e. Intellectual property rights), marketing (i.e. brand), and operations-related factors (i.e. material types) play different roles.

A similar impact on location and ownership decisions might has be envisioned also for other 4.0s technologies. IoT enhance coordination at the international level and the overlap between product and information flows, hence reducing transaction costs and an even more distributed location of production (Strange & Zucchella, 2017). Firms can invest in order to develop connectivity competences to coordinate a wide, distributed set of activities from production to customer services, where co-location can be a key advantage for firms, however considering ubiquity not only from a geographical point of view, but also organizationally and in terms of value creation ("digital ubiquity" as proposed by Iansiti & Lakhani (2014). Advanced, versatile and interconnected robotics can reduce the convenience of locating production in low-cost countries,, modifying the convenience of offshoring decisions and pushing re-shoring initiatives (Müller, Dotzauer, & Voigt, 2017).

To sum up, the literature suggests that, exploiting industry 4.0 technologies, firms might be considering to modify their location decisions, i.e. relocating production activities domestically (reshoring) (Ancarani & Di Mauro, 2018) and/or close to final markets so as to important revising the organization of activities at the global scale, at least in the context of advanced countries (UNCTAD, 2017). However, this process is not fully explored nor empirically developed. In this scenario we can expect that manufacturing firms with different degrees of internationalization may adopt industry 4.0 technologies. On the one hand, in fact, firms with upstream internationalization can see the advantages of investing in Industry 4.0 to reconfigure their value chains by locating production at home (reshoring linked to automation for productivity) or close to the market for enhanced product variety (*via* 3D printing). On the other hand, also firms producing domestically may adopt such technologies, but rather for improving efficiency, productivity, or support higher levels of customization. This could be especially true for firms located in high-cost countries, where not only the headquarter, but also the production is located, and that might be willing to invest in relation to the need of strengthening their international competitiveness (de Treville et al., 2017).

As suggested by Strange & Zucchella (2017), the consequences on the location of value chain activities and the ownership of Industry 4.0 investments, are open and have to be further investigated. Our research question is to explore the technological investment strategies of manufacturing firms related to Industry 4.0 considering for different levels of internationalization of production. It should investigate the motivations that drive domestic firms and firms with international production towards the fourth industrial revolution. Similar discussion should be reported considering for the exporting attitude of firms, when the drivers could be linked to increase the scale or firm's ability to mass customize products to adapt to different market characteristics (i.e. via automation) or to increase the value added of the products, i.e. investing in data management technologies that might allow broader servitization (via big data and IoT).

EMPIRICAL ANALYSIS

Methodology

To explore our research question, we conducted a survey targeting Italian firms. Italy is among the most important manufacturing countries worldwide, and in 2016, the Italian government promoted a "National Plan for Industry 4.0" specifically oriented to provide financial support and fiscal incentives to spread the adoption of Industry 4.0 technologies among manufacturing firms. This study focused on the firms of Made in Italy sectors (fashion, automotive, furnishing and home-products) located in northern Italy. Firms located in northern Italy account for a major portion of the Italian gross domestic product (GDP), and in national competitiveness in international markets. The population consisted of 7,714 manufacturing firms drawn from the Aida–Bureau van Dijk database that contains comprehensive financial and economic information on companies in Italy. We sampled firms in 11 industries (automotive, rubber and plastics, electronic appliances, lighting, furniture, eyewear, jewelry, sport equipment and textile-footwear-clothing) and with firm annual revenue higher than 1 million Euros. For industries such as lighting, eyewear, jewelry and sport equipment, we selected firms with annual turnover of less than 1 million Euros. We made this choice because those industries are characterized by the strong presence of industrial districts. As the literature (Becattini, Bellandi, & De Propris, 2014) has pointed out, even small firms can be competitive, due to the high specialization within the local value chain. To capture this peculiarity, we enlarged the sample accordingly.

Based on a structured questionnaire submitted through computer-assisted web interview (CAWI) methodology to entrepreneurs, chief operation officers (COOs) or managers in charge of manufacturing and technological processes, we contacted firms, and 1,229 firms (15.3%) responded to the questionnaire. Based on the literature (Almada-Lobo, 2016), the questionnaire was built to assess the adoption of the following technologies: (1) robotics, (2) additive manufacturing, (3) laser cutting, (4) big data and cloud, (5) 3D scanners, (6) augmented reality and (7) IoT (Internet of Things) and intelligent products. From the 1,229 (15.93% of population) questionnaires collected, 205 firms declared to adopt at least one of the seven industry 4.0 technologies considered. These technologies are those that more than others, support the strategic needs of manufacturing firms in B2C and in B2B markets (Bonfanti, Del Giudice & Papa, 2018; Sanders et al., 2016). The questionnaire also assessed other firm characteristics, the process of adoption, the reasons underlying the firm's decision to adopt or not adopt the new technologies and the value chain activities on which the firm focused its Industry 4.0 investment. Table 1 and 2 report the descriptive statistics of the sample considered and the key characteristics of the adopting firms.

