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THE MACHINE TOOL INDUSTRY IN ITALY: INDUSTRIAL INNOVATIONS AND PERFORMANCES

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Abstract

The machine tool industry has a leading role in the Italian manufacturing system, above all in Northern Italy. This industrial branch is a strategic intermediate point in many manufacture dies, with an average innovation intensity higher than that of many other industrial branches. This work investigates if and in which way the innovation and the R&D processes carried out in the sector firms affect their productivity. We built a significant sample, which answered a questionnaire based on the CIS (Community Innovation Survey). Also a regional geographic dimension is used, to test the presence of specific local effects. Results show a positive and strong contribution from human capital to productivity, while, in the short term, physical capital have a negative impact, a result probably influenced by the economic crisis.

Keywords: Innovation; Machine tool industry; Firm productivity; Regions

JEL Classification: L1; L64; O3

1. The role of innovation in the economic systems

The innovation theme is a scholars' focusing point, starting from the seminal works of Schumpeter (1912; 1942), from different point of views. The strategic relevance of this kind of activity is established also for the machine tool industry, which sees Italy among the main world players (Calabrese & Rolfo, 2006), despite his firms have a smaller size (about 60% of the firms have less than 50 employees) than that of competitors such as German and Japanese firms (about 200 employees, on average). If we take into account the recent international economic crisis, that has deeply hit the industrial branch, it gets even more important to analyse the impact of innovation and human capital on firms' performance, in order to assess the effectiveness of those strategies.

The innovation processes (also those made by machine tools industry's firms) can have a significant impact on business performance, in terms of turnover, profitability and productivity (Bottazzi et al., 2008); at the same time, also the business organisation can benefit from innovation (Azadegan & Wagner, 2011; Oke, 2012), giving birth, so, alongside with human capital development and R&D, to a competitive triangle (Vivarelli et al., 2004) that can generate a virtuous circle for the businesses. In a scenario like the present one, productivity is a very important focusing point, given the fact that the increasing competition from the so-called BRIC countries (and, in particular, from China) is a demanding challenge for the enterprises of the industry we analyse. Given so, increasing productivity (both seen as turnover per employee and added value per employee) is the path that many businesses have to walk to stay alive and competitive in the long run, also because it allows to increase turnover and market shares. Moreover, it is well recognised that innovation, especially if described as internal formal R&D, allows the creation of products more capable of meeting the market needs, and it also produces highly positive effects and synergies (Catozzella & Vivarelli, 2007; Valle & Vázquez-Bustelo, 2009), also from the point of view of the employees' number and qualification (Vivarelli et al., 2004; Piva & Vivarelli, 2009).

Innovation is a multi-faceted phenomenon, with the presence of many features at different levels. First of all, one of these features concerns the firm's dimensions (Conte & Vivarelli, 2005; Piergiovanni et al., 2007): this feature affects the kind of technological innovation made (Conte & Vivarelli, 2005), which can be distinguished into product innovation and technology acquisition. The former is strictly bounded to formal R&D (carried out mainly internally by big enterprises), while the latter concerns the process innovation (SMEs), and it is achieved through technology acquisition or cooperation agreements. Another factor of differentiation is the geographical location (primarily at a regional level), which includes elements such as infrastructures, business environment, clusters' networks, that could determine significant differences among firms' performances (Sternberg & Arndt, 2001; Crevoisier, 2004; Piva & Vivarelli, 2005; Conte & Vivarelli, 2005). Moreover, the choice to implement innovation processes is led by many aspects that must be taken into account in a preliminary way (Piga & Vivarelli, 2003): in fact, innovation has a key role in businesses' strategies and performances (Rosenberg, 1991; Crépon et al., 1998; Janz et al., 2004; Snowdon & Stonehouse, 2006; Chen et al., 2009; Hall et al., 2008 and 2009; Huang, 2011). An increasing trend about “networking” also emerges, with particular attention to those themes that are crucial for firms' survival and competitiveness: as regards Italy, this phenomenon is increasingly spreading over, mainly about R&D. In fact, cooperation in innovation and product development turns out to be very effective (Valle & Vázquez-Bustelo, 2009), and this behaviour can be detected in particular in industrial districts (Chiarvesio et al., 2004), and in medium and high-tech productions.

Another differentiation factor about innovation is whether the industrial branch in which the firm operates is low or a high-tech one. In fact, as Pavitt (1984) highlights, technological knowledge is specific to firms and applications, with a cumulative path in development and a high variability amongst sectors in source and direction. Given so, Pavitt (1984) draws, according to these features, his famous three part taxonomy based on firms; in fact, we have: (1) supplier dominated firms; (2) production intensive firms (which can be divided into scale intensive and specialised suppliers); (3) science based firms. The machine tools industry is included, according to Pavitt (1984), as a specialised supplier sector, that is a production intensive one. Industrial branches of this kind have, as source of technology, design and development users (who are performance sensitive), while the main means of appropriation are design know-how, patents, and the knowledge of users[4]. So, human capital turns out to be one of the most important hallmarks of Italian firms in the machine tool industry, so that has been proposed the statement "made by Italians" instead of the more classical "made in Italy" (Boldizzoni & Serio, 2010).

Furthermore, we can say that the machine tools sector is relatively more dedicated to product innovations, and that is why it follows a product design's technological trajectory, with the main sources of process technologies being the in-house and customers. Finally, we can say that the innovating firms are relatively small (which is even more true for Italian firms in this branch), with a low concentric intensity and high technological diversification.

The present work is structured in the following way: the first part analyses the firms' performances in the machine tool industry in Italy, while the second one shows data (collected through a specific purpose survey) about innovation processes in a significant sample of businesses. The third part analyses, making use of econometric estimations, the existing relations between productivity measures and innovation. Finally, the fourth and last part gives some final remarks.

2. The machine tool industry in Italy: trend and performance

The balance sheet data used in the analysis of the sector are about the average annual turnover[5] (in millions of Euro) and the turnover's CAGR (Compounded Annual Growth Rate), in order to determine the average growth rate in a given period of time. Profitability is analyzed through the average annual EBITDA/sales ratio (in percentage), which depicts the gross profitability on sales. This ratio allows to verify if the firm makes positive profits from the ordinary administration: a positive value means that the business is able to cover the operating costs and the employees' wages. Finally, productivity is measured through the added value per capita (in thousands of Euro).

