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IMPACTS OF INDUSTRY 4.0 INVESTMENTS ON FIRM PERFORMANCE: EVIDENCE FROM ITALY

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Impacts of industry 4.0 investments on firm performance

Evidence From Italy

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ABSTRACT

The adoption of industry 4.0 technologies is assumed to bring superior competitive advantage for adopting firms as drivers of efficiency, differentiation as well as support to innovation. However, no studies capture the impacts of industry 4.0 technologies on firm's financial performance. The paper explores the relationship between investments in digital technologies and firm performances, by also examining which are the technologies more likely to be associated with superior performance and eventually the cumulative effect of technologies on performance. Based on unique data gathered in 2017 on a sample of 1,149 Italian firms, results show the positive impacts on adopters' performance and the role of robotics and laser cutting in this relationship. No cumulative effect (i.e. adopting more than one or two technologies) is instead observed.

Keywords: digital technologies, performance, strategy, industry 4.0

Impacts of industry 4.0 investments on firm performance

Evidence From Italy

There is a growing attention on how new emerging technologies – from 3D printing to robotics, from big data to artificial intelligence - are enabling the rise of the forth industrial revolution. On the one hand, many studies are exploring how operations are reorganized adopting a new factory concept (i.e. the smart factory) as well as how the entire organization can be affected (Holmström, Holweg, Khajavi, & Partanen, 2016). Scholars stress specifically the efficiency gains related to a digital transformation of manufacturing processes where firms have an advanced and distributed control over production processes (also at the supply chain level). Moreover, specific technologies such as 3D printing deeply affect the organization of manufacturing activities in terms of scale and variety (Berman, 2012).

On the other hand, digital manufacturing and industry 4.0 technological solutions allow firms transforming their innovation processes by actively involving customers in product design and product development (Agrifoglio, Cannavale, Laurenza, & Metallo, 2017). To the extreme, firms are able rethinking their business models transforming the sources of value generation, from manufacturing to service i.e. through smart products (Internet of Things – IoT) (Bogers, Hadar, & Bilberg, 2016; Porter & Heppelmann, 2014). In addition, industry 4.0 technologies can potentially restructure global value chains affecting the degree of spatial proximity between manufacturing and market (Strange & Zucchella, 2017), together with environmental sustainable results (Chen et al., 2015; Stock & Seliger, 2016).

Within this discussion, the adoption of such technologies is assumed to bring superior competitive advantage for adopting firms as drivers of efficiency, differentiation as well as support to innovation. Despite the growing attention on the rise of the fourth industrial revolution, few studies have captured how investments in new digital technologies (industry 4.0) affect firm performances, also disentangling the role of specific technologies. This paper aims at investigating which is the link between firm's strategy and technological innovation strategies related to new digital technologies (applied to new product development, manufacturing, or marketing processes) and firm performance. We investigate such relationship relying on the theoretical framework proposed by (Porter, 2001) and (Porter & Heppelmann, 2014) suggesting the positive implications of Internet and Internet-based technologies on firm's competitive advantage. Moreover, studies on dynamic capabilities (Teece, 2007) suggest that firms can achieve sustainable performances by constantly and proactively adapting to evolutionary changes in the technological and business environment. The radical shift rooted in the technological change requires dynamic capabilities aiming at supporting firm's successful response to the new competitive scenario (Afuah, 2000; Teece, 2007; Tripsas & Gavetti, 2000). Firms that demonstrate to be able to modify their internal processes – in the innovation, manufacturing, or marketing domains – properly to exploit the advantages of industry 4.0 technologies can achieve positive results against their competitors. The rise of new digital technologies enacting a paradigmatic shift from the established competitive scenario toward a new industrial revolution (Anderson, 2012) calls for a better understanding on how firms exploit the digital potentialities to enhance their competitive advantage and gain superior performance.