[insert table 1 about here]

[insert table 2 about here]

In order to analyze the differences in industry 4.0 adoption between firms that engage in different internationalization strategies, we focus just on firms that have adopted at least one of the 4.0 technologies mentioned and divide the sample of such adopters in two groups. Based on a question asking the location of suppliers (taking into the size of the firms and the main focus on sourcing rather than FDI as form of internationalization for the population considered) (Chiarvesio & Di Maria, 2009; Coviello & McAuley, 1999), we classify in the group 'Global Sourcing' firms that reported that at least part of the production has been realized abroad through foreign suppliers, in the group 'Domestic Sourcing' all the others. Furthermore, in order to identify if any differences exist, considering also for the export propensity of the firms, we further divide each of these groups in two, considering if they have been exporting at least part of their offering or not. Figure 1 visualizes the four internationalization strategies that we are analyzing in the following, depicting the different degree of internationalization of the interviewed firms. As for our sample, 45.9% of the firms do global sourcing, whereas the majority (54,1%) relies on domestic sourcing, coherently with the expectations as for the Italian manufacturing context. When contextually considering for the export propensity of firms, the majority of firms (40.5%) falls within the group 1, i.e. being internationalized both upstream and downstream or within the group 3 (performing domestic sourcing yet being export oriented, i.e. the 32.2% of the total sample). Groups 2 and 4, representing firms that are not exporting and they are performing global and domestic sourcing respectively, are instead less numerous (5.4% and 22% of the total sample respectively): the underlying population – Italian firms specialized in the so-called *made in Italy* sectors – are indeed quite export oriented.

[Insert Figure 1 here]

Results

As emerges from the literature, the different technologies that are included in the umbrella term industry 4.0 can have very diverse impacts on firms' activities and different implications for location decisions. As emerges from Table 3, the first analysis performed regards the types of industry 4.0 technologies adopted. Robotics, Additive Manufacturing, Laser cutting and Big data are by far the most adopted industries in both samples. However, interesting differences emerges among the groups of firms that are sourcing Globally vs. Domestically. As for firms that are managing a production network that spans international borders (group 1) Big data and laser cutting are the most diffused technologies (47.9% and 45.7% respectively). As for domestic sourcing firms, Robotics is instead the most diffused (adopted by 45.9% of the adopters considered), followed by laser cutting (diffused at a rate quite similar to the other group – 45.0%). 3D scanner, AR, IoT are instead less diffused, among both groups, despite interesting differences emerges especially as far as IoT is considered. When controlling for the statistical significance of those differences, the chi square test suggests that technologies that manages data are statistically significant. Indeed, Big Data and IoT are more likely to be adopted by firms that are sourcing globally than firms that are just focused on domestic sourcing.

[Insert table 3 about here]

Table 4 shows to what extent such results are consistent when further subdividing the sample, considering also for the export propensity of firms. The analysis suggests the importance to consider for different technologies separately: each group of firms is characterized by different technology adoption patterns. In Group 1 (Global Sourcing & export), the most 'internationalized group', half of the firms adopted Big Data technologies (50.6%); whereas a good share adopted also more manufacturing related technologies, i.e. Laser Cutting (43.3%) and Robotics (42.2%). Global sourcers that are not exporting (group 2, being the smallest of the sample) is characterized by a stark diffusion of both laser cutting (63.6%) and AM (54.5%). As for Domestic sourcing firms, group 3 (including the exporter firms) is characterized by the diffusion of production related technologies (Robotics and Laser Cutting, but at 50%); group 4, depicting the less internationalized firms, is characterized by the diffusion of the same technologies and yet a higher diffusion of IoT technologies. Differences among the groups are significant especially when comparing group 1 and 3, i.e. when comparing firms that are exporting yet have a different configuration of production activities between the domestic and global level, which differs significantly (at the 5% level) as for data related technologies (Big Data and IoT). Less statistically significant is the difference in the use of Big Data between group 1 and 4, and on Robotics as for group 2 and 3. As for the number of technologies adopted not statistical differences emerges: firms of all groups are adopting, on average, more than one technology at a time, suggesting the existence of potential complementarities among technologies.

