Industrial districts and the fourth industrial revolution

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Abstract

Purpose – This paper aims to explore if firms located in industrial districts (IDs) have different adoption paths concerning Industry 4.0 technologies and get different results with respect to other similar firms located outside IDs.

Design/methodology/approach – The study is based on a quantitative analysis related to an original data set of 206 Italian manufacturing firms specializing in made in Italy industries and adopting Industry 4.0 technologies. A case study of a district firm is also presented to explain the rationale of investment strategies and results obtained.

Findings – The analysis shows that there are differences between district and non-district firms when Industry 4.0 technology investments are concerned (higher investment rate in big data/cloud and augmented reality for district firms than non-district ones). In contrast to a breakthrough view of the fourth industrial revolution, the study suggests that 4.0 technologies emphasize the peculiarities and competitiveness factors typical of the district model in terms of customization and flexibility. There are differences in the motivations of adoption (product diversification for district firms vs productivity enhancement for non-district firms) and in the results achieved.

Originality/value – The paper is one of the first attempts to empirically explore the technological innovation paths related to Industry 4.0 within IDs, therefore, contributing to the debate on the possible evolution of the district model

Keywords Italy, Industry 4.0, Fourth industrial revolution, Clusters, Robotics, Industrial districts

Paper type Research paper

1. Introduction

The diffusion and adoption of new technologies, known as Industry 4.0, is shaping a new industrial revolution. Specifically, there is a growing attention on how some types of technologies – such as three-dimensional printing, robotics, additive manufacturing, big data, internet of Things, artificial intelligence and others – are changing the rules of competition and driving the rise of new business paradigms (Almada-Lobo, 2016). The rise of this forth industrial revolution (Kenney *et al.*, 2015) is opening new opportunities of

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growth for territories and firms, which can obtain superior performance through these technological advances. Studies on Industry 4.0 technologies have highlighted the strong impact on manufacturing activities and the rise of new "smart factories" characterized by more efficient production processes as well as enhanced productivity (Mittal *et al.*, 2018). Small, other than large firms can benefit from this technological revolution (Moeuf *et al.*, 2018), yet differences might be expected, considering for the amount of resource endowments needed but also for the opportunities that might be captured from firms of different size. Furthermore, such technologies are expected to transform the relative advantage of territories, with studies suggesting it can boost globalization and others that it can counteract it. Indeed, the ongoing digital transformation can change the geography of activities of firms and their suppliers (Villa and Taurino, 2018). Some technologies such as robotics, might allow firms reducing their production costs, allowing firms to keep the production locally as a strategic competitive option. Other technologies, as three-dimensional printing, might allow firms producing components locally instead of sourcing them from suppliers located in faraway countries. Finally, other types of technologies [big data, cloud and internet on things (IoT)] might allow firms being more international, getting in touch with a larger base of customers and/or industrial partners (Piccarozzi *et al.*, 2018).

Despite this growing discussion, little has been said on the adoption of the Industry 4.0 technologies and its value in the field of industrial districts (IDs) (Götz and Jankowska, 2017), which are localized agglomeration of interconnected firms, mostly small or medium-sized, specialized in different manufacturing activities needed to produce a category of end product (Becattini, 1979; Pyke *et al.*, 1990). Having been for years the backbone of growth for developed countries such as Italy and Spain, they have recently gone into severe transformations, which might underminetheir ability to be competitive in international markets (De Marchi *et al.*, 2018c; De Marchi and Grandinetti, 2014; Zucchella, 2006). This paper aims at understanding the impact of location of firms on their propensity to adopt Industry 4.0 technologies and specifically to explore how district firms invest in such technologies within the theoretical debate on the evolutionary dynamics of IDs (Molina-Morales and Martínez-Fernández, 2009; Belussi and Sedita, 2009; Belussi and Hervas-Oliver, 2017; Hervas-Oliver *et al.*, 2017; Belussi, 2018; Hervas-Oliver and Belussi, 2018; Lazzeretti *et al.*, 2019).