In this scenario, we investigate the impacts of investments in industry 4.0 technologies on firm performance by comparing adopters and non-adopters on a sample of 1,149 Italian firms. Based on an original dataset related to primary data collection carried out by the authors between May and

September 2017, the study aimed at a) exploring the relationship between the adoption of one of the technology 4.0 and firm performance, b) which are the technologies more likely to be associated with performance and c) if there is a cumulative effect of different technologies on firm performance. To measure firm performance, we refer to multiple financial performances (EBITDA/Sales, ROS, ROA, and ROE) for the period 2014-2016. Econometric analyses confirmed the positive relationship between investments in digital technologies and firm performance, where instead there is no cumulative effect in terms of number of technologies and performance. Robots and laser cutting are the only technologies that influence firm performance. Final theoretical and managerial implications are provided.

THEORETICAL FRAMEWORK

A broad set of new digital technologies – from 3D printing to robotics, from Internet of Things to artificial intelligence – are reshaping business activities, innovation dynamics, business models, as well as business ecosystems (OECD, 2017). Starting from the Internet revolution and the rise of new form of enterprise (Bughin, 2008) the present technological scenario is offering multiple strategic opportunities for firms in defining how they may compete, create, and achieve value.

According to some authors (Roblek, Meško, & Krapež, 2016) a new industrial revolution is emerging. Firstly, the new wave of digital technologies sustains a more radical open innovation scheme tightly linked with manufacturing processes: customers become more and more active players not only in the definition of the product, but also in the production itself. The paramount relevance of additive manufacturing in this regard is particularly evident. Customers can become *makers* (Anderson, 2012) reversing the order in the value chain between manufacturer and customer in product idea generation and manufacturing (*direct digital manufacturing*) (Chen et al., 2015).

Secondly, specific technologies - 3D printing and robotics – the organization of manufacturing activities can be substantially revised under multiple perspectives. Direct digital manufacturing opens opportunities for *distributed* manufacturing processes where the distance between production and consumption is revised and manufacturing activities can be located closely to markets. Moreover, the efficiency in the scale of production is increased and firms can augment product variety up to one-to-one solutions, reducing the difference between large and small firms (Weller, Kleer, & Piller, 2015).

Thirdly, the extraordinary enhancement in information management *via* big data analysis, artificial intelligence, and IoT solutions allows firms expanding their control over internal as well as external processes and relationships with actors of the value chain, partners in the business ecosystems up to consumers (Adner, 2006; Coreynen, Matthyssens, & Van Bockhaven, 2017; Huberty, 2015).

Digital Technologies, Competitive Advantage, and Performance

The digital transformation can be interpreted as a disruptive phenomenon (Kenney, Rouvinen, & Zysman, 2015) transforming the rules of competitions (Christensen et al., 2016) and the rise of a new paradigm (Almada-Lobo, 2016). Firms able to transform technological advancement into competitive opportunities can catch new value streams and obtain superior performance than competitors.

Porter and Heppelman (2014) suggest that the possibility to conceive and offer smart connected products radically transform competition, removing industry barriers and redefining the characteristics and composition of value chains. Firms that want to exploit the economic advantages of connectivity related to products have to invest in entirely new technological infrastructures, coupling hardware and software levels and integrating new solutions with existing business systems. Smart products offer new capabilities (monitoring, control, optimization, and autonomy) that impact on the relationships between actors in the value chains and the related power across them. Above all, new strategic opportunities may rise and the firm has alternative strategic options to build sustainable competitive advantage in the outlined scenario.

On the on hand, the firm can embrace new digital technological solutions to enhance productivity. Recent studies on direct digital manufacturing outline the gain in terms of efficiency in the adoption of new technological solutions (Holmström et al., 2016; Zangiacomi, Oesterle, Fornasiero, Sacco, & Azevedo, 2017). Operations processes can be hardly redefined and restructured within a new factory concept (Reinhard, Jesper, & Stefan, 2016), where modularity and flexibility are coupled with firm' superior capability to face market request, provide higher product variety, and levels of customization. Through industry 4.0 solutions the firm may effectively implement lean manufacturing solutions, relying on new technological solutions to increase the control over material and information flows (Sanders, Sanders, Elangeswaran, & Wulfsberg, 2016). This transformation has also implications for the supply chain management, where for instance 3D printing technologies restructure supply chain relationships towards lean and more agile supply chains ((Nyman & Sarlin, 2014). Related to this perspective, few scholars suggest also the consequences of digital manufacturing and industry 4.0 solutions on environmental sustainability of business activities (Stock & Seliger, 2016).