[Insert table 4 about here]

When comparing the motivations across the different groups, it seems the groups of firms that are implementing global sourcing is quite similar to those that are implementing domestic sourcing strategies (see Table 5). For both the most important motivations that spur the investments in 4.0 technologies regards the possibility to improve customer service (rated 3.9 for both groups, in a 5 points likert scale, spanning from 1 to 5), followed by the importance to search for efficiency (slightly more relevant for global sourcing firms rather than domestic sourcing ones, i.e., 3.7 vs 3.5). An interesting result emerges, however, which is particularly relevant for the present study. Indeed, the only significant difference across the two groups is the possibility to face the international competition, which is more relevant for firms that are sourcing globally (3.7 in a 5 points likert scale, the second most important motivation for investments) rather than for firms that are producing and sourcing within the national boundaries (3.1, the fourth most important reason).

[Insert table 5 about here]

The analysis reported in Table 6 allows further understanding this element, confirming again the highest importance of the international competition in spurring investments in industry 4.0 technologies. Such element is the most important for the group of firms being more internationally open (1) (3.9 in a 5 s likert scale), together with the importance to improve customer service. This relevance is significantly higher than for all the other group of firms (group 2, 3, 4). Interesting, and significant differences characterizes also the less internationalized group, i.e. the group of firms that are not engaging in global sourcing nor in exporting activities. Indeed, this is the group for which the interest in increasing the variety in the products offered and the possibility of opening new market opportunities has been the less relevant to spur the adoption of industry 4.0 technologies.

[Insert table 6 about here]

Other than the *what* (which technologies), and the *why* (the motivations for adoption), our analysis has been focused also on understanding the *where (in which phase of the value chain)* of industry 4.0 adoption, considering for different internationalization strategies. Table 7 reports information regarding the activities of the value chain in which 3D printing, robotics or any other of the industry 4.0 technologies considered in this study have been adopted. Confirming what supported in the literature, such technologies have been adopted mostly in the production process (an evidence that is even more so for the group of domestic sourcing firms). Another area in which they have been adopted by more than half of the firms in both samples is the prototyping. Interestingly, a stark difference among the two groups regards instead the New Product Development phase, which is much more relevant for Global sourcing firms (53.9% of them) than for the domestic sourcing firms (33.8%). Such results should be interpreted in connection with the evidence of the highest diffusion of information-related industry 4.0 technologies for global firms, which might easy the process of development of new products connecting actors spread across the globe. Another important result, which is important to discuss if interested in understanding the relationship between the diffusion of 4.0 and firms' internationalization strategies regards the importance of their use to support the logistic and supply chain management functions. While this is the case for just a small group, it is important to notice that adoption is significantly higher for firms implementing global sourcing strategies (15.7% vs 5.4%) – again, a result that can be easily interpreted with the higher need to coordinate the wider network.

[Insert table 7 about here]

Table 8 allows confirming and further deep into the issues just reported, reporting differences in adoption across the four groups, considering for the value chain activity in which the technology has been adopted. Again, production activity is the phase that emerges as the most important area of application of 4.0 technologies; this is especially the case of the most local firms (group 4: domestic sourcing and no export activity), being statistically different from all the other groups considered. The focus on the earlier stage of the value chain (new product development and prototyping) is instead higher for the groups which are internationally open downstream; the use of industry 4.0 to support new product development is significantly higher for the group of firms that are implementing global sourcing and exporting strategies (being diffused among 55.1% of the firms in this group), as respect to firms that are sourcing domestically, irrespectively to their final market strategies (as respect to 34.5% and 31.6% respectively). Results confirm statistically significant differences among the four groups also as far as logistic and supply chain management is considered, which is particularly absent for firms that are sourcing domestically but selling globally (group 3). Another difference worth commenting regards the use of 4.0 technologies to support the marketing or sales functions. While this is not an area of major investments for any group (spanning from 29.1% for group 2 to 36.6% for group 1) this is never adopted by the firms that are both sourcing and distributing within the national borders. It is interesting to notice that domestic firms (no global sourcing and no export) present the highest value (84,2%) -statistically significant with group 1 and 3 - in terms of adoption of 4.0 technologies in production. In other words, domestic firms are the ones that are implementing more 4.0 technologies at the factory floor.

