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Digitalization in the Italian Auto Industry*

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Abstract

The paper analyzes the Italian auto industry investments in Industry 4.0 technologies and firms' perceived risks, constraints and limits to new technologies adoption. Results show that firms 4.0 are those at the higher level of the supply pyramid and closer to the final market, and are among the most innovative, dynamic and performing companies. Particularly firms invested to improve the Production, Quality, Logistics and Maintenance areas. The study also analyzes the relevance of the Italian Government's plan for sustaining innovative investments and overall the main risks and constraints that could hinder the activation of Industry 4.0 initiatives in this setting.

Keyword: Industry 4.0; Auto Industry; Innovation; Public Investments; Competences; Global Markets.

1. The Fourth Industrial Revolution: Technologies, Opportunities and Threats

Product and process innovations enabled by new technologies have become a primary condition to stand up to global competition on the market (Brondoni, 2015). The term Industry 4.0 identifies an emerging industrial model, the "fourth industrial revolution", characterized by a set of enabling technologies interconnected and communicating through the Internet. These innovations involve products, processes, organizational and business models of all business functions, from research and development to production, and affect all actors along the value chain: the technological interconnection goes beyond the company's boundaries and embraces suppliers and customers creating a cyber physical system that connects people and technologies. All phases of value creation can be managed and communicate with each other thanks to new digital technologies (Liao e al., 2017; Wang e al. 2016).

In particular, with the fourth industrial revolution, production processes will be based essentially on the following enabling technologies: Internet of Things (IoT) (networked computerized devices), Cloud (storage, processing and data transmission space that is accessible on demand via the Internet), Big Data and Analytics (collection and analysis of a large database to optimize products and production processes along the entire value chain), advanced manufacturing solutions (mainly interconnected and rapidly programmable collaborative robots

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that, thanks to sensors, will be able to work side by side with humans and learn from them), additive manufacturing (production by superimposition of material realized through 3D printers that allow the mass customization of the product, the production of complex shapes and flexibility in the use of the same production line for different productions), augmented reality (generally refers to devices that can be worn or otherwise able to increase the information available to the user in real environments), simulation (simulation between interconnected machines to optimize processes with data obtained in real time through intelligent systems), cybersecurity (technologies to protect connections, devices and data from unauthorized access, ensuring privacy) (Chen et al., 2018).

Several benefits are expected thanks to the introduction of these technologies. In particular, the new technologies would increase the flexibility of production processes combining mass customized production, shorter lead times, and higher product quality. Also, the new technologies would offer to Italian companies the opportunity to modernize, strengthen and integrate their supply network and to improve its efficiency, responsiveness and innovation to then stimulate the demand and eventually bring back to the national territory part of the production capacity lost in the past (reshoring).

Therefore, the Industry 4.0 paradigm has become, also in Italy, the primary reference for process and product innovation. Nevertheless, data suggests that Italian firms still have made minor investments to date. Between the end of 2017 and the beginning of 2018, the Ministry of Economic Development analyzed the diffusion of these technologies in our companies ("The spread of enterprises 4.0 and policies: evidence 2017", Ministry of Economic Development, 2018): only the 8.4% of Italian firms use at least one of the 4.0 technologies. Companies that do not use 4.0 technologies or plan future interventions account for 86.9% of the total. The propensity to adopt these technologies increases with the growth of the company's size: 35.5% of medium sized companies and 47.1% of large companies have made investments in 4.0 technologies. But Italy counts about 95% of small businesses. Furthermore, the new technologies already available in Italian companies are not so much innovative and mainly concern numerical control machines integrated with robotics.

The digital transformation therefore requires specific investments in technologies, skills and infrastructure that can constitute significant obstacles, especially for small and medium enterprises. Italy also has some limitations linked to the development of ultra-wideband communication infrastructures, to the difficulty of accessing the credit and to the still scarce managerial competences, especially in smaller firms. Moreover, there is a lack of graduates in technical-scientific subjects and the entire school system is lagging behind the skills needed to access and use new technologies. According to Eurostat, in Italy low-medium competences prevail in the digital field, while the level of high competences is clearly lower than the European average (European Commission, 2018).