[4] This fact tells us why human capital is even more important in machine tool industry than in many other manufacturing sectors.

[5] Turnover's data are referred to the voices about "value of production" (A.1 + A.5).

The database AIDA (Analisi Informatizzata Delle Aziende) allowed us to investigate the balance sheet dynamics for the industrial branch firms from 2004 to 2009. The construction of the sample has been based upon the selection of firms identified by the Ateco 2002 29.4 code ("Manufacture, installation, maintenance and repair of machine tools"). From this sample we selected only those observations without missing values for the considered years. As a result, we obtained a sample of 1,160 Italian firms. Once isolated the sample, we analysed the average trend for each chosen variable, for the selected period, firstly at a national level, then focusing on Northern Italy, and finally at a regional point of view for Lombardia, Emilia-Romagna, Piemonte and Veneto, the most industrialized regions in Italy, and also those ones where machine tool industry's firms are most present (see Graph 1 below). In addition, we also selected a sample about the whole manufacturing industry (machine tool one included) in Northern Italy, in order to compare it with the sector under investigation. More precisely, a sample of manufacturing firms operating in those branches identified by Ateco codes between 15 and 37, settled in Northern Italy and with dimensions (in terms of turnover) similar to those of 29.4 sector.

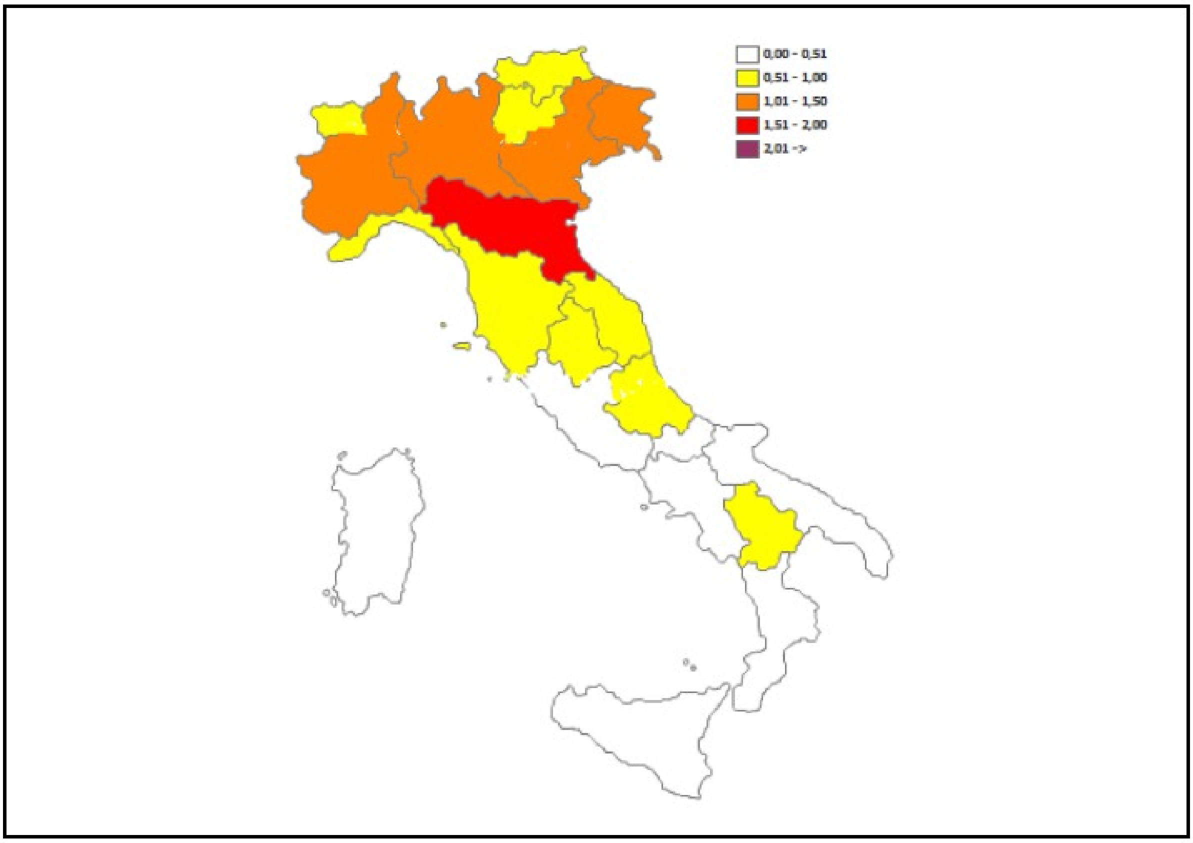
The outlook of the macroeconomic dimension and commercial performance for the Italian machine tools industry in recent years (2007-2011) allows us to highlight the relevant international role of Italy, which is the 4th world producer (6.5% of total production) and the 3rd world exporter (9.2% of total exportations).

The effects of the global economic crisis on the production and export are also evident: in 2009 the decrease in production was about 20%, mainly due to the drop of deliveries on the domestic market. In the following years the recovery has been slow, but there has been an improvement in the last two years thanks to exportations (see also Rizzi et al., 2012).

Table 1 shows some significant data which show the evolution of some variables related to the branch, while Table 2 exposes the trend about average annual turnover and turnover CAGR in the period 2004-2009.

The 2004-2009 sample analysed about the average annual turnover (in millions of Euro), counts 1,160 Italian companies. Those operating in the 29.4 branch and settled in the four main regions are 936 (46.58% in Lombardia; 18.48% in Emilia-Romagna; 10.04% in Piemonte and 24.89% in Veneto); in Northern Italy, the 29.4 industry has 1,000 firms, while values for the whole manufacturing system in Northern Italy are about a sample of 10,051 businesses.