In the past 15 years, literature testified that (IDs) have deeply transformed to face the globalization challenges, so that global connections became more and more important for local firms that are embedded in the global value chains (GVC)(Belussi and Sammarra, 2009; De Marchi *et al.*, 2018a). At the same time, the local system is still a context for production, where manufacturing activities are located and support the firm's competitiveness and performance internationally(Bettiol *et al.*, 2017; Bettiol *et al.*, 2018; De Marchi *et al.*, 2018d). Investments of district firms related to information and communication technologies (ICT) in the past years have demonstrated to be aligned with the district model and to enable connections with global markets(Chiarvesio *et al.*, 2004). The development and diffusion of Industry 4.0 technologies has suggested that a new industrial revolution is taking place, which is going to impact heavily firms' business models and ability to compete at the national and international level. The adoption of Industry 4.0 technologies might open up different types of opportunities, yet it is not clear what the direction of such transformation will be and if it will represent a key boost for ID competitiveness and resilience (Sedita *et al.*, 2017). With this contribution we aim at enlarging the discussion by focusing on the implication of the diffusion of the wave of technologies for local manufacturing systems. Transformation driven by the Industry 4.0 technologies are important to observe also because they could ask for a change in the theoretical perspective that is associated to the study of IDs and clusters (Lazzeretti *et al.*, 2014; Sedita *et al.*, 2018).

Based on unique data gathered in 2017 on a sample of about 1,400 Italian manufacturing firms, including 206 adopters, we verify the relation between the profile of firms located within and outside IDs and their propensity to adopt Industry 4.0 technologies. Our analyzes suggest that Industry 4.0 technologies are adopted for reaching objectives that are consistent with the peculiarities of the district model (customization, flexibility). Moreover, results align with the "traditional" differences between district and non-district firms, specifically in terms of resource endowments, industry specialization and competitiveness focus.

2. Theoretical background

2.1 Manufacturing and industry 4.0

The definition of the fourth industrial revolution highlights the radical transformation in the way firms create value and how value is retained within the value chain. Beyond the ICT revolution implemented during the late 1990s and the new millennium, mainly focused on the web, technologies related to Industry 4.0 (Reinhard *et al.*, 2016) promised to reshape the entire process of value creation starting from new manufacturing, to product development and new business models. Very diverse technologies are included in this umbrella term all, having a potential disruptive impact on how, when and where (manufacturing) activities take place.

Technologies related to automation, like robotics, allow firms incrementing productivity and control over the operation processes. The set of technologies connected to manufacturing improvement support many areas of intervention (Mittal *et al.*, 2018), namely, real-time responsibility, predictive maintenance, self-optimization and self-configuration. In an integrated view with big data and artificial intelligence implementation (Zheng *et al.*, 2018), automation in the factory sustains a radical shift in operations management and control.

Transparency and traceability, granted by the new technologies, affect the whole value chain, including suppliers as well as distributors and customers. Big data platforms favor value co-creation between firms and customers through the formation of cooperative assets (Xie *et al.*, 2016). Through the investments in cloud solutions and the design of a cloud manufacturing framework(Liu and Xu, 2017) firms can extend their visibility on extended products and develop also service-based business models. Related to this scenario, the development of IoT transforms products that become data-driven objects, also supporting further business model transformation(Manyika *et al.*, 2015; Ceipek *et al.*, 2020).

Among the many technologies mentioned, three-dimensional printing became the flagship of such revolution (Anderson, 2012), as it highlights the redesign in the innovation process and new product development with a shift toward the customers' involvement (Bogers *et al.*, 2016). Not only small firms but also large companies are able to achieve mass customization and also bespoke production, transforming their business models and value creation mechanisms (i.e. Adidas case study). Indeed, additive manufacturing allows firms increasing variety beyond scale (Petrick and Simpson, 2015). All in all, such transformations in the competitive scenario push firms to rethink their products and business models (Sorescu, 2017).