Industry 4.0 therefore opens up a double challenge: to acquire new technologies and acquire the skills to learn how to use them and to integrate them into a network of artifacts and people open to suppliers and customers. And all this in a scenario of moderate economic recovery where the estimates of growth of the Italian economy are positive but constantly lower than in the main European countries, with a long-standing problem with respect to productivity growth and with a delay in investments in Industry 4.0. Moreover, the propensity of the Italian industry to

innovate has a strong heterogeneity in the forms through which the innovation effort is translated, with the prevalence of informal and often sporadic learning processes, mainly linked to incremental innovations, especially in small businesses. In a long-term scenario, investments in Industry 4.0 represent both a great challenge and an opportunity.

2. The Industry 4.0 and the Italian Government Policies for Growth

In September 2016 the Italian Government presented a new investments plan, called *Calenda Plan*[1], with the aim of helping Italian companies to approach the Industry 4.0 opportunities by providing them resources, technologies and know-how. The plan had two key investment directions: investments in innovations and skills.

The first line aimed, through various tools such as over-amortization or innovation credit, to encourage and support investments in new technologies, such as digital technologies, to increase firms' R&D investments and open innovation strategies.

The second line recognized the need to start new training paths to create the new skills and a 4.0 culture along the entire training cycle, from school to university, from technical colleges to doctoral courses. For example, with this aim in mind, the Government created the national Competence Centers, with a function of launching and accelerating innovative projects and technological development and of supporting the experimentation and production of new technologies in SMEs (small medium enterprises), and the Digital Innovation Hubs, with the task of connecting businesses and the research system with a role of directing them towards the most appropriate skills to accelerate the innovative investments and encourage public-private collaborations in the field of technology transfer.

After the introduction of the Plan, the results obtained until the first half of 2017 have been monitored. These indicate an increase in orders for capital goods with peaks of +11.6% for machinery and other equipment and expectations of future orders at the highest levels since 2010. The data are also positive with respect to the number of companies investing in R&D and the amount of investment (+10%/+15%). Finally, subsidies were granted for about 1.9 billion euros distributed mainly in the automotive (17%) and food (21%) sectors.

The second line of the plan has experienced greater delays, especially in the establishment of the Competence Centers.

If the overall picture seems encouraging, it remains to be understood which companies are actually investing in Industry 4.0, in which business areas and if the tools of the Calenda Plan have been used and by whom.

Interestingly enough, data shows that among the sectors most affected by this innovative weave there are the aeronautics and aerospace industry, pharmaceuticals, mechanics and automotive.

The next section answers to the above questions in the case of the Italian automotive industry.

[1] Carlo Calenda is the Italian Minister of Economic Development that launched the plan.

3. The Fourth Industrial Revolution in the Italian Automotive Industry

3.1 Data and Method

The Italian automotive industry is among the most competitive in Europe and is characterized by small and medium size firms, highly specialized on few phases of the production process, and with different propensity towards innovation (Cleff, Grimpe and Rammer, 2015). Production choices of Italian automotive firms have been traditionally affected by the national carmaker Fiat, now Fiat Chrysler Automobiles (FCA). But from 2006 to 2015, FCA cars production in Italy diminished of about 24%. This raised the need for suppliers to re-organize the whole production network, and to be attractive for foreign clients (Cabigiosu, Zirpoli and Camuffo, 2013; Zirpoli and Becker, 2011, Zirpoli and Caputo, 2002, Zirpoli and Whitford, 2016). Which is the role of 4.0 technologies in this setting? Are Italian automotive firms investing to improve their competitiveness?