On the other hand, direct digital manufacturing is potentially tightly linked with new innovation approaches activating consumers' involvement in product development and production (Rayna & Striukova, 2016). Following an open innovation approach (Laursen & Salter, 2006), firms adopting direct digital manufacturing sustain open and distributed innovation processes (Roblek et al., 2016). From this perspective multiple business activities and processes are affected by digital technologies, while multiple technologies can provide a large variety of advantages that a firm can exploit to achieve superior performance (Moeuf, Pellerin, Lamouri, Tamayo-Giraldo, & Barbaray, 2017)

Based on the above-mentioned theoretical premises, our research hypothesis is that firms adopting industry 4.0 technological solutions obtain superior financial performance than non-adopters. To best of our knowledge, no research has been developed so far in this direction, measuring empirically the connection between industry 4.0 technologies and firm performance.

The new digital landscape is characterized by high variety of technologies that address multiple business needs and can be applied to different activities of the value chain (Reinhard et al., 2016; Roblek et al., 2016). Firms can select the most appropriate technology to achieve its objectives (i.e. efficiency, quality improvement, or cost reduction) (Moeuf et al., 2017), hence the firm's digital investment is driven by business strategic goals. As discussed above, technologies such as 3D printing and additive manufacturing are perceived as effective tools for innovation purposes in terms of customization and efficiency or for distributed manufacturing processes (Berman, 2012; Rayna & Striukova, 2016). Big data and IoT are instead more focused on facilitating process and product monitoring, also enhancing product value through services (Manyika et al., 2015). The huge discussion concerning robots is related to the possibility to augment productivity in operations and manufacturing processes. However, automation may be applied to a large set of business activities, hence opening new issues concerning the future of work and how firms should manage internal competences and employment in the forthcoming years (Autor, 2015; Brynjolfsson & McAfee, 2011).

On the one hand, one could expect that a firm invest simultaneously in many industry 4.0 technologies to achieve multifold goals and obtain superior competitive advantage. As soon as the firm has a clear strategic focus and the business needs are clear, technological investments will follow consistently (Mcafee, 2006) We could expect that the higher the number of industry 4.0

technologies, the better. The cumulative effect of a large basket of technologies may positively support the firm in achieving its objectives more extensively. On the other hand, firms are required to have distinctive capabilities to cope with dynamic technological changes (Teece, 2007), thus larger firms may be more able to exploit the benefit of the current digital revolution. Nevertheless, technologies such as 3D printing offer cost advantages without necessarily relying on economies of scale (Weller et al., 2015), hence enabling also SMEs to exploit such technologies for competitive purposes. Prior studies have discussed on specific technologies and their implications for firms under different perspectives, as stated also above. However, it is not clear whether firms approaching industry 4.0 technologies adopt one or multiple technologies and the consequences on their financial performances. In this respect our research question is to investigate whether there is a positive results in terms of financial performance of a firm's cumulative investment strategy in digital technologies. Moreover, our interest is to verify whether such large set of technologies affect financial performance in the same manner or there are specific technologies that have a higher impact on firm performances due to the variety of advantages offered – efficiency, quality improvement, customization, sustainability, etc. – and the activities and processes where digital technologies can be applied (Almada-Lobo, 2016; Roblek et al., 2016; Strange & Zucchella, 2017).

METHODS

The study focuses on the firms of Made in Italy sectors (see table 1) located in the North of Italy. Companies located in North Italy have a major relevance on Italian Gross Domestic Product (GDP) and on the national competitiveness in the international markets. The universe consisted of 8,022 manufacturing firms drawn from AIDA database selected in the industry considered (namely automotive, rubber and plastics, electronic appliances, lightning, furniture, eyewear, jewelry, and sport equipment) and with a turnover higher than 1 Ml Euro (in industries characterized by the presence of industrial districts firms with a turnover lower than 1 Ml Euro have been also considered).