Graph 1 – Machine tool industry structure in Italian regions (Localization quotients (QL)[6] of employees on a regional basis)



Source: MUSP elaborations on AIDA data

[6] In order to verify the level of sectoral specialization of the regional local system compared to the national context, a location quotient is used, which can be defined as the ratio between the share of companies on the machine tools sector estimated at local level and the same proportion of firms related to the whole country. Given the formula: $Q_i = (A_{ps} / A_{p.}) / (A_{.s} / A_{..})$. Where: A = variable capable of expressing the weight of economic activity in the area, p = local entity; s = manufacturing sector (sector of manufacturers of machine tools, Ateco DK294 and 295); A_{ps} = number of firms in sector s and local entity p; $A_{p.}$ = No. of total manufacturing enterprises in the local entity p; $A_{.s}$ = the sector's enterprises in the whole national territory; $A_{..}$ = No. of manufacturing firms nationwide. If the quotient of specialization is greater than 1, it means that the territory (local entity) has a number of firms in the given sector higher than the share of companies in the same sector at the national level.

Table 1 – Machine tool industry in Italy (values in millions of Euros and annual % variations)

	Millions of Euros					% variation in current terms				
	2007	**2008**	**2009**	**2010**	**2011**	**2007**	**2008**	**2009**	**2010**	**2011**
PRODUCTION	5,330	5,352	3,770	3,789	4,250	17.0	0.4	-29.6	0.5	12.2
EXPORT	2,969	3,206	2,399	2,462	3,070	12.1	8.0	-25.2	2.6	24.7
DELIVERIES ON THE DOMESTIC MARKET	2,361	2,146	1,371	1,327	1,180	23.9	-9.1	-36.1	-3.2	-11.1
IMPORT	1,403	1,470	642	691	806	25.8	4.8	-56.3	7.6	16.7
CONSUMPTION	3,764	3,617	2,013	2,018	1,986	24.6	-3.9	-44.3	0.2	-1.6
TRADE BALANCE	1,566	1,735	1,757	1,771	2,264	2.2	10.8	1.2	0.8	27.8
	% share									
IMPORT ON CONSUMPTION	37.3	40.6	31.9	34.2	40.6					
EXPORT ON PRODUCTION	55.7	59.9	63.6	65.0	72.2					
	Number of employees									
EMPLOYMENT	28,560	29,250	28,710	28,900	28,820					

Source: UCIMU, 2011

Table 2-Average annual turnover and turnover's CAGR (Millions of Euros and %) at current values.

	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**Turnover's CAGR 04-09 (%)**	**% variation 2008-2009**
ITALY (29.4)	5,250	5,583	6,224	6,793	6,753	4,470	-3.17	-33.81
NORTHERN ITALY (29.4)	5,720	6,075	6,758	7,401	7,385	4,892	-3.08	-33.76
LOMBARDIA	5,113	5,466	6,180	6,778	6,896	4,891	-0.88	-29.07
EMILIA ROMAGNA	6,123	7,138	8,007	8,673	8,574	4,323	-6.73	-49.58
PIEMONTE	11,030	9,796	9,899	10,231	9,385	5,954	-11.60	-36.56
VENETO	4,905	5,331	5,985	6,769	6,912	5,000	0.38	-27.66
MANUF. NORTH	3,831	4,562	4,844	5,271	5,742	4,788	4.56	-16.61

Source: MUSP elaborations on AIDA data

Due to the worldwide economic crisis, in 2009 the average annual turnover in the 29.4 industry, in Northern Italy, is reduced by almost 34% over 2008. If we compare this result with that for the manufacturing system in the North of the country (-16.6%), we can see that the machine tool industry undergoes an almost double decrease in size. In the 2004-2009 period, the manufacturing industry registered a turnover average annual growth of 4.56%, compared to a negative rate in the sector of machine tools (-3.2%). It is possible to deduce that other industrial branches (different from the 29.4 one) contributed to the whole manufacturing industry growth in Northern Italy, in the given period.

Table 3 – Average added value per capita (thousands of Euros per employee)

	2004	2005	2006	2007	2008	2009
ITALY (29.4)	53.50	57.88	62.14	67.20	64.85	52.36
NORTHERN ITALY (29.4)	54.23	58.70	62.59	68.06	65.73	53.68
LOMBARDIA	54.38	60.13	64.03	69.32	66.28	54.00
EMILIA ROMAGNA	54.68	56.55	59.89	63.56	55.79	40.98
PIEMONTE	52.94	56.47	58.59	60.57	71.34	65.19
VENETO	52.41	54.96	63.31	71.24	65.86	52.37
MANUFACTURE NORTH	n.a.	80.00	93.00	91.00	83.00	75.00

Source: MUSP elaborations on AIDA data

Table 3 highlights data about the average annual added value per capita (thousands of Euro/employee) between 2004 and 2009. The sample, in this case, counts 284 companies. Those operating in the 29.4 industry and settled in the four main regions are 248. The manufacturing industry in the North shows an average value higher than that for the 29.4 branch in every year observed. Now, paying attention to the four target regions of our analysis, the added value per capita for the firms of the 29.4 branch shows an increasing trend until 2007, and after that it becomes a decreasing one (except for companies from Piemonte). Moreover, we can point out that the consequences of the international economic crisis have strongly affected the manufacturing firms in Northern Italy: in fact, they saw a sharp decrease in productivity starting from 2006.

Table 4 – Average annual EBITDA/sales (%)

	2004	2005	2006	2007	2008	2009
ITALY (29.4)	8.04	8.60	9.43	9.61	6.07	-2.83
NORTHERN ITALY (29.4)	7.80	8.48	9.24	9.50	5.76	-2.66
LOMBARDIA	7.85	8.27	8.79	9.74	6.61	-2.91
EMILIA ROMAGNA	7.95	8.45	8.01	8.24	0.16	-11.53
PIEMONTE	8.59	9.11	9.44	9.98	8.78	0.98
VENETO	6.85	8.48	10.17	9.33	6.16	0.40
MANUFACTURE NORTH	n.a.	6.35	8.26	7.59	5.67	n.a.

Source: MUSP elaborations on AIDA data

Table 4 shows, for the 2004-2009 period, the trend about average profitability making use of the EBITDA/sales index (%). The sample examined counts 1,128 companies, 907 of them

settled in Lombardia (46.86%), Emilia-Romagna (18.74%), Piemonte (9.59%) and Veneto (24.81%); the 29.4 industrial branch in Northern Italy has 969 companies.
It must be noticed that the 29.4 branch (both at national and regional level) suffered a decrease in profitability starting from the booming of the crisis in 2008.
In Northern Italy, instead, the 29.4 industrial branch always shows a value for EBITDA/sales higher than that for the manufacturing industry: it could mean that the machine tool industry is featured by better efficiency and profitability at firms' level.