2.2 Industrial district firms facing the fourth industrial revolution: research questions

Being considered an alternative form of organization to the large enterprise (Piore and Sabel, 1984), IDs or clusters are forms of production characterized by:

- a (numerous) population of firms (mostly small and medium-sized) and institutions;
- a specialization on as specific business area;

- a division of labour among firms and consequent inter-organizational relationships, being mostly vertical; and
- a circumscribed territory.

Such a form of organization of production, which has been observed mostly in the context of mature industries in Italy, became popular starting the 1980s, having been recognized globally as an example of growth and international success, so to become an inspiration for developing countries too (Becattini *et al.*, 2014; Schmitz and Nadvi, 1999; Giuliani *et al.*, 2019). Because of their features, indeed, IDs have be recognized to entail high flexibility, innovation and productivity (Belussi, 2006; Camuffo and Grandinetti, 2011; Molina-Morales, 2002; Ortega-Colomer *et al.*, 2016).

Starting from those initial contributions, a vast literature has described the evolutionary trends of such peculiar model of economic activity over the past two decades, considering for the deep transformations that have been taking place (Belussi and Sedita, 2009; De Marchi *et al.*, 2014; De Marchi and Grandinetti, 2014; Rabellotti *et al.*, 2009).A first and very populous stream of literature highlighted the changing advantage of localization considering for the increasing pervasiveness of GVC and the opening up of cluster boundaries (Belussi and Sedita, 2008; Belussi and Sedita, 2012; Giuliani and Rabellotti, 2018; De Marchi *et al.*, 2018b).

A second and interconnected field address the impact of digitalization on cluster dynamics (Biggiero, 2006). Past studies on the adoption of digital technologies at the district level suggests that the adoption of district firm's investments on ICT is consistent with the district model (Chiarvesio *et al.*, 2004; Belussi, 2005). At the same time, an uneven distribution of adoption rates is observed among district firms, suggesting the presence of internal cluster differentiation. Past debate on digitalization in clusters focused on the implications for the district – and its firms – on the internal mechanisms of knowledge creation and sharing peculiar of the district model (Biggiero, 2006). Because of such technologies enabling external connectivity, the internal district could suffer in terms of internationalization and reconfiguration of the supply base beyond the district boundaries (De Marchi and Grandinetti, 2014). ICT has been explored in terms of both potentialities in reaching (distant) market (e-commerce) and information sharing within the supply chain.

The fourth industrial revolution opens a completely new scenario for district firms, further impacting on the evolutionary trends of the ID model (Hervas-Oliver *et al.*, 2015). Götz and Jankowska (2017) in their theoretical analysis suggest that the peculiarities of the district model related to cooperation, knowledge sharing and agglomeration externalities may favor the adoption of Industry 4.0 technologies by cluster firms. However, it is not clear if there is the need for minimum technological competences and experience for a successful adoption, consistently with the absorptive capacity concept (Cohen and Levinthal, 1990). Prior studies related to the ICT scenario – also within clusters – demonstrate that investing in ERP and more complex IT solutions sustain the competitiveness and growth of district firms and small-sized firms more in general (Micelli and Di Maria, 2000). Hence, especially medium-sized firms should have the IT competences and experience to exploit and implement the digital transformation, thus including Industry 4.0 technologies within their processes and business strategies.

Nevertheless, limited prior study has empirically investigated the adoption of Industry 4.0 technologies at the district level. An interesting exception is Hervas-Oliver *et al.* (2019). In their analysis of the ceramic cluster in Castellon, they explore the role of place-based policies to allow the digitalization of the district. Through the action of local institutions and the support of policies at the regional level, cluster firms have been able to overcome their inertia and limited knowledge concerning the opportunities of investments related to Industry 4.0 technologies. Additionally, Garcia-Muiña *et al.* (2018)showed how investments in IoT technologies by an Italian ceramic tile company – based in the Italian ceramic tile district of Sassuolo – can be a way to achieve sustainability. From this point of view, in line with ID theory, institutional actors may have a fundamental role for district transition toward the fourth industrial revolution.