Each year the Italian observatory of automotive industry components manages an on-line survey involving all firms belonging to the industry with the aim of monitoring the industry evolution (Moretti and Zirpoli, 2018). In 2018, the Italian observatory introduced a special section dedicated to understand whether, in which areas and which firms of this industry are investing in Industry 4.0 technologies and tools. Furthermore, the study focused on the main risks and constraints that could hinder the activation of Industry 4.0 initiatives.

The database on Italian automotive suppliers is developed and updated annually by the National Observatory. The updating process is developed relying on the national registry of firms using the ATECO 2007 codes linked to automotive suppliers, and partly by a direct intervention of the national industrial association of automotive suppliers.

The respondents are the managing director of the firm or the contact person within the firm who expressed the interest in participating to the observatory. The survey was performed through an online questionnaire developed on the Qualtrics platform (www.qualtrics.com). Each company was contacted following Dillman's techniques (Dillman, 1991, 2000).

The firms that completed the section of the survey about the Industry 4.0 were 441 up to 2190 firms initially involved (response rate of 20.16%).

3.2 Results

Two specific questions analyzed firms' 4.0 investments, development plans and their relevance within firms' business strategy (see Tables 1 and 2).

Of the 441 companies that responded to the survey, 54% declared that they launched Industry 4.0 initiatives and 28.1% of these declared that these initiatives are part of a strategic plan for a gradual or, in some cases, priority implementation of Industry 4.0 innovations. The 40.05% of the respondents have no investment plan in the Industry 4.0 area (see Table 1). The data therefore suggest that not only pioneer and innovative companies have made the first investments in Industry 4.0 but overall the majority of firms is investing in this direction.

If we look at the companies that have already introduced some innovations that can be traced back to Industry 4.0, the percentage is 48.5%.

Table 1: *The Strategic Importance of Innovation 4.0 in the Automotive Sector.*

How Much Important Is Industry 4.0 Innovation in Your Business Strategy?	Number of firms	% of respondents
No reflection/initiation of innovation plans in the Industry 4.0	189	40,5%
We have launched several Industry 4.0 initiatives that are not closely related to each other	121	25,9%
We have defined a strategic plan for the gradual implementation of the opportunities offered by the Industry 4.0	103	22,1%
The implementation of solutions related to Industry 4.0 is the strategic priority of our company	28	6,0%
No answer	26	5,6%
Total respondents	441	100%

Source: Observatory of the Italian Automotive Industry Components (2018).

Only the 14.3% declare that they do not want to make any investments while the 37.2% will do so in the future (see Table 2). The combined reading of Tables 1 and 2 shows how companies that invest in Industry 4.0 are basically companies capable of grasping Industry 4.0 long-term strategic value.

Among the companies that answered the question in Table 1, the companies defined as pure "specialists" (producers of parts and components mainly for the first plant, but can also produce for the spare parts market) are the companies that are the most active in the 4.0 area with about 72% who declare to have started 4.0 initiatives and more than 40% who have structured investment plans. Then, in the order of who developed 4.0 initiatives, there are the subcontractors (processing) with 65%, the subcontractors tout court (59%), the system integrators and suppliers of modules (55.2%), the specialists (Motorsport) (53.8%), the activities of Engineering and Design (42.6%) and the specialists (Aftermarket) (41.3%).

Looking at the answers given to the question in Table 2, once again the Specialists is the category that claims more investments (about 60%) while System integrators and module providers claim the lowest percentage (about 24%).

The automotive industry data are clearly encouraging compared to that of other Italian industries. In the next sections we look at who are the companies that are investing the most in Industry 4.0 plans and in which areas, and whether they have benefited from the Calenda Plan. Moreover, the Observatory also tried to understand why about the half of car companies are interested in Industry 4.0 plans.