[Insert table 8 about here]

DISCUSSION AND CONCLUSIONS

Results suggest that when considering the adoption of 4.0 technologies, this is independent from the degree of internationalization. Both international firms and domestic firms use those technologies. What emerge are the differences in the technologies adopted and the motivations behind the investment. Indeed, global sourcing firms invest more on technologies that are based on data and data management i.e. Big Data and IoT. Other 4.0 technologies have similar rate of adoption among the two groups of firm except Robotics that, although the difference is not statistically significant, is more used on average by domestic sourcing firms (45.9%) than global ones (39,4%). The relative higher investments in data management technologies could be explained by the fact that those firms have to deal with the complexity of managing activities at the global scale. This is particularly true for firms that source globally and export: one out two firms uses that technology to cope with global value chains. As confirmed by the literature (Gereffi, Humphrey, & Sturgeon, 2005) technology is a driver of coordination and competitiveness for global firms.

The different level of internationalization does play a role when we consider the motivation of the adoption of 4.0 technologies. The necessity to face global competition is one of the most compelling reasons for investing in 4.0 technologies. Especially firms that source globally and export present the highest level of sensitiveness to global competition in the investments in 4.0' technologies. This is true also for both the need to increase the variety of production and to search new market opportunities that are higher for firms that have at least some degree of internationalization. On the contrary, domestic firms manifest a higher motivation in adopting 4.0 technologies when we consider environmental sustainability. This surprising result could be explained in several ways. Recent literature (Antonietti, Valentina De Marchi, & Di Maria, 2017; Chiarvesio, De Marchi, & Di Maria, 2015) highlighted the importance of the sharing the same institutional environment in order to support achieving environmental results. The fact of collaborating with suppliers or clients under a common language and institutional setting does help tackling the complexity of sustainability. An alternative interpretation is that environmental sustainability is becoming a way for domestic firms to differentiate themselves and to attract the interest of the market and they saw in 4.0 technologies the opportunity for doing so.

The literature has highlighted (Rehnberg & Ponte, 2018; Strange & Zucchella, 2017) the role that 4.0 technologies could play in reconfiguring international activities. The results we gathered, at least at this moment in time, do not totally support this vision. As a matter of fact, reshoring (the relocation of previously offshored manufacturing production to the home country) is the less relevant in terms of the motivation of adoption. That result does not mean that a reconfiguration of the international activities could not occur in the next future but, as far as we understand from our research, it could be a byproduct of the adoption more than the motivation to invest in those technologies in the first place. Maybe firms need to get acquainted to those news technologies in order to explore their potentiality and then modify their internationalization level.

If we consider in which activity of the firm 4.0 technologies were implemented, it becomes more clear the different strategies of the firms. Global sourcing firms apply 4.0 technologies in the New Product Development and in Logistics and Supply Chain Management. This choice seems coherent with the need to respond to the global competition both in terms of new products and more efficient and quick value chains. On the contrary, as Table 8 shows, domestic companies (no global sourcing and no export) concentrated their effort in adopting 4.0 technologies in production. Again, this choice seems coherent with firms that specialized in manufacturing in a high-cost country (as Italy is) and have to increase their productivity in order to compete.

We may conclude that, as far as the adoption of 4.0 technologies is concerned, there is no strong difference taking into account internationalization. Both domestic and global firms invest in those technologies and the intensity of the adoption does not change among the four groups. This picture could change in the near future when firms could be more aware of the potential of those technologies and learn how to use them creatively.

Internationalization becomes relevant if we consider both the motivations and activity of the value chain in which 4.0 technologies are implemented. Firms with at least some degree of internationalization are pushed to invest by the several elements: the first one is to face international completion, the second is to develop new market opportunities and the third is to increase their production variety. Those three motivations seem strictly interrelated: in order to compete at global level firms have to quickly adapt to new requests from the market with the capacity to produce a greater variety of products.

In terms of firms' value chain, the internationalization degree is relevant. Global firms tend to invest in the use of 4.0 technologies in the New Product Development phase and in Logistics and Supply Chain Management while domestic firms adopt more technologies in productions. These differences could be justified by the different strategy of the firms. Global firms need to speed up the development of new products and to improve the efficiency in the management of the value chain while domestic firms need to upgrade their manufacturing capabilities investing in the factory.