The above cited studies testified how such technologies are indeed adopted by (some) cluster firms, nevertheless, they lack in deepening present understanding on the extent to which they are adopted within districts and on the characteristics of this process of adoption. Against this background, the study aims at answering to the research question: are there differences regard the adoption of Industry 4.0 technologies between district and non-district firms? Based on original survey data, we aim at exploring if firms located in districts have different adoption paths and get different results respect to firms located outside the district, yet having similar features. Specifically, we aim at evaluating if there are significant differences on:

- the types of Industry 4.0 technologies adopted;
- the motivations of adoption; and
- the impacts of the adoption.

3. Data and methodology

To explore our research question, we use a mixed-method approach, using data collected via an original survey and on in-depth interviews, both targeting Italian manufacturing firms. The choice of a mixed-method approach seems particularly suited to the analysis of a research area on which very few knowledge is yet developed, as it allows overcoming the limitations of the survey analysis and of the case study, allowing data triangulation and supporting the robustness of the results (Bryman, 2012; Jick, 1979).

Italy seems a particularly interesting empirical setting for two reasons. On the one hand, it is considered the cradle of IDs, hosting some of the most studied IDs, which became reference point for other countries (Belussi and Sedita, 2009; De Marchiet al., 2018c; De Marchi and Grandinetti, 2014; Schmitz, 1989). On the other hand, it has recently experienced important policy activities to foster Industry 4.0 adoption at firms' level. 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 manufacturing firms operating in a selection of made in Italy sectors located in northern Italy (in the regions Emilia Romagna, Friuli Venezia Giulia, Veneto, Trentino Alto Adige, Lombrdia, Piemonte [1]). The population of the survey analysis consisted of 8,002 manufacturing firms drawn from the Aida – Bureau van Dijk database, belonging to 12 industries (automotive, rubber and plastics, electronic appliances, lighting, furnishings, eyewear, jewelry, sport equipment, textile, clothing, footwear and leather) and having an annual revenue higher than €1m (for industries such as lighting, eyewear, jewelry, footwear and sport equipment, we selected also firms with annual turnover less than €1m, considering the distribution of turnover in the population). We collected responses from 1,400 firms (with an acceptable response rate of 17.5%), with 206 (14.7% of the sample) adopting at least one of the Industry 4.0 technologies investigated. The final sample is composed of both firms localized inside and outside IDs.

We admin istereda structured questionnaire to entrepreneurs, chief operation officers or managers in charge of manufacturing and technological processes adopting a computer-assisted web interview methodology in the period May-December 2017. The questionnaire was composed of several sections and oriented to investigate specifically, which Industry 4.0 technologies firms adopted and in which stage of the production process. Finally, we also retrieved information on the motivations for the adoption and the impacts of such investments on the organization of the business.

To identify firms that adopted Industry 4.0 technologies we asked if any of the following was adopted: robotics, additive manufacturing, laser cutting, big data and cloud, three-dimensional scanner, augmented reality or IoT (internet of things) and smart products.

To identify which firms were part of an ID, we used the classification offered by the Italian National Statistics Office, which identify districts based on the combination of two variables, namely, industry specializations (identified via ATECO industry classification codes) and geographical location (identified in terms of local labor systems).In our sample, 321 firms out of 1,400 (22.9%) are located in a district. Within this group only 25 (7.8% of the district firms sub-sample) adopted at least one technology.

To address our research question, we verified if there was any difference among adopting firms, discriminating for the location within or outside an ID. Accordingly, we performed a multivariate analysis of variance (χ^2 test and t-tests) comparing the two groups for different dimensions, namely, technologies adopted, motivations of adoption and results achieved after the adoption. Given:

- the disproportion among the two groups of adopting firms (25 ID-based vs 181 non-ID based); and
- the different features of ID firms (e.g. the smaller size of companies and the focalization in certain industries), we decided to adopt a *quasi* difference-in-difference approach, i.e. to compare ID adopters with a sub-set of the non-ID adopters.