Based on a structured questionnaire submitted through CAWI methodology to entrepreneurs, Chief Operation Officers or managers in charge for manufacturing and technological processes, firms have been contacted and 1,149 firms (14.3% of the universe) answered to the survey. The questionnaire assessed the adoption of the following technologies: (1) Robotics, (2) Additive manufacturing, (3) Laser cutting, (4) Big data and cloud, (5) Scanner 3D, (6) Augmented reality and (7) IoT and Intelligent products. These technologies are those that more than others fit the strategic needs of the manufacturing firms both in B2C and in B2B markets (Sanders et al., 2016). The subsequent questions aimed to assess the motives underlining the adoption and the no-adoption of the technologies mentioned before. For the adopting firms, the questionnaire continued assessing (a) the output of the production process (products for final customers vs. products for business clients), (b) the activity of the value chain where the firm focused the investment in the new technologies and (c) the results obtained. Table 1 and table 2 show descriptive statistics on the firms interviewed.

Insert table 1 here

Insert table 2 here

From the table 1 and table 2 it emerges that the sample is mainly composed by small and medium-sized firms. About 17% of the firms adopt at least one technology with a small prevalence of B2B firms with respect to the B2C firms. Table 2 specifically shows the characteristics of adopters.

Table 3 reports the frequencies about the different type of technology adopted, distinguishing between B2C and B2B firms and taking into consideration the firms adopting only one technology, two technologies, and three or more technologies.

Insert table 3 here

Among the adopters (197 firms, 17.5% of the sample), the most adopted technologies are the robotics (43.7% of the adopters), with a higher rate of adoption in the B2B firms (70.9%), and the additive manufacturing (44.2%), without a significant difference between B2B (56.3%) and B2C (43.7%). It is interesting to see that also Big data and cloud have good adoption rate (41.1%), while more recent IoT and smart products show a rather good percentage of adoption (23.9%). Moreover, firms show to adopt two or more technologies (58.4%), rather than only one, even if the share of firms with 1 technology is not negligible (41.6%). Finally, the Table 4 reports information about the activity of the value chain where the firm made the investment in digital technologies and the impact that these investments had on several competitive dimensions.

Insert table 4 here

The most important activities of the value chain where firms focused the investment in new digital technologies are principally linked to the manufacturing processes, new product development process and prototyping activity. Among the most important results achieved (measured in terms of firms rating 4 (much) or 5 (very much) in a scale from 1 to 5), adopters mentioned efficiency improvement, productivity improvement, and improved customer service. This preliminary evidence suggests that digital technologies should have a relevant impact on firm's performance indicators.

In order to evaluate the relationship between investments in new digital technologies and the firm performance we carry out multiple regression analyses. Firstly, we test the impact on performance of the adoption of digital technologies. Secondly, we explore the effect of cumulative investment on digital technologies of performance indicators of adopters. Thirdly, we explore the effect of single technologies on performance indicators to evaluate the impact of each of the seven technologies investigated on performance.

As *dependent variables* we considered:

- *Normalized Average EBITDA/Sales*, *ROS*, *ROA* and *ROE* (2014-2016). For each one of the performance indicators we divided firm's individual average of the performance (EBITDA/Sales, ROS, ROA and ROE computed considering years 2016, 2015 and 2014) by the industry average of the same performance indicator.

We have considered the performance indicators referring to the period 2014-2016 comparing adopters and not adopters. As far as the adopting firms are concerned, we have taken into consideration the firms that have adopted at least one of the seven digital technologies listed in the questionnaire before 2014 (and that have mentioned the year of adoption. On average between 132 out of 197 for robotics to 173 out of 197 for augmented reality did not provide any information concerning the year of adoption). In doing so, the sub-sample of adopting firms reduced from 197 to 92 firms. With regard to the performance indicators we have taken into consideration the average of the EBITDA/Sales, ROS, ROA and ROE over the period 2014-2016. As the performance indicators were referred to the years 2014, 2015 and 2016, firms for which at least one of this information was not available on AIDA database were not considered in the analyses. Moreover, in order to normalize the values of each performance indicator the average value 2014-2016 has been standardized with the average value of each sector. Finally we excluded 10% of the values, the top 5% in terms of performance and the bottom 5% performance. This is a common method to exclude possible outliers that could greatly bias the results (Wooldridge, 2013).