3. The innovation in the machine tool industry

To analyse the innovation processes' characteristics, a specific survey on a representative sample of the firms in the machine tools sector has been realized. The data about innovation activity and R&D in the 2007-2009 period were collected through directly administered questionnaires, based upon those used by Eurostat for CIS (Community Innovation Survey).
The used dataset is composed by 102 Italian firms, of which the balance sheet data about productivity (both as turnover per employee and as added value per employee) come from on-line data bank AIDA (Analisi Informatizzata Delle Aziende), by Bureau van Dijk. Moreover, our dataset was purified from distortions that may occur due to mergers and acquisitions.
The geographic distribution of the sample faithfully reproduces the actual location of the businesses of the industrial branch, with a higher concentration in Northern Italy, above all in Lombardia (52.94% of the sample), Emilia-Romagna (22.55%), Piemonte (9.80%) and Veneto (7.84%). The residual 6.87% is about firms settled in other Italian regions.
The aim of the analysis is to verify the relationship between firms' strategies and performances. Among these we chose some variables related to innovative processes (product, process and organisational innovations; R&D expenditure; type of research conducted; employed human capital), alongside with some strategic decisions that are discriminating factors for corporate policies. These factors are: participation in formal or informal business networks; use of facilitations and incentives (mainly public); policies for intellectual property's protection.
One of the main features of the Italian machine tool industry is a good propensity to innovate, despite the fact that most companies are SMEs (in fact, about 60% of the firms have less than 50 employees). The most popular way to compensate this weakness, is the creation of networks together with other firms and/or with research centres, in order to reach a greater critical mass. This fact can be traced mainly in Lombardia and Emilia-Romagna, but with

different types of networks: in fact, in the first one more than 50% of firms' total cooperates with other firms, while in the second one more than 40% of firms' total cooperates with research centres. Another important feature is the fact that, in 75% of cases, the group's (or network) headquarters are settled in Italy, although in the last years a greater propensity to internationalization can be detected, regardless of the firms' size. This phenomenon is relevant, above all, for companies from Emilia-Romagna, more focused on multi-localization, especially when the firm has more than 50 employees. In relation to networks, regional differences exist (Table 5): in fact, Piemonte and Veneto point mainly at R&D-purpose cooperation, Emilia-Romagna aims to a mix of joint production and R&D, while in Lombardia there are cooperation networks in order to create, sell and export products. This trend can be easily traced, above all, among firms with a number of employees between 50 and 100.

Firms settled in Lombardia are the most inclined to realize product innovations, while technology acquisition, differently from process innovation, is not widespread. The best practice is that of Emilia-Romagna, which prove to be involved in fostering design processes, production management and business administration; on the other hand, Veneto and Piemonte count on production processes, while Lombardia is more susceptible to the development of technologically innovative production processes (Table 6 and 7). Also in this case, this trend is more plain for medium size businesses.

Paying now our attention to organizational and marketing innovations (Table 8), we can see that in the last years this item has seen great efforts by firms. Work organization is the field in which companies settled in Emilia-Romagna are more active, while in Lombardia firms are more focused on products appearance. In general, we can say that organizational innovations see a greater investment intensity among big enterprises, while SMEs care most about marketing innovations.

If we have a look to know-how protection (Table 9), we can see that the trend is positive, in the last years: in fact, we can see that there has been a general increase in the use of these instruments, in particular for confidentiality agreements, registration of trademarks and patents; as a consequence, the machine tool sector has a general expenditure in this fields higher than the average for Italian manufacturing industry. Also in this case, the best performance is the one for Emilia-Romagna, although here firms are the ones with the lowest innovation expenditure, at the firm level, while Veneto and Piemonte show the highest one.

As already said, the machine tools industry has the highest total innovative expenditure among the manufacturing branches, with an average of € 18,000 per capita in the last three years, (Lombardia and Emilia-Romagna are in the trend, while Veneto and Piemonte have an higher value); this datum is 10 time greater than the one for the whole manufacture. The items that contribute the most to this result are those about internal R&D (about 41%) and machinery acquisition (21%), although the existence of a decrease on behalf of external R&D, participation in research programs and industrial design.

At a regional level, some differences come out; in particular, we can point out that, while Veneto and Piemonte are more inclined to dialogue with consultants, associations and suppliers, Lombardia is more tightly joint with suppliers and customers, and only marginally with private research institutes. Firms settled in Emilia-Romagna, instead, are more slanted to create networks and partnerships with research institutes, both public and private (Table 10).

An important role in innovation is played by human capital. The machine tool industry is a high-intensive human capital sector, given the fact that more than 70% of employees have a university degree (we have peaks of 15% in Piemonte and Emilia-Romagna) or a technical high school degree. We can also note the existence of a "cluster effect", due to the fact that about 90% of the employees come from the same geographic area where the enterprise is settled. This fact, which denotes the presence of a local productive culture, is fostered by a low payroll substitution rate, also explained by the low employees' average age (under 40 years). This draw a particular dynamic, featured by the hiring of workers at a young age (better if highly skilled), who grow professionally and then, at some point, can create their own firm ("spin-off", above all in Emilia-Romagna), or go to another one, although remaining in the same region. Business operators expect that graduated workforce share importance will increase, given the need, for companies, of gaining continuously new knowledge, in order to compete adequately in markets with an increasing competitiveness. So, the quest for new competitive advantages, which allow to reach an high added value through a continue innovation about offered products and services, has a primary role, in particular for big companies.

Given the above mentioned features, it results clear that the machine tool industry is made object of attention by policymakers (both at local and national level), with these ones that give support to innovation activity. These policy is well diffused in Piemonte and Emilia-Romagna (about 60% of firms received public support), while in Lombardia and Veneto not (about 40%). The trend for the last years is a strongly increasing one, so demonstrating growing interest and public involvement.