The sub-group of non-ID firms have been identified by pairing each ID firms with the “closest” non-ID ones as for industry (ATECO code at 4-digit level), size (measured in terms of number of employees) and location (region). Indeed, the two groups of firms showed important differences along these dimensions, as it emerges in Figure 1. We acknowledge that the quasi-experiment suffers from self-selection and will only give information about companies with a specific pool of features, therefore results are difficult to be extended to the population as a whole, never the less, our approach allows providing a first exploration on differences between ID and non ID firms. By doing so we control for features such as the industry specialization or the firm size, which might have an important impact on the strategies for adoption of 4.0. Considering that not all the ID firms in our sample provided full information on the questions of interest for this study, the quantitative analysis is finally based on the comparison between 20 ID and 20 non-ID firms (belonging to 7 out of 12 industries considered, namely, rubber and plastics, furnishing, eyewear, jewelry, textile, footwear and clothing).

To gain a deeper understanding of the dynamics emerging from the quantitative analysis, we coupled such analysis with an in-depth study of one of the adopting firms located in an ID. Following Eisenhardt (1989), Eisenhardt and Graebner (2007), we adopted a theoretical sampling strategy and purposefully selected a firm located in a dynamic ID, with the objective to show the full range of opportunity that ID can provide to small and medium-

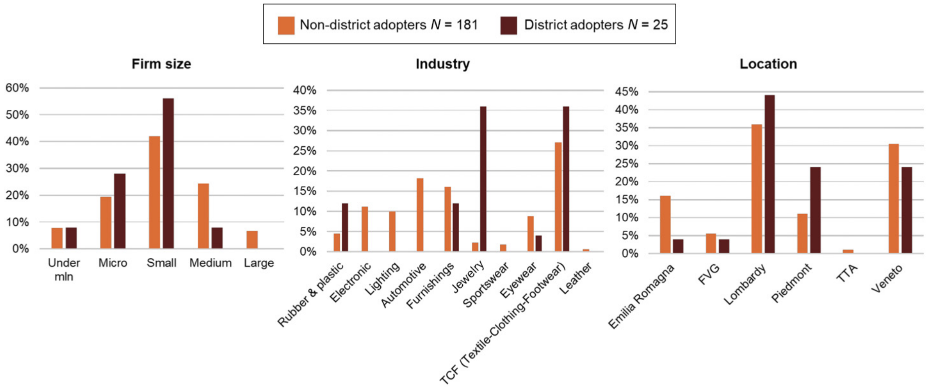

Figure 1. Distribution of the sample of ID and non-ID adopters

Notes: Firm size (under 1 Million Euro; Micro 1-2 Million Euro; Small 2 – 10 Million Euro; Medium: 10-50 Million Euro; Large: > 50 Million Euro); Location (FVG: Friuli Venezia Giulia; TTA: Trentino Alto Adige)

sized enterprises (SMEs) specialized in low-tech industries. The sampled firm is located in the Riviera del Brenta district, being one of the most well-known ID in Italy (Belussi and Scarpel, 2002; Amighini and Rabellotti, 2006; Camuffo and Grandinetti, 2011) – for which, therefore, there is a large amount of information about the strengths and weaknesses, challenges and opportunities the firms have faced during time. Additionally, it is a very dynamic one, i.e. a context in which firms are potentially receptive to new technological trends and have to deal with global buyers, which might possibly encourage the adoption of Industry 4.0 technologies (De Marchi *et al.*, 2018d). The specific firm selected (Del Brenta) represents a clear case where it is possible to observe how Industry 4.0 technologies can enable a deep organizational change – a "talking pig," to use the metaphor by Siggelkow (2007).