As *independent variables* we considered:

- the dummy variable *Adopter* (1) - *No-adopter* (0), before the 2014;
- the *Sum of technologies adopted* before the 2014; a continue variable as the result of the sum of technologies adopted by each firm (with values from 0 to 6);
- the dummy variables *Only one technology* (45 firms out of 92) which refers to the firms that adopted only one technology; *Only two technologies* (26 firms out of 92) which refers to the firms that adopted two technologies; and *Three or more technologies* (21 firms out of 92) which refers to the firms that adopted three or more technologies;

Finally, as *control variables* we decided to consider the following variables:

- the *firm's industry*;
- the *age* of the firm;
- the *average number of employees* calculated as the average of the numbers of employees firm had in the years 2014, 2015 and 2016.

In the next section regression results on the relationships between the adoption of the new digital technologies and firm's performances will be presented.

RESULTS

We started evaluating whether firms that adopt at least one of the digital technologies have higher performances. We performed a set of regression analyses with the dummy variable *Adopter-No-*

adopter, as the main independent variable, the variables *firm's industry*, *firm's average number of employees 2014-2016* and *firm's age* as the other independent variables and the *normalized performance indicator* (EBITDA/Sales, ROS, ROA and ROE) as the dependent variable. The Table 5 shows the results of the analyses.

Insert table 5 here

Results show that being an *Adopting firm* is associated to a higher performance for all the four indicators considered.

We run a second regression to evaluate if the number of technologies adopted impacts firm performances considering the variable *Sum of technologies adopted* as the main independent variable. We run two types of regression, linear and quadratic to test for the possibility that the relation between the number of technologies adopted and the performances follows a U inverted shape. The Table 6 presents the results of the analyses.

Insert table 6 here

Results reported in the table 6 show that the number of technologies adopted as a positive influence on firm performances. Moreover, the R square of the quadratic regression is higher than the R square of the linear model, and all b2 are negative. This indicates that the relation between the number of technologies and the performance seems to be inverted-U shaped. In order to verify the goodness of the quadratic model and the significance of b1 e b2 values of the quadratic regression we run a regression analysis between the variables *Sum of technologies adopted* ant the

S*quare* of the same variable as independent variables on firm performances. Table 7 shows the results of the analyses.

Insert table 7 here

Results of the table 7 confirm the inverse U-shaped relationship (only for the ROE the result is not significantly). However these results have to be considered with all the limitations of the sub-sample analyzed, because there is a high numeric difference between the two side of the variable *Sum of technologies adopted*, therefore, they need to be improved when the number of adopting firms analyzed will be higher.

The last two steps of analyses refer (a) to impact on firm's performance of having *only one technology*, only *two* technologies and *three or more* technologies (for these regression we consider the sample of the firms that adopt at least one technology) and (b) to the influence on firm performance that each single technology (in this case we consider only the sub-sample of firms that adopted only one technology). Table 8 shows the results of the regression between the dummy variables *only one technology*, *only two technologies* and *three or more technology* as dependent variables on firm performances.

Insert table 8 here

Results highlight that only the sub-samples of firms adopted one or two technologies have significantly positive relationships between the adoption of the technology and their performances. Finally, table 9 shows the impact each single technology on firm's performances.

Insert table 9 here

Results of the Table 9 show the positive impact of only two technologies robotics and laser cutting on performance of adopters.

DISCUSSION

The result of the regressions shows a positive relationship between the adoption of industry 4.0 technologies and firm performances. This confirms our hypothesis that Industry 4.0 positively impact firms' performance. We controlled our results for firms' age and size (number of employees). We tested this result not only in terms of EBITDA/sales but also in terms of ROS, ROE and ROA, taking into account however that especially ROE and ROA are more complex performance indicators and that are influenced by several factors. Nevertheless, even for these three indicators considered the adoption of industry 4.0 technologies is significant.