Our research seems to conduce us to consider that the adoption of 4.0 does not change the international strategy of the firms but is guided by the necessity to find coherence between the opportunity of those technologies and the present strategy of the firms. From this perspective, manufacturing companies seems to react to the potential of the new technologies more than proactively embracing the fourth industrial revolution. Learning requires time and, more importantly, experimentation. These technologies, although advanced and solid, do not have clear best-practices in the business context. This is understandable because we are still at the first stages of the revolution.

We acknowledge that our study has some limitations. The first one is related to the fact that our study is cross-sectional and we are not able to disentangle the transformation in the internationalization strategy, but only the relationship between the adoption of 4.0 technologies – which could have occurred during several years- and the present international (vs. domestic) configuration of the firm. The second one is related to the context of the research. Our results could be influenced by the specific structure and organization of Italian firms and manufacturing activities. We need to strength our results comparing with the behavior of firms coming from different regions.

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FIGURE 1

The Groups Analyzed

	(a) Global Sourcing	(b) Domestic Sourcing
Export	(1) Global Sourcing & export 40.5%	(3) Domestic Sourcing & export 32.2%
No export	(2) Global Sourcing & no export 5.4%	(4) Domestic Sourcing & no export 22%

TABLE 1

Descriptive statistics of the sample

Firm' size (EU turnover class)		
Under million (<1mln)	14.2%	
Micro firms (1mln<€<2mln)	28.8%	
Small firms (2mln<€<10mln)	41.9%	
Medium firms (10mln<€<50mln)	13.0%	
Large firms (>50mln)	2.0%	
Industry		
Electrical Motors and parts	21.6%	
Footwear	17.0%	
Jewelry	11.6%	
Automotive	9.3%	
Clothing	9.3%	
Textile	6.9%	
Lighting	5.8%	
Furniture	5.1%	
Rubber and plastic goods	5.0%	
Eyewear	4.2%	
Sport equipment	4.2%	
Industry 4.0 technologies adoption	**Adopting**	**Non-adopting**
Firms adopting at least one of the seven industry 4.0 Technologies listed in the questionnaire	205 (16.68%)	1,024 (83.32%)

Note: N = 1,229.

TABLE 2

Characteristics of adopting firms

Variable	*Mean*	*Min*	*Max*	*St. Dev.*
Turnover (2016 thousands of euros)	14,224	47	321,167	35,535.19
Employees (2016)				
Total	57.15	5	935	100.55
Operations	35.9	2	407	62.77
R&D	4.6	0	121	12.24
Marketing	2.4	0	121	10.53
% Export on turnover (2016)	45.6	0	100	32.85
% First export Country	27.5	0	100	23.38
% R&D expenditure on turnover (2016)	6.1	0	64	8.20
Production output (%)				
Bespoke products	46.7	0	100	39.65
Standard products	33.8	0	100	36.07
Customizable products	19.5	0	100	26.17
Location of production (based on value) (%)				
Region (headquarter/firm location)	62.3	0	100	44.96
Other Italian regions	29.9	0	100	41.52
Abroad	7.8	0	100	19.28
Supplier location (% on total number of suppliers)				
Region (headquarter/firm location)	35.8	0	100	37.36
Other Italian regions	47.3	0	100	35.35
Abroad	16.9	0	100	24.70

Note: N = 205.

TABLE 3

Investments in Industry 4.0 technologies in international and domestic firms

4.0 technologies	**(a) Global Sourcing**	**(b) Domestic Sourcing**	**Sig.**
Robotics	39.4%	45.9%	
AM	35.1%	34.2%	
Laser	45.7%	45.0%	
Big data	47.9%	33.3%	**
3D scanner	19.1%	17.1%	
AR	14.9%	12.9%	
IoT	28.7%	18.0%	*
Number of 4.0 technologies adopted	2.31	2.06	

Note: *** p < .01; ** p < .05, * p < .10. N for group (a)= 94; N for group (b)=111.

TABLE 4

Investments in Industry 4.0 technologies according to degree of internationalization

4.0 technologies	(1) Global Sourcing & Export	(2) Global Sourcing & No Export	(3) No Global Sourcing & Export	(4) No Global Sourcing & No Export	**Δ1-2**	**Δ1-3**	**Δ1-4**	**Δ2-3**	**Δ2-4**	**Δ3-4**
Robotics	42.2%	18.2%	50.0%	40.0%				*		
AM	32.5%	54.5%	33.3%	35.6%						
Laser	43.4%	63.6%	50.0%	37.8%						
Big data	50.6%	27.3%	33.3%	33.3%		**	*			
3D scanner	20.5%	9.1%	18.2%	15.6%						
AR	15.7%	9.1%	13.6%	11.1%						
IoT	28.9%	27.3%	13.6%	24.4%		**				
4.0 technologies adopted	2.35	2.09	2.12	1.89						

Note: *** p < .01; ** p < .05, * p < .10. N for group (1)= 83; N for group (2)=11; N for group (3)=66; N for group (4)= 45.