4. Comparing industrial district adopter with non-industrial district ones: preliminary analysis

A first empirically-driven questions that might arise when questioning if adoption of Industry 4.0 technologies differs inside and outside districts regards the type of technology adopted. Accordingly, in Table 1 we compare the two subgroups (ID vs non ID firms) for the

Table 1. Adoption of industry 4.0 technologies in ID and non-ID firms

Industry 4.0 technologies	District (%)	Non-district (%)	Sig.
Big data and cloud	50	15	**
Laser cutting	45	50	
Robotics	35	40	
Additive manufacturing	35	30	
three-dimensional scanner	25	10	
Augmented reality	25	5	*
IoT and smart products	15	20	

Notes: Data is sorted by higher percentage of district group. N = 20 (ID), 20 (non-ID); multiple choice option, statistically different at *10%; **5%

frequencies of adoption of the seven technologies considered. Interestingly, while there is quite a similar pattern for technologies such as laser cutting, additive manufacturing and robotics – being more likely related to production activities and being rather the “oldest” technologies among the one considered – significant differences emerge across the two groups if considering the “newest” technologies, i.e. big data and cloud and augmented reality. Indeed, the largest difference regards the adoption of big data and cloud, which is the most adopted technology for ID firms (adopted by half of the sample of ID firms considered). Another important difference regards the adoption of augmented reality – while being less diffused than other technologies, it is disproportionally adopted by the 25% of the ID firms vs the 5% of the non-ID firms). While caution should be adopted when interpreting these results, considering the very small sample size and the already acknowledged sample selection bias, they shed light on what it seems a very relevant fact. ID firms might be more likely to adopt data-driven technologies, which are better suited to pursue strategies aimed at increasing the value of the product and increasing the traceability and connectivity of the processes, rather than boosting productivity. These results might be connected with the higher propensity to engage in inter-firms relationship of ID firms, given the interdependencies among firms performing different stages of the final products, i.e. the division of labor.

Other interesting results regard the motivations for adoption, explored in Table 2, which allows reflecting on the strategic intent of the adoption. For both groups of firms, Industry 4.0 technologies are adopted mostly as a mean to improve the customer service and to search for new product/market opportunities. Interesting differences, however, emerges if comparing the full range of motivations. ID firms seem to be more likely motivated by the need to imitate existing practices in the industry, especially when it comes to imitate competitors. Interestingly, 25% of the ID firms reported this was an important motivation for adoption, yet none of the non-ID reported the same. On the contrary, non-ID firms are far more likely to be driven by efficiency-seeking purposes (73.3% vs 42.9%), which is consistent with the above discussion on the type of technologies adopted. Another interesting and significant difference emerging from Table 2 is the fact that ID firms are less likely to be driven by specific requests from (possibly large and global) customers (40 % vs 8.3%). The interpretation of there sult might be twofold. On the one hand, it might be driven by the fact that ID firms are less likely to be engaging with demanding customers – for examples because they have more difficulties to engage with global buyers. On the other

Motivations of adoption	District (%)	Non-district (%)	Sig.
Improving customer service	76.9	78.6	
New product-market opportunities	61.5	64.3	
Increasing variety	57.1	42.9	
Maintaining the international competitiveness	53.8	53.3	
Efficiency seeking	42.9	73.3	*
Maintaining production in Italy	27.3	40.0	
Imitating competitors	25.0	0.0	**
Adjustment to the industry standards	25.0	14.3	
Environmental sustainability	8.3	42.9	**
Request from customers (i.e. multinational)	8.3	40.0	*
Back-shoring of production activities	0.0	0.0	

Notes: Data is sorted by higher percentage of district group. N = 20 (ID), 20 (non-ID); multiple choice option, statistically different at * 10%; ** 5%

Table 2. Comparing motivations of adoption in ID and non-ID adopters

hand, it might be interpreted as a sign of a more "proactive" strategic intent, where ID firms specifically and autonomously invest in technologies that can reinforce their competitiveness for facing the transformations driven by the global competitive scenario. Finally, the only other significant difference across the motivations regards (environmental) sustainability reasons (42.9% vs 8.3%), which suggests ID firms are less concerned of non-economic impacts of their activities, at least when implementing investments decisions in 4.0 technologies.