In terms of intensity of digital investment, the link between industry 4.0 and performance is significant but not for any level of adoption. Our research points out that this link does hold for the adoption of just one and two industry 4.0 technologies. When firms use more than three technologies there is no significant influence on performance. It seems there is an increasing relationship between digital technology and firm's performance only for those firms that adopt few technologies (one or two technologies) and that this relationship disappears for those firms that adopt three or more technologies. We could interpret this result both in a negative and in a positive way.

The positive interpretation has to do with the fact that firms that select the (few) technologies that best fit their context and their specific situation are the ones that enjoy a higher benefit in terms of performance from these technologies. In this respect, it is not the quantity of technologies *per* *se* that matters. As table 3 shoes the type of industry (B2B or B2C) greatly influence the type of technology adopted. Firms choose those technologies that are more suitable for their business. Selection of the right technologies is more important than the quantity of the technologies that are adopted (McAfee, 2004).

The negative interpretation of the fact that the positive relationship between digital technologies and firm's performance holds only for those firms that adopt few technologies (one or two) may be related to the limited capabilities of interviewed firms – mostly SMEs – to approach and manage a high number of technologies that can deeply impact on their processes and activities. These kind of technologies are not technologies available *off the shelf* – unless perhaps additive manufacturing – but require customized implementation projects as well as radical change in the way firms approach internal activities or relationships with other actors of the value chain (Freddi, 2009). Future research will evaluate whether what we observe is just a short-term phenomenon and in the future also firms with more than three technologies could increase their performance.

As regards the effect of specific technologies, robotics and laser cutting seems to have the higher effect in terms of performance than other technologies. This is due to two factors. The first one is that those are the most frequently adopted technologies. The second one is that those technologies are better known due to their domain of application in operations – where automation usually occurs even prior to digital revolution - in comparison with others (IoT, Big Data, Augmented reality) that are more recent and for which the firm may not necessarily be ready in fully exploiting their potentialities. Indeed for these technologies there is more expertise and know-how available within firm. In particular, know-how exists on how to integrate these technologies into production processes.

CONCLUSION AND LIMITATIONS

Based on original data and extensive empirical analysis, our research shows a positive link between industry 4.0 technologies and financial performance. This result is confirmed for several performance indicators. Our study provides evidence of the competitive advantage firms can achieve through digital technologies and related positive outcomes. Investing in industry 4.0 pays, also for SMEs and not only for large firms.

When considering the relationship between the intensity of investments in industry 4.0 technologies and performance interesting results emerge. The adoption of industry 4.0 technologies pays off at low level of adoption intensity (only for one or two technologies). If firms adopt more than three technologies the positive effect disappears. This evidence suggests that the firm can select the most appropriate technologies to fit with specific business needs and obtain economic returns without the requirement of a full investment in a wide set of technologies. From a managerial point of view this is a remarkable outcome, supporting also small firms and firms with limited (financial, but also organizational) resources to invest in industry 4.0 solutions. It is also important to identify the business goals and then select the technology (or two) more consistent with them.

Among the industry 4.0 technologies, robotics and laser cutting are the ones with the largest effect on performance. This shed further light on the technological-related drivers of performance, but also the link with productivity. Future research should disentangle more deeply how the characteristics of single technologies influence financial performances. As far as our research is concerned, the advantages of a digital transformation of operations and manufacturing processes described by many scholars (Almada-Lobo, 2016; Holmström et al., 2016) can be observed in the positive performances adopters are able to achieve. On the contrary, other promising technologies such as IoT (Manyika et al., 2015; Porter & Heppelmann, 2014) require more extensive changes at the product and process level, but also in terms of business models (Bogers et al., 2016). In this direction further research is required to capture the nature of organizational transformation of the emerging digital enterprise and the following performances (Reinhard et al., 2016)

Our research has several limitations. The first is related to the time span to consider in order measuring the effect of industry 4.0 technologies on performance. We decided to take into account only firms that have invested before 2013 in order to verify the results on performance on three following years (2014/2015/2016). We did not found in the literature a common method in order to measure the impact on performance and we know that this is arbitrary to cut the sample at 2013. The second limitation is related to time needed for the effect on performance to take place. We do not know if the effect are only on medium term or we should have considered a longer term. We thought that a three years span could have been a reasonable amount of time for analyzing the effect on performance. The third is that we did not consider several other elements that could have influenced performance such as the internationalization strategy of the firm, innovation, modifications of the organization, etc. Although these limitations, we think that our preliminary study could open a fertile stream of research on the relevance of industry 4.0 technologies.