Table 2: *The Importance of Innovation 4.0 in the Automotive Sector.*

Have you Adopted Or Are You Willing to Adopt Innovative Industry 4.0 solutions?		
	Number of firms	% of respondents
Yes, at least one	214	48,5%
No, but we will adopt at least one in the future	164	37,2%
We are not willing to adopt Industry 4.0 innovations	63	14,3%
No answer	26	
Total respondents	441	100%

Source: Observatory of the Italian Automotive Industry Components (2018).

We also analyzed who are the companies that have developed Industry 4.0 plans by giving the answers b), c) or d) in Table 1. The variables considered to create a profile of these companies, henceforth "Firms 4.0", are:

- Firms 4.0. The variable takes the value of "0" if the company has no Industry 4.0 plans, "1" if the company has Industry 4.0 plans. The enterprises that have 4.0 plans are those that have given the answers b), c), d) to the question described in Table 1;
- the turnover in 2017;
- the turnover growth between 2016 and 2017. The variable takes the value "1" if the turnover decreased more than -20%, "2" if the turnover decreased between -11% and -20%, "3" if the turnover decreased between -6% and -10%, "4" if the turnover decreased between -1% and -5%, "5" if the turnover remained unchanged, "6" if the turnover was between +1% and +5%, "7" if the turnover was between +6% and +10%, "8" if the turnover was between +11% and +20% "9" if the turnover increased by more than 20%;
- the percentage of employees with a university degree in 2017 (graduates). The variable is equal to “1” if the percentage is 0, “2” if the percentage is between 1-4, “3” if the percentage is between 5-9, “4” if the percentage is between 10-24, “5” if the variable is between 25-49, “6” if the variable is between 50-74, “7” if the variable is between 75-100%;
- investments in R&D as a percentage of the turnover in 2017. The variable takes the value "1" if the percentage is 0, "2" if the percentage is between 1-3, "3" if the percentage is between 4-5, "4" if the percentage is between 6-9, "5" if the percentage is between 10-15, "6" if the percentage is over 15;
- membership of a group. The variable has a value of "1" if the enterprise is independent, "2" if it belongs to a foreign group and "3" if it belongs to a national group;
- the position in the supply pyramid (Tier_level). The variable takes the value of "1" if the company is tier I, the variable takes the value of "2" if the company is tier

II, the variable takes the value of "3" if the company is tier III, the variable takes the value of "4" over the fourth level;

- the percentage of turnover achieved with customers abroad.

The data in Table 3 show a positive and significant correlation between being a firm 4.0 and the turnover (0.10), growth (0.21), investment in R&D (0.13), the (high) position occupied in the supply pyramid (0.16). The main descriptive statistics also confirm these data and above all the higher turnover of Companies 4.0 (see Table 4). It is interesting to note that although Specialists declare themselves Firms 4.0 in the highest percentage of cases, they do not have average values of the variables considered in Table 4 higher than that of other types of enterprises.

Finally we have set up a probit model in which the dependent variable is whether or not to be a Firm 4.0 and the explanatory variables are those described above (see Table 5). The results show that the probability of being a Firm 4.0 is positively correlated with a high positioning in the supply pyramid, the turnover growth and the investments in R&D.

Table 3: *Correlations between the Analyzed Variables***.**

	1	2	3	4	5	6	7	8
1. Firms 4.0	1.00							
2. Turnover 2017	0.10*	1.00						
3. Tier_level	-0.16	-19*	1.00					
4. Group	0.02	0.24*	-0.27*	1.00				
5. Turnover growth	0.21*	0.09*	-0.02	0.07	1.00			
6. Graduates	0.04	0.21*	-0.23	0.18*	0.00	1.00		
7. R&D investments	0.13*	0.10*	-0.06	-0.03	0.04	0.37*	1.00	
8. Export	0.05	0.05	-0.12*	0.05	-0.03	0.04	0.03	1.00

***p ≤ 0.1**

Source: Observatory of the Italian Automotive Industry Components (2018).