In relation to those companies benefiting from public subsidies, also in this case size matters: in fact, above the 70% of firms with more than 100 employees receives support, while SMEs less (33% of small and 47% of medium enterprises receives subsidies to innovation). This trend is common to all the regions, while differences emerge about the authority that pay out subsidies. In fact, firms from Emilia-Romagna receive support primarily by the local authority; in the other three regions we analyzed, there is a lower support from local authorities (above all in Lombardia), a fact that is compensated in Piemonte and Veneto by the recourse to funding from the European Union. Moreover, there is in every region the intention to give subsidies to sustain internal R&D (mainly in Lombardia), but Piemonte and Emilia-Romagna pay more attention to research made in collaboration with other firms (national or foreign) and/or institutions. Also in this case, the size of the firm is a crucial element: in fact, the 76% of companies with more than 100 employees are involved in calls for tenders and support programmes, against a 4% of those with a maximum of 25 employees. Compared to the national average (33%), Emilia-Romagna appears to be the most active in this field, given the fact that 42% of the whole number of machine tool industry's firms create or is member of an innovative network/partnership.

To sum up, the machine tool industry, above all in Northern Italy, turns out to be a strategic industrial sector, also thanks to some unique features. In fact, given its nature of capital goods manufacturer, this sector is subjected more to economic dynamics, a feature that makes this sector a vantage point of view to understand economic and sectoral dynamics. This industrial branch is strategic also because it is particularly able to innovate and compete advantageously in an increasingly globalized market, with the growing importance of new players. This is why the understanding of innovation dynamics and of their impact on firms' performance can be crucial for the future of this industrial branch and of the whole Italian economy.

4. An econometric analysis of the impact of innovation on productivity in the machine tool industry

The dataset used in the following empirical analysis is the same described in the previous paragraph. Table 11 shows the definitions of the variables used, while in Table 12 descriptive statistics can be found.

The dataset used is composed by the following variables, following the works by Crépon et al. (1998), Janz et al. (2004) and Hall et al. (2009).

As dependent variable we use productivity ("Productivity1"), that is expressed as turnover per employee, with a logarithmic transformation. In the second version of our model, we define productivity as added value per employee ("Productivity2"), in order to test whether the specification of the dependent variable in this way causes some changes in the results of our econometric estimations.

Firm size is measured through the firm number of employees (“Firm Size”); also a dummy variable for firms belonging to a group (27.45% of our sample) is used (“Group”).

As regards trade openness to foreign countries, the variable “Export” represents the share of turnover coming from exportation. We also make use of a dummy variable (“International”) that indicates if the firm’s most significant market is international, in order to capture effects about global competition that, in our vision, could lead the firm to accelerate the investments in R&D to give birth to more competitive products, with an important return on turnover and added value.

In order to measure the impact of innovative activity on business performance, we used various regressors, which represent the different channels through which innovation happens, depending on companies’ policies and characteristics. A particular importance is given to the logarithm of sales income coming from products new for the reference market (“Innovation Output”), the adoption of innovations of processes (“Process Innovation”, defined as a dummy for firms having introduced a production process innovation between 2007 and 2009). Also the items about innovative investments, too, are important: they are measured as per capita expenditure in R&D,(“Innovation Input”), it doesn’t matter if made inside or outside the firm. Also gross investments in instrumental goods (machinery and disembodied technology acquisitions), measured per employee (“Physical Capital”), are thought to be an important issue to account for. Dummy variables about cooperation with subjects such as universities or other higher education institutes, government or private research institutes or R&D laboratories (“Cooperation – Science & Technology”), clients or customers (“Cooperation – Market demand”) and competitors and other firms from the industry (“Cooperation – Other firms”) are inserted in the model, given the fact that most enterprises cooperate among them or with other subjects on innovation activities. There are also other two important dichotomous variables, the first about the use of instruments of protection of intellectual property (“Protection”), such as patents, and the second about receiving (1) or not (0) public subsidies for innovation (“Support”). In order to verify if having a human capital highly skilled gives a positive contribute to firms performances, we make use of two variables (“Human Capital1” and “Human Capital2”). The first one depicts the share of employees with a university degree, while the second one is about the share of employees with a high school degree, because the machine tool industry in Italy shows a high number of employees that come from a technical school or have a HND, above all in mechanics. Moreover, as Boldizzoni and Serio (2010) point out, both these categories give a substantial and valuable contribution to the sector's production and innovation. In fact, workers with a (technical) HND are equipped with skills that often result to be crucial not only in the tasks of daily work in mechanical firms, but also for a good and effective innovative process. We expected that both these workers' categories show a positive and significant contribution to innovation and firms' productivity.

Finally, we test the presence or not of regional factors, making use of four regional dummies (“Piemonte”, “Lombardia”, “Veneto”, “Emilia Romagna”), which indicate if the company is settled in one of this four regions, which are relevant for the Italian machine tool industry.

In order to analyze the relationships between the above described variables, and in particular to investigate how R&D and innovation affect the productivity, we made some econometric estimations.

First, we decided to rely on a simply OLS model which use, as a dependent variable, productivity. At this setting, which uses the White correction to make standard errors robust, we added the before mentioned variables (except “Innovation Output”), so having an estimation that uses as landmark a modeling well established in literature, in particular for what concerns the use of regressors which capture consequences due to firm size, export propensity and regional effects (see: Piergiovanni et al., 1997; Antonelli et al., 2000; Piga & Vivarelli, 2004; Conte & Vivarelli, 2005). We made firstly an estimation using as dependent variable the first definition of productivity (“Productivity1”), and then the second one (“Productivity2”), in order to test the interchangeability between the two definitions of the target measure of our analysis. If we take a look at Table 13, we can see that in both cases we have a positive influence of human capital on productivity; in particular, employees with a university degree (“Human Capital1”) are found to be more productive than their colleagues with a high school one (“Human Capital2”), although the coefficient is less significant. Another similarity is the negative impact of investment in physical capital (“Physical Capital”): this result could be driven by the fact that the period we analyze is characterized by a deep economic crisis, that implicates less investments; moreover, this kind of investment usually displays its effects in the medium-long run. The differences between these two estimations concern the cooperation with clients or customers (“Cooperation – Market demand” is negative and significant in the first version of the OLS model) and the R-squared value, that is a little bit higher in the second estimation.