Finally, in Table 3 we investigate the implications of the adoption of the technologies, in terms of economic and environmental results achieved. Again, interesting differences emerge across the two groups, suggesting potentially diverse approaches toward the adoption of the technologies of the fourth industrial revolution. The most sticking difference regards productivity improvements, which is a result achieved by the vast majority of non-ID firms (80.0%), yet a minority of ID firms (28.6%). Interestingly, the opposite occurs for product diversification (20.0% vs 64.3%), which is by far more likely to be realized in the case of ID firms – indeed the most recurrent, together with the obtainment of improvements in the customer service. Such results complete the picture emerging before, which suggested the ID firms seem to be more likely to adopt such technologies as a tool to improve the value of their offer, possibly changing the products offered or at least the level of service attached to it, rather than to pursue cost-effectiveness types of strategies. This is indeed coherent with the evidence that Italian IDs are increasingly moving toward niche markets and a diversification of their offer, which is quite a consistent feature of the most resilient IDs (De Marchi *et al.*, 2018d; Rabellotti *et al.*, 2009).

5. A case study of an ID adopter

Del Brenta was founded by Giorgio Polato in 1969 in Vigonza at the heart of the Riviera del Brenta Shoe's district (30 km North-West from Venice, Italy). Del Brenta is a typical district family-owned small firm specialized in the production of heels. During the 1980s and the 1990s, Del Brenta has been working mainly for small clients localized in the district, specializing in the production of heels with an average number of 2,000 pairs per batch. The production was based on handwork of trained workers with the help of traditional mechanical technologies. In 2000 the company faced a major transformation when the son of the founder, Luciano Polato, took the lead. Luciano Polato has to deal with a different economic scenario than the one his father faced. The increasing globalization of value

Results of industry 4.0 adoption	District (%)	Non-district (%)	Sig.
Product diversification	64.3	20.0	**
Improving customer service	64.3	46.7	
Efficiency improving	50.0	73.3	
Turnover increasing	46.2	53.8	
New markets penetration	35.7	26.7	
Productivity improving	28.6	80.0	***
Maintaining international competitiveness	28.6	20.0	
Environmental sustainability	21.4	13.3	
Improving customized products share	14.3	20.0	
Reorganization of activities Italy/abroad	0.0	13.3	

Notes: Data is sorted by higher percentage of district group. N = 20 (ID), 20 (Non-ID); multiple choice option, statistically different at ** 5%; *** 1%

Table 3.
Results achieved

chains, the rise of new competitors from low cost countries and the introduction of the euro currency changed the base of the competitive advantage of the production of shoes in the district, requiring a competitive repositioning toward quality and product differentiation. Luciano Polato focused on the idea of product upgrading, adding more services to improve customer service, while also increasing flexibility to be more proactive toward product diversification: Del Brenta became a one-stop-shop for luxury brands, from design to product development and production. In line with the results of the analysis mentioned above, the entrepreneur decided to invest in technologies and new managerial processes to achieve such competitive goals. At the factory level, Computer Numerical Control (CNC) milling machines were introduced to speed up production and increase the variety of products. Those investments forced the firm to move from paper to digital information in the management of the internal processes.

Moreover, technological investment allowed a different allocation of tasks between employees and machines as follows: craftsmen were able to focus on design and development of the heels. In this transformation, Del Brenta changed its business model moving from products to services. In particular, Del Brenta deliberately started selling the service of design and development of the heels independently from the production. Luciano Polato understood that designer/stylist need a lot of technical advice for designing a heel that has aesthetic quality and is also producible by existing technologies. To the be able to deliver that new service, Del Brenta developed new competences and invested in new technologies. Del Brenta combined the know-how of the craftsmen with the three-dimensional design competences. The company bought three-dimensional printers and three-dimensional scanners to speed up the process of prototyping and transformed a physical prototype into a digital model that could be processed by CNC machines in production. It is surprising to observe how the quality of the handwork of the artisans could be coupled with the potential of digital technologies. In the design and development of the heels there is an iterative process of back and forth between analogic-physical prototype and digital ones. Once the process reaches the level of satisfaction of the client (in this case the designer/stylist of the brand that ordered the heels) the digital information is sent to the production phase. More recently, Del Brenta added a new service to the design and development: the possibility to interact at distance with the designer/stylist of the brand that ordered the heels. Because of advanced distributed digital communication systems, the company is able to design and develop the heel concurrently with its client at a distance. They interact on the same digital objects and make modifications in real-time. This new company capability opens a new market: luxury brands that have designers and stylists, concentrated in large metropolitan areas like Paris of New York, can now interact with the firm through digital and communication technologies, making Del Brenta a point of reference for the design, development and production of heels for all the major luxury brands. It is interesting to note that the adoption of all these technologies helped the firm to become even more artisanal than in the past, supporting also the growth of the firm. Del Brenta has now €10m of turnover and over 40 employees.