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TABLE 1

Descriptive statistics of the sample

Sample	
Firms interviewed	1,149
Firm’ size (EU revenue class)	
Under million (<1mln)	14.8%
Micro firms (1mln<€<2mln)	29.1%
Small firms (2mln<€<10mln)	41.3%
Medium firms (10mln<€<50mln)	12.8%
Big firms (>50mln)	2%
Industry	
Rubber and plastic goods	5.4%
Electrical Motors and parts	23.1%
Lighting	6.3%
Automotive	10%
Furniture	5.5%
Jewelry	12.4%
Eyewear	4.5%
Sport equipment	4.5%
Clothing	9.9%
Textile	7.3%
Leather/Footwear	11.1%

Technologies adoption	**Total**	**B2B**	**B2C**
Firms adopting at least one of the digital technologies listed in the questionnaire	197 (17.15%) (% of the sample)	118 (59.9%) (% of adopters)	79 (40.1%) (% of adopters)

TABLE 2

Characteristics of adopting firms

Turnover (average 2016)	14,745 Ml Euro (min 5 – max 321,167)
Employees (average 2016)	56.8 total 35 in operations 4.5 in R&D 2.4 in marketing
% Export on turnover (average 2016)	47.5% (first export market: 28.1%)
R&D expenditure (% on turnover)	6.3%
Main activity	40.1% B2C – 59.1% B2B (average weight of 1st customer on turnover: 28.4%)
Production output	47.4% bespoke products 34.3% standard products 18,3% customizable products
Production location (value)	63.3% Region 29.1% Italy 7.6% Abroad
Supplier location (% on total number of suppliers)	35.8% Region 46.8% Italy 17.4% Abroad

TABLE 3

The adopting firms: technologies adopted

Type of technology adopted	Total*	B2B	B2C
Robotics	86 (43.7%)	61 (70.9%)	25 (29.1%)
Laser cutting	65 (33%)	36 (55.4%)	29 (44.6%)
Additive manufacturing	87 (44.2%)	49 (56.3%)	38 (44.7%)
Big Data – Cloud	81 (41.1%)	49 (60.5%)	32 (39.5%)
Scanner 3d	30 (15.2%)	21 (70%)	9 (30%)
Augmented reality	27 (13.7%)	18 (67.7%)	9 (33.3%)
IoT/Intelligent products	47 (23.9%)	28 (59.6%)	19 (41.4%)
Number of technologies adopted	**Total***	**B2B**	**B2C**
Only one technology	82 (41.6%)	59 (59.8%)	33 (40.2%)
Only two technologies	59 (29.9%)	35 (59.3%)	24 (40.7%)
Three or more technologies	56 (28.5.%)	34 (60.7%)	22 (29.3%)

Note: *N = 197; Questions about the adoption were a multiple-choice option.

TABLE 4

Activity of the value chain interested from the investment and the results obtained

Activity of the value chain where the firm invest in industry 4.0 technologies*	**Frequency**
New product development	45.2%
Prototyping	49.7%
Manufacturing activity	61.1%
Manufacturing management	35.7%
Logistic and SCM	10.8%
Marketing & Commercials activities	24.2%
Production of spare parts / Post-sale activities	5.1%
Other	1.3%
Results obtained through investments in industry 4.0**	
Reduction of production costs – Efficiency improving	60.8%
Improving of productivity	53.8%
Improving customer service	52.8%
Increasing of firm's revenue	38.2%
Product diversification	36.1%
New markets penetration	22.9%
Maintaining international competitiveness	21.7%
Increasing the share of customized products	18.8%
Environmental sustainability	16.8%
Re-organizing the activities between Italy and Abroad	7.0%
Other	3.5%

Note: *N = 157; **N = 144; the questions were a multiple-choice option.