In order to carry out a more sound analysis, we decided to rely on the so-called CDM approach, firstly introduced by Crépon et al. (1998), and which is now well-established in literature (i.e. Janz et al., 2004; Hall et al., 2009). By the way, given the nature of the analyzed industry (characterized by a widely spread propensity towards innovation) and of our data set, we decided to ‘truncate’ the CDM-model, so we use only the second part of this empirical approach. More specifically, we eliminated the selection equation and the one about the amount of money to invest in innovation. Moreover, like Janz et al. (2004), we are aware of the fact that the CDM approach assumes time-series data, while we treat a three-years period (2007, 2008 and 2009) as a cross-section, due to the nature of our data set; these considerations lead us to agree with the modifications of the original model made by Janz et al. (2004). On the other hand, to avoid endogeneity problems, we decided not to allow the use of some variables both in the equation about innovation output and in the one about productivity, in this relying more on the framework proposed by Hall et al. (2009) than on the one from Janz et al. (2004).

As a consequence, the analytical framework can be identified as a 2SLS model in which the equations are:

$$y_1 = \alpha RD + \beta_1 x_1 + \varepsilon \qquad (1)$$

where y_1 is “Innovation Output”, RD is “Innovation Input” and x_1 a set of variables about innovation (“Process Innovation”; “Support”; “Protection”; the three dummies about cooperation; “Group”; “International”), and ε the error term for this equation; then

$$y_2 = \gamma\, y_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \upsilon \qquad (2)$$

is the second equation, where y_2 is productivity, x_2 a set composed by regional dummies, x_3 the set of variables about human capital, and x_4 a set of other variables (“Firm Size”; “Export”; “Physical Capital”). Also in this case, the White correction is used.

To test whether our instruments are uncorrelated with the error term and that our equation is misspecified (and that one or more of the excluded exogenous variables should be included in the structural equation), we implemented a Wooldridge's (1995) robust score test of overidentifying restrictions, which is robust to heteroskedasticity. Test results tell us that our instruments are valid.

The results about this methodology are reported in Table 13 (first stage estimation is displayed in Table 14), alongside with those about Wooldridge's robust score test.

The first-stage regression (which is obviously the same both for the estimation that uses the first definition of productivity and for that that uses the second one) shows positive contributes to innovation output from firm size, innovation input and use of knowledge protection instruments; at the same time, there is a positive effect given by the dummy about Lombardia, while physical capital and the belonging to an industrial group display negative and statistically significant coefficients. Instead, the second-stage regression for the model that has “Productivity1” as dependent variable shows a good R-squared (0.3491) and some interesting results. First of all, the instrumented variable (“Innovation Output”) is found positive and statistically significant, a result that tells us that a greater percentage of turnover coming from products innovative for the market is positively correlated with a greater productivity (in terms of turnover per employee). The estimated coefficients about human capital confirm the importance of it in the machine tool industry; in particular, we can note that employees with a university degree have a coefficient higher than that for people with only a high school degree, unless a lower statistical significance. This finding confirms what emerges from the qualitative analysis of this work’s first part, namely that this industry, in Italy, rely more on human capital than on the physical one (in fact, “Physical Capital” is not significant). In fact, machine tool industry is a sector where investment goods are produced, so the main goal of innovation is not about production quantity or speed (i.e. efficiency), but about efficacy; as a result, machine tool producers are more focused on quality and customization than on quantity and mass-production. So, R&D plays the main role in the innovation activity of this sector businesses, and this fact lead to a great expense in this field of innovation (in fact, R&D is the main invoice in innovation expenditure) and to a human capital highly skilled and qualified. These characteristics help us in understanding why human capital is so more important than physical capital. Going now directly to the second version of this econometric model, we can note that the instrumented variable (“Innovation Output”) and “Human Capital2” are now not statistically significant, while the dummy about employees with a university degree shows a coefficient nearly equal to that displayed in the first version of the 2SLS model, with also a greater significance. Another difference can be detected in the statistically significant (and negative) result for investments in physical capital.

Making a comparison between the results for the 2SLS estimations with the different specification of the dependent variable, we can say that, in the short run, there are some important differences. In fact, if we are more prone to turnover, we can rely more on human capital (better if more highly educated) and on what comes out from innovation process; on the other hand, if we are more focused on added value, we have a positive impact from employees with a university education, and a negative one from physical capital. However, we have to make some considerations about these results: first of all, the three-years period we analyzed is affected by the consequences of the big economic crisis that, after the financial sector, hit deeply the manufacturing system. In particular, the machine tool industry suffered most from this negative economic conjuncture, given his nature of sector producer of instrumental goods, so data about turnover and, consequently, also added value could be distorted. As a consequence, the impact of innovation, human and physical capital, regional features and exportation propensity, could be underestimated or, anyway, not properly captured. Secondly, our estimation is concentrated on a short period of time (2007, 2008, and 2009), moreover treated as a cross-section. This characteristics, driven by the dataset nature and the lack of data for previous and (for the moment) following years, could have affected results about physical capital and other variables impact on innovation and productivity (mainly if measured as added value). In fact, it is well established in literature and in day-by-day experience that some kinds of investments display their positive return in the medium/long run. So, the combined effect of the above mentioned issues could have lead some results in our econometric analysis.

5. Conclusions

The present work analyzes the existing relations between the innovation activity and the Italian industrial performances in the machine tool industry. The latter are about the industrial productivity: we try to explain its dynamics through a set of innovation activity data, collected directly from the firms. Specifically, we evaluate the influence of product (revenue share of products new for the market) and process innovations, R&D, cooperation, export intensity, human and physical capital and intellectual property rights, on business performances. We also made use of a set of regional dummies for the four most important regions in Italy in the machine tool industry (Lombardia, Emilia-Romagna, Veneto and Piemonte), in order to evaluate the presence of regional effects.

Our results, obtained through econometric estimations, show how productivity is linked to some innovation activity indicators. In particular, productivity (expressed as turnover per employee) is influenced by the share of graduates (and also of employees with a high school degree) on the whole employees number, and by innovation output. On the other hand, added value per capita is positively influenced by the share of graduates on the whole employees number and, negatively, by physical capital. No effects are found about regional dummies, except that for Lombardia (positive) in the first stage regression.