TABLE 5

Motivation of Industry 4.0 investments in international and domestic firms

Motivations	**(a) Global Sourcing**	**(b) Domestic Sourcing**	**Sig.**
Efficiency searching	3.7	3.5	
Increasing variety	3.2	2.9	
New market opportunities	3.2	3.2	
Maintaining production in Italy	3.0	2.6	
Reshoring	1.7	1.5	
Facing the international competition	3.7	3.1	***
Imitating competitors	1.9	1.8	
Improving customer service	3.9	3.9	
Environmental sustainability	2.9	2.6	
Request form customers (i.e. multinational)	2.7	2.4	
Adjustment to the industry standards	2.7	2.6	

Note: *** $p < .01$; ** $p < .05$, * $p < .10$. N for group (a)= 94; N for group (b)=111.

TABLE 6

Motivation of Industry 4.0 investments according to degree of internationalization

Motivations	(1) Global Sourcing & Export	(2) Global Sourcing & No Export	(3) No Global Sourcing & Export	(4) No Global Sourcing & No Export	**Δ1-2**	**Δ1-3**	**Δ1-4**	**Δ2-3**	**Δ2-4**	**Δ3-4**
Efficiency searching	36.80%	40.00%	34.50%	37.10%						
Increasing variety	31.80%	36.70%	31.60%	23.10%			**		***	**
New market opportunities	31.40%	38.90%	34.20%	26.90%	*				**	**
Maintaining production in Italy	30.30%	25.60%	27.20%	24.40%						
Reshoring	17.60%	16.30%	15.30%	15.70%						
Facing the international competition	38.70%	26.00%	31.60%	28.70%	***	***	***			
Imitating competitors	18.50%	24.40%	17.50%	19.30%				*		
Improving customer service	39.00%	41.00%	38.60%	41.30%						
Environmental sustainability	28.50%	30.00%	23.40%	32.90%		*				**
Request form customers (i.e. multinational)	27.00%	28.90%	22.70%	26.00%						
Adjustment to the industry standards	26.00%	31.00%	25.70%	27.10%						

Note: *** $p < .01$; ** $p < .05$, * $p < .10$. N for group (1)= 83; N for group (2)=11; N for group (3)=66; N for group (4)= 45.

TABLE 7

Value chain activities and Industry 4.0 in international and domestic firms

Value Chain activities of 4.0 implementation	**(a) Global Sourcing**	**(b) Domestic Sourcing**	**Sig.**
New Products Development	53.9%	33.8%	***
Prototyping	50.6%	51.4%	
Production activity	59.6%	64.9%	
Production management	33.7%	39.2%	
Logistic & SCM	15.7%	5.4%	**
Marketing/Sales	25.8%	21.6%	
Spare parts & Post-sale services	5.6%	4.1%	

Note: *** p < .01; ** p < .05, * p < .10. N for group (a)= 94; N for group (b)=111.

TABLE 8

Value chain activities and Industry 4.0 according to degree of internationalization

Value Chain activities of 4.0 implementation	(1) Global Sourcing & Export	(2) Global Sourcing & No Export	(3) No Global Sourcing & Export	(4) No Global Sourcing & No Export	**Δ1-2**	**Δ1-3**	**Δ1-4**	**Δ2-3**	**Δ2-4**	**Δ3-4**
New Products Development	55.1%	45.5%	34.5%	31.6%		**	*			
Prototyping	51.3%	45.5%	52.7%	47.4%						
Production activity	60.3%	54.4%	58.2%	84.2%			**		*	**
Production management	32.1%	45.5%	43.6%	26.3%						
Logistic & SCM	15.4%	18.2%	3.6%	10.5%		**		*		
Marketing/Sales	25.6%	27.3%	29.1%	0.0%			**		**	***
Spare parts & Post-sale services	5.1%	9.1%	3.6%	5.3%						

Note: *** p < .01; ** p < .05, * p < .10. N for group (1)= 83; N for group (2)=11; N for group (3)=66; N for group (4)= 45.