Since the dataset is cross-sectional, it is not possible to understand whether it is the most innovative and performing companies that have the resources and skills to develop 4.0 plans or whether this capacity already had positive effects on growth in the short term (endogeneity and reverse causality associated with the turnover growth variable). On the contrary, it seems more likely that companies with a higher propensity to spend in R&D and involved in the development of more complex subsystems (Tier_level variable) have a higher propensity to innovate also in the 4.0 field.

Table 4: *Comparison between the descriptive statistic of Firms 4.0 and those firms of the automotive industry without Industry 4.0 plans.*

	Firms 4.0				
	N	Mean	Standard deviation	Minimum	Maximum
Turnover 2017	251	53404,17	144569,30	175,00	1702294,00
Turnover growth 7 (%)	251	6,47	1,93	1,00	9,00
Graduates (%)	251	3,05	1,44	1,00	7,00
R&D investments (%)	251	2,58	1,40	1,00	6,00
Export (%)	251	33,84	35,90	0,00	100,00
Tier_level	251	1.81	0.80	1,00	4,00
	Other firms				
	N	Mean	Standard deviation	Minimum	Maximum
Turnover 2017	189	26847.51	92330,28	1,20	1085000,00
Turnover growth 7 (%)	189	5,54	2,28	1,00	9,00
Graduates (%)	189	2,94	1,74	1,00	7,00
R&D investments (%)	189	2,21	1,44	1,00	6,00
Export (%)	189	30,41	35,76	0,00	100,00
Tier_level	189	2,11	1,02	1,00	4,00

Source: Observatory of the Italian Automotive Industry Components (2018).

Table 5: *Probit Model, With Robust Errors, that Correlates the Probability of Being a Firm 4.0 with the Identified Explicative Variable.*

	Firm 4.0
Turnover 2017	8.89e-07 (9.38e-07)
Tier_level	-0.22*** (0.75)
Group	-0.07 (0.94)

Turnover growth	0.13***	(0.03)
Graduates	-.05	(0.05)
R&D investments	0.12**	(0.05)
Export	0.00.	(0.00)
Constant	-0.27	(0.32)

N=439
Chi Square= 33.52***
Pseudo R-square= 0.0684

Source: Observatory of the Italian Automotive Industry Components (2018).

The results do not change even if we check for the number of employees in R&D. The results remain substantially unchanged even considering as Firms 4.0 those enterprises that have a structured strategic plan of Industry 4.0 (enterprises that given the answers c) and d) in Table 1). In this case, however, the investments in R&D are not significant.

The observatory also analyzed the main functions affected by Industry 4.0 investments. The areas of greatest interest are, in order, Production, Quality, Logistics and Maintenance. Less than the 10% of the companies report investments in Supply Chain, Human Resources, Marketing, Customer care and sales.

Of course, there are differences based on the categories of suppliers considered. Specialists and Engineering and Design activities mainly invest in the design and engineering area. Specialists make the highest investments also in Maintenance, Quality, Logistics, Supply Chain and Production. Engineering and Design activities excel in 4.0 investments in Human Resources, while Specialists (aftermarket) mainly invest in 4.0 tools in Marketing, sales and customer care.

Finally we analyzed the impact of Calenda Plan. The Calenda Plan was conceived by the Italian government to offer dedicated resources to firms willing to make investments in Industry 4.0. The Observatory has therefore asked to automotive companies that have adopted 4.0 innovative solutions (or intend to adopt them) if they have taken advantage of the Calenda incentives.

The most of respondents, more than 70%, have not benefited from these incentives. Specialists are the companies that made the highest use of these incentives, followed by Engineering and Design activities.

The Observatory also tried to clarify the difficulties encountered by automotive firms willing to implement the Industry 4.0 model and invest in the new technologies. Firms state that the main risks and constraints to the activation of 4.0 plans are the related costs (27.9% of the respondents), the company culture and the difficulties in evaluating the opportunities offered by the 4.0 paradigm (17.5%) and the scarcity of competent internal resources (17.5%). Follow the perceived opacity of the still unknown 4.0 world, perceived as risky and for which firms find it difficult to identify suitable partners with whom to start innovative paths.