The limits of the present survey are ascribable to the absence of a temporal dimension in the econometric estimations, where the verified relations are cross-sectional. The lack of a sequential temporal dimension (innovative processes vs. businesses performances) stopped us from creating and using lagged variables that could allow a more effective analysis of the relation between innovation and productivity. Although, it is a future analysis' objective to widen as much as possible the sample, both about the numerosity and the temporal dimension, in order to deepen the study.

Finally, another analysis critic point is the coincidence of the survey with the world economic crisis, whose effects could have determined bias in collected data and estimations results. A proof of this fact could be the variable used to estimate productivity (added value per capita): the crisis arise caused severe consequences both on the side of job losses and on the resort to instruments such as temporary lay-off ("Cassa Integrazione Guadagni"), so that productivity variations feel directly the effects caused by the recent economic trend. So, it is desirable the quest for productivity indexes and estimation methods less bias sensitive and, so, more reliable.

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Appendix

Table 5 – Collaboration typologies (% values, total companies that have relationships per region, multiple answers possible)

	Lombardia	Emilia Romagna	Other regions	Total
Design in common	29.4	44.4	33.3	34.2
Joint purchasing	23.5	33.3	16.7	23.7
Joint production	52.9	44.4	33.3	44.7
Joint selling	58.8	33.3	50.0	50.0
Export with other companies	17.6	11.1	8.3	13.2
R&D in common	23.5	44.4	41.7	34.2

Source: MUSP elaborations

Table 6 - Revenues share of the different categories of product innovation introduced in the last three years (% of the total turnover of enterprises by region)

Products or services	Lombardia	Emilia Romagna	Other regions	Machine tool 2010	Machine tool 2000	Manufacture total
New to the market	37.3	22.8	27.6	30.6	24.7	15.4
New only to the company	19.0	11.8	16.4	16.3	8.1	7.4
Not edited or modified in part	44.8	65.4	56.0	53.7	67.2	77.2
Total	100	100	100	100	100	100

Source: MUSP elaborations

Table 7 - Types of process innovations introduced in the last three years (% of total firms with process innovations by region)

	Lombardia	Emilia Romagna	Altre regioni	Totale
Design processes technologically new	50.0	58.3	53.8	53.3
Production processes technologically new	27.5	37.5	38.5	33.3
New processes of production management	42.5	37.5	30.8	37.8
New logistics systems and supply of new products	12.5	16.7	19.2	15.6
Other new processes (purchasing, ...)	25.0	66.7	50.0	43.3

Source: MUSP elaborations

Table 8 - The introduction of organizational and marketing innovations in the last three years (% of total business by region)

	Lombardia	Emilia Romagna	Other regions	Machine tool 2010	Machine tool 2000	Manufacture total
Organizational innovations						
Adoption of new management techniques	57.5	70.8	33.3	53.8	25.0	23.4
New ways of organizing work	42.5	45.8	40.7	42.9	50.0	39.1
Changes in relationships with companies or institutions	25.0	33.3	25.9	27.5	36.7	30.8
Marketing innovations						
Changes in product's appearance	32.5	25.0	37.0	31.9	51.7	40.3
New trade and distribution practices	12.5	29.2	11.1	16.5	n.a.	n.a.
New techniques to communicate and marketing	52.5	62.5	44.4	52.7	30.0	26.9

Source: MUSP elaborations

Table 9- The adoption of instruments of protection of company know-how in the last three years (% of total enterprise per region, several answers possible)

	Lombardia	Emilia Romagna	Other regions	Machine tool 2010	Machine tool 2000	Manufacture total
At least one patent application filed	37.5	62.5	44.4	46.2	21.7	12.2
Recorded at least a design or a model protection design	2.5	12.5	3.7	5.5	20.0	9.4
Recorded at least one brand	5.0	41.7	33.3	23.1	11.7	16.5
Required copyright (also for software protection)	5.0	8.3	3.7	5.5	5.0	2.5
Used confidentiality agreements to protect know-how	35.0	37.5	22.2	31.9	18.3	19.7
Patents acquired from third parties	7.5	8.3	0.0	5.5	n.a.	n.a.
Operated under license from third	10.0	12.5	3.7	8.8	n.a.	n.a.

Source: MUSP elaborations

Table 10- Partnerships for innovation activities on a regional scale (% of total enterprises).

	Lombardia	**Emilia-Romagna**	**Other regions**
Other group's firms	10.3	25.0	7.7
Suppliers	56.4	41.7	42.3
Customers	28.2	25.0	15.4
Firms of the same branch	2.6	12.5	0.0
Consultants	28.2	37.5	26.9
Research institutes and private laboratories	15.4	41.7	11.5
Universities	17.9	20.8	15.4
Public research institutes	7.7	20.8	7.7
Trade associations	25.6	29.2	23.1

Source: MUSP elaborations

Table 11 – Variables' description

Variable	Description
Productivity1	Sales per employee (in log.).
Productivity2	Added value per employee (in log.).
Firm Size	Number of employees (in log.).
Group	Dummy variable being 1 for firms belonging to a group.
Export	Share of export per sales.
International	Dummy variable being 1 if the firm's most important market is international.
Innovation Output	Sales income from innovative products for the market, per employee (in log.).
Innovation Input	Innovation expenditure in R&D, per employee (in log.).
Physical Capital	Gross investments in machinery and disembodied technology, per employee (in log.).
Protection	Dummy variable being 1 if the firm has made use of patents and/or other similar instruments to protect inventions and/or innovations.
Support	Dummy variable being 1 if the firm received any public financial support for innovation during 2007-2009.
Process Innovation	Dummy variable being 1 for firms that introduced process innovations between 2007 and 2009.
Human Capital1	Share of employees with a university degree.
Human Capital2	Share of employees with a high school degree.
Cooperation – Science & Technology	Dummy variable being 1 if the firm had a cooperation arrangement on innovation between 2007 and 2009 with universities, research institutes or R&D laboratories.
Cooperation – Market demand	Dummy variable being 1 if the firm had a cooperation arrangement on innovation between 2007 and 2009 with clients or customers.
Cooperation – Other firms	Dummy variable being 1 if the firm had a cooperation arrangement on innovation between 2007 and 2009 with other firms from the same industry.
Piemonte	Regional dummy.
Lombardia	Regional dummy.
Veneto	Regional dummy.
Emilia Romagna	Regional dummy.