TABLE 5

Regression analyses between Adopters/No-adopters and firm performances

Independent variables	**EBITDA/Sales**		**ROS**		**ROA**		**ROE**	
	B	*t*	*B*	*t*	*B*	*t*	*B*	*t*
Constant	1.142*	13.642	1.165*	14.238	1.300*	13.089	1.108*	9.934
Firm's industry	-.010	-.987	-.028	-2.926	-.033	-2.816	-.024	-1.678
Firm's age	.001	.621	.001	.479	.002	.689	-.001	-.367
Firm's average number of employees	.000	-.486	.000	1.069	.000	.879	.001	1.773
Adopters/No-adopters	.601*	5.097	.345**	2.959	.416**	2.972	.364°	2.131

Note: N=1,044; * p = .000; ** p < .005; ° p < .05

TABLE 6

Regression analyses between *Sum of technologies adopted* and firm performances

Perfo	Regression	Model resume					Par. estimates		
		R	*F*	*df1*	*df2*	*Sig.*	*B*	*t*	*B*
EBITDA /Sales	Linear	.009	9.365	1	1006	.002	1.142	.161	
	Quadratic	.023	11.605	2	1005	.000	1.126	.607	-.139
ROS	Linear	.004	4.027	1	957	.045	1.053	.103	
	Quadratic	.010	4.676	2	956	.010	1.043	.377	-.084
ROA	Linear	.004	3.611	1	1002	.058	1.185	.119	
	Quadratic	.012	6.255	2	1001	.002	1.169	.544	-.132
ROE	Linear	.005	4.818	1	932	.028	1.001	.168	
	Quadratic	.007	3.452	2	931	.032	.993	.420	-.080

Note: N=92

TABLE 7

Regression analyses between *Sum of technologies adopted* and firm performances

Independent Variables	EBITDA/Sales		ROS		ROA		ROE	
	B	*t*	*B*	*t*	*B*	*t*	*B*	*t*
Constant	1.126*	33.267	1.043*	31.592	1.169*	29.183	.993*	20.716
Sum of techs	.607*	4.625	.377**	2.909	.544*	3.494	.420°	2.202
Sum of techs²	-.139*	-3.705	-.084°	-2.304	-.132**	-2.979	-.080	-1.443

Note: N=92; * p = .000; ** p < .005; ° p < .05

TABLE 8

Regression analyses between the number of technologies adopted and firm performances

Independent Variables	**EBITDA/Sales**		**ROS**		**ROA**		**ROE**	
	B	*t*	*B*	*t*	*B*	*t*	*B*	*t*
Constant	1.134*	34.288	1.052*	32.530	1.180*	1.180	1.024*	21.745
Only one	.846*	5.158	.469°°	2.773	.574**	.574	.096	.393
Constant	1.155*	34.869	1.062*	32.946	1.189*	30.457	1.000*	21.529
Only Two	.537°	2.553	.266	1.307	.596°	2.410	1.038*	3.580
Constant	1.168*	35.203	1.065*	33.082	1.205*	30.852	1.026*	21.992
Three or more	.043	.186	.193	.864	-.048	-.172	.082	.245

Note: N=92; * p = .000; ** p < .005; °° p < .01; ° p < .05.

TABLE 9

Regression analyses between single technologies adopted and firm performances

Independent Variables	**EBITDA/Sales**		**ROS**		**ROA**		**ROE**	
	B	*t*	*B*	*t*	*B*	*t*	*B*	*t*
Constant	1.265*	9.816	1.109*	.000	1.217*	10.593	1.357*	9.529
Robotics	1.519*	3.824	.331	.320	.900°	2.495	-.047	-.099
Additive manufacturing	-.390	-.364	-.639	.398	-.467	-.494	-.967	-.827
Laser cutting	.547	1.110	1.165**	.002	.637	1.533	.093	.164
Big data – Cloud	-.008	-.014	.299	.499	.657	1.188	-.229	-.334
Scanner	-.245	-.279	-.742	.231	-.977	-1.263	-1.722	-1.472
Augmented reality	.185	.173	.131	.862	-.332	-.351	-1.037	-.886
IoT – Intelligent products	.370	.345	.871	.249	1.063	1.127	.273	.165

Note: N=92; * $p = .000$; ** $p < .005$.