6. Conclusions

Our study is among the first attempts to provide evidence of the technological investments strategies of ID firms in the Industry 4.0 scenario. According to our results, relevant differences emerge in the way ID and non-ID firms approach the potentialities of such technologies. In particular, the way ID firms look at the Industry 4.0 paradigm seems to be related to some peculiar features that characterize the ID ideal type, specifically for what relates the cooperative and competitive (co-petitive) environment where ID firms behave considering the behavior of other firms in the district, orienting their technological investments accordingly. On the one side the adoption leads to increase their competitive advantage, on the other side it stimulates some forms of collaborations within the value chain.

More relevant, Industry 4.0 technologies further enhance the ID firms' competitive peculiarities. As the Del Brenta case study highlighted, through the adoption of such technologies, ID firms are able to increase their ability to cope with a variety of market requests and provide more customized products within a high flexible – and monitored through data-driven technologies – manufacturing environment. While non-ID firms are motivated to adopt Industry 4.0 technologies for achieving efficiency and productivity improvement, this is not in general the case for ID firms. On the contrary, our evidence informs that the fourth industrial revolution helps ID firms to be even more consistent with the competitive traits that characterizes the ID model, where high customer orientation, flexibility, product diversification, reduced time-to-market are coupled with specialized manufacturing competences (also artisanal ones). Comparing motivations between ID and non-ID firms, it also emerges the stronger emphasis of the latter for increasing environmental sustainability.

An important result of our analysis is that Industry 4.0 does not generate a strong discontinuity in the strategic orientation of ID firms, as long as they understand the potentialities of the new emerging technologies. In this respect our analysis also suggests that it is not the size that matters when Industry 4.0 technological investments are concerned, rather its business model. Even small, but pro-active ID firms have invested in new technologies consistently with the peculiarities of their products and processes, as far as they changed the business model to develop traditional manufacturing competences together with new abilities of deploying new technologies for offering new services and increase customer care and customer loyalty. In addition, the new technological infrastructure further enhances the international competitiveness of ID firms, as it allows them better interacting with their suppliers and customers within extended value chains.

Our study shows some preliminary and explorative results on the relation between IDs and Industry 4.0 technologies, which could be further deepened enlarging the sample size to include other Italian regions and controlling for long-time evolution of the phenomenon through subsequent recognitions. Additional research should verify differential impacts on value chain reconfiguration and firm's performance using a longer time span, in particular to evaluate any potential transformation in the location strategies of ID firms, manufacturing-wise. Moreover, the use of qualitative study could allow going more in-depth with the analysis of differences between ID vs non-ID firms, by adding other in-depth case studies.

Nevertheless, our study points at a truly new phenomenon that deserves preliminary exploratory analysis, before being able to establish any type of causality between the adoption of the new technologies and related effects on performance measures. In the future, we expect to find an enlarged pool of adopting firms and a group of firms where these technologies will be more consolidated, with entrepreneurs and managers having an increased awareness of how to implement and integrate them in modified business models. Important differences between ID firms and non ID firms leave room to further reflections on how to customize policy interventions for increasing the impact of these technologies on firms' strategy and performance.

Note

1. Because of financial constraints related to the project supporting the survey we had to limit our analysis to a specific geographical area and we chose the North of Italy because accumulated knowledge from previous published research works on the functioning of firms operating in this area allowed the authors giving better interpretation of the results.

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