Table 12 – Descriptive statistics

	N	Mean	Standard Deviation	Min	Max
Productivity1	102	5.0964	1.0014	0	6.8697
Productivity2	102	3.9606	0.8226	0	5.7683
Firm Size	102	3.7812	1.1105	1.3863	7.1261
Group	102	0.2745	0.4485	0	1
Export	102	0.4914	0.2915	0	1
International	102	0.5686	0.4977	0	1
Innovation Output	102	6.1822	3.3678	0	12.5235
Innovation Input	102	1.5902	1.1175	0	4.9532
Physical Capital	102	0.0314	0.0916	0	0.8589
Protection	102	0.6667	0.4737	0	1
Support	102	0.5392	0.5009	0	1
Process Innovation	102	0.9412	0.2365	0	1
Human Capital1	102	0.1105	0.1056	0	0.6667
Human Capital2	102	0.4690	0.2244	0	1
Cooperation – Science & Technology	102	0.4118	0.4946	0	1
Cooperation – Market demand	102	0.8235	0.3831	0	1
Cooperation – Other firms	102	0.8039	0.3990	0	1
Piemonte	102	0.0980	0.2988	0	1
Lombardia	102	0.5294	0.5016	0	1
Veneto	102	0.0784	0.2702	0	1
Emilia Romagna	102	0.2255	0.4200	0	1

Table 13 – OLS and 2SLS (second stage) regressions results (*to be continued*)

Variable	**β (Std. Err.) OLS 1**	**β (Std. Err.) OLS 2**	**β (Std. Err.) 2SLS 1**	**β (Std. Err.) 2SLS 2**
Innovation Input	0.1359 (0.0958)	0.0706 (0.0661)		
Innovation Output			0.1674* (0.0896)	0.0482 (0.0466)
Process Innovation	-0.3042 (0.3844)	-0.1094 (0.3644)		
Support	-0.0921 (0.2555)	0.1327 (0.1414)		
Protection	0.3843 (0.2521)	0.0403 (0.1787)		
Cooperation – Science & Technology	0.1774 (0.1795)	-0.0537 (0.2171)		
Cooperation – Market demand	-0.4437* (0.2378)	-0.0980 (0.1793)		
Cooperation – Other firms	0.3639 (0.3917)	-0.1319 (0.2102)		
Group	-0.3759 (0.3132)	-0.0922 (0.1689)		
International	-0.2899 (0.3177)	0.1116 (0.2847)		
Firm Size	-0.0142 (0.0777)	0.0434 (0.0965)	-0.2083 (0.1290)	-0.0108 (0.1051)
Human Capital1	1.6719* (0.9013)	1.3292** (0.6360)	1.2081* (0.6984)	1.1857** (0.5756)
Human Capital2	1.2291*** (0.4562)	0.6649* (0.3779)	0.9953*** (0.3714)	0.6592 (0.4397)
Export	0.5952 (0.7335)	-0.5073 (0.5813)	0.2278 (0.3566)	-0.3980 (0.2984)
Physical Capital	-3.5017*** (0.7730)	-4.3091*** (0.5012)	-1.8861 (1.1858)	-3.9412*** (0.5603)
Lombardia	0.0770 (0.2747)	0.1857 (0.2661)	-0.1805 (0.2812)	0.0343 (0.2845)
Emilia Romagna	0.1595 (0.2637)	0.2416 (0.2661)	0.2672 (0.2440)	0.1718 (0.2619)
Veneto	0.3931 (0.3463)	0.3572 (0.3855)	0.3856 (0.3230)	0.3535 (0.3355)
Piemonte	0.0152 (0.2956)	0.2999 (0.3246)	0.2349 (0.3455)	0.2908 (0.3161)
Cons.	4.2290*** (0.6545)	3.5752*** (0.5244)	4.1778*** (0.5803)	3.4691*** (0.4186)
Number of observations	102	102	102	102
F(18, 83)	5.93	35.72		
F(10, 91)			25.21	34.52
Prob>F	0.0000	0.0000	0.0000	0.0000
R squared	0.3818	0.4076	0.3491	0.3881
Dependent variable	Productivity1	Productivity2	Productivity1	Productivity2
Woolridge's robust test of overidentifying restrictions			4.7860 (p = 0.7802)	4.2158 (p = 0.8371)
Instrumented variable			Innovation Output	
Instruments			Innovation Input; Process Innovation; Support; Protection; Cooperation – Science & Technology; Cooperation – Market demand; Cooperation – Other firms; Group; International.	

*** p<0.01, ** p<0.05, * p<0.1 – robust standard errors in parentheses.

Table 14 – 2SLS first stage regression results

Variable	β (Std. Err.) OLS 1
Innovation Input	0.8934*** (0.2944)
Process Innovation	0.8774 (1.2573)
Support	-0.5892 (0.6616)
Protection	1.1923* (0.6816)
Cooperation – Science & Technology	0.6667 (0.6898)
Cooperation – Market demand	-0.2258 (0.8317)
Cooperation – Other firms	0.7481 (0.8210)
Group	-2.1525*** (0.7295)
International	-1.4301 (1.2263)
Firm Size	1.2553*** (0.3284)
Human Capital1	2.9518 (3.1394)
Human Capital2	1.0100 (1.3260)
Export	1.6781 (2.1008)
Physical Capital	-8.1794** (3.3001)
Lombardia	2.0345* (1.1541)
Emilia Romagna	0.1891 (1.2412)
Veneto	1.1429 (1.5149)
Piemonte	0.1291 (1.4903)
Cons.	-3.1632 (2.1515)
Number of observations	102
F(18, 83)	3.70
Prob>F	0.0000
R squared	0.4451
Dependent variable	Innovation Output
Instrumented variable	Innovation Output
Instruments	Innovation Input; Process Innovation; Support; Protection; Cooperation – Science & Technology; Cooperation – Market demand; Cooperation – Other firms; Group; International.

*** p<0.01, ** p<0.05, * p<0.1 – robust standard errors in parentheses.

Note: the above displayed regression is the same both for the 2SLS regression that uses as dependent variable "Productivity1" and for that one that has, as dependent variable, "Productivity2".