It is interesting to notice that while the variables that describe the perceived uncertainty regarding these investments (lack of knowledge of existing solutions, incentives, possible partners and communication along the supply chain) have a low weigh each, but on the whole they cover the 56% of the total motivations that hinder the diffusion of 4.0 innovations.

4. Discussion and Conclusions

The automotive sector has a propensity to invest in 4.0 innovations higher than the national average: about half of the companies have 4.0 plans and invest in 4.0 innovations even if they did not take advantage of the Calenda Plan's incentives.

The Observatory results also show that the probability of being a firm 4.0 is positively correlated with a higher position in the supply pyramid (tier level), with the turnover growth and with R&D investments: firms 4.0 are among the most innovative, dynamic and performing companies. Consistently, we find that the companies that made the greatest investments in 4.0 innovations and have more frequently 4.0 plans belong to the Specialists category. In fact, the results of the 2017 Observatory show that these companies are among the most dynamic in terms of turnover growth and export. Moreover, in 2016 the Specialists had the highest percentage of R&D activities, with a total of 83% of companies that declared R&D investments (Moretti and Zirpoli, 2017). Consistently, they are now also investing in the 4.0 area.

The results of the Observatory also show that the manufacturing is the area in which firms invested the most in terms of 4.0 innovations, in line with the industrial tradition of Italian companies. Particularly firms invested in the Production, Quality, Logistics and Maintenance areas. These data also reflect the investment choices made by the Specialists who make up the majority of 4.0 companies.

The companies analyzed claimed that the main risks and constraints to the activation of 4.0 plans are the cost of the initiative, the ability to evaluate opportunities, the scarce availability of resources and information. In general, the 4.0 world still seems opaque and not sufficiently known. These data help in part to explain the lack of use of the Calenda Plan and suggest a general lack of information.

Moreover, our data on the utilization of the Calenda Plan are in contrast with the Government data in which the 56.9% of the firms declared to have used at least one public support measure with a high propensity to cumulate incentives ("The diffusion of 4.0 enterprises and policies: evidences 2017", Ministry of Economic Development, 2018). Of course, the data should be read and compared with caution because the Plan was introduced at the end of 2016 and both surveys took place shortly after, in 2017, when part of the Plan, such as the Competence Centers, have not yet been implemented.

Overall, the data presented so far show a dynamic sector, which looks with interest to Industry 4.0 but in which the most performing and innovative companies are once again those that traditionally invested and grew the most. And the incentives that could help less performing firms entering in the growth spiral to date have been used only by a minority of companies. Moreover, we do not know how many of the companies that have not invested in Industry 4.0 have tried to access the incentives without success.

Policy makers should identify and plan specific actions to support the investments of that late majority of firms that would invests in Industry 4.0 innovations if supported by costs reduction and the necessary skills, and that need more information about incentives and available partners to build a 4.0 plan. In doing so policy makers can also increase the involvements of key stakeholders, such as the banking system, the Universities, entrepreneurial associations and others, that historically played a crucial role in supporting innovative production systems and that can foster knowledge transfer between big and small firms. Furthermore multiple institutions and stakeholders should participate and guide the introduction of new technologies that are expected to affect employees' competences and the labor market with relevant ethical consequences (Bonekamp and Sure, 2015).

The policy implications drawn from our contribute stress how firms are not evenly equipped to deal with the fourth industrial revolution. They face challenges related to the need to adapt their strategies, business models, partners and resources (Bellini and Brondoni, 2015; Schneider, 2018). Of course, this concerns especially small firms rather than large enterprises, which have developed strategies to approach Industry 4.0 and are investing, and calls for targeted measures aimed at facilitating innovation in SMEs.

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