Innovation in the Automotive Industry

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Abstract

The recent evolution of international trade and the emergence of the Global Value Chain paradigm have reshaped the geography of the automotive industry. On the one hand, final assembly plants and their supply bases have spread all over the world, especially in fast-growing emerging markets. On the other hand, design, engineering, R&D and other high-value-added activities have remained concentrated in a few specialized clusters (so called "motor cities"), where the headquarters of automakers are located and where global production and innovative activities are organized. In this paper we use detailed firm-level data to provide evidence on the geography of innovation in the Italian automotive industry. Italy represents an interesting case study: it has only one car-maker with several production factories (and hence their supply bases) spread across the country. We find evidence that innovation is higher for firms that are closer to the car-maker along the supply chain and decreases with the distance from its headquarters.

1 Introduction

In the last few decades globalization and the Information and Communication Technology (ICT) revolution have fostered a substantial industrial and geographical reorganization in the automotive industry. The rise in product complexity boosted outsourcing and the involvement of suppliers in design and R&D activities. Lower costs attracted final assembly plants of automobiles to peripheral areas of OECD countries, while geographic proximity to large and fast growing markets spread assembly sites to developing economies. Despite the diffusion of production plants, R&D, design, engineering and other higher-value-added activities remained concentrated in a few specialized clusters. These clusters are usually located in the cities where car-makers originally set up their headquarters and where specialized labour markets and other institutions developed to support the automotive industry (so called "motor cities").

The study of innovation in the automotive industry deserves careful attention. Innovation is a key determinant of the long-run growth of an economy. Therefore understanding its determinants is crucial from a policy perspective. The automotive industry is one of the most

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innovative. According to the report "Sectoral Innovation Performance in the Automotive Sector" (Ploder et al. (2010)) in 2005 the automotive sector accounted for more than 20 per cent of all R&D expenditure in Europe. This share may well be underestimated because it does not consider firms that operate in the automotive supply chain but belong to sectors different from the manufacture of motor vehicles (Nace 29), for example machinery, electronics, ICT and energy. According to the report, between 2002 and 2004 more than half of the firms in the automotive sector with more than 9 employees innovated and this share was higher than the average of all Nace sectors (although not as high as in high-technology sectors or knowledge intensive engineering services): these innovative firms invested 6.3 per cent of their total turnover in R&D, compared with an average of 3.0 per cent.

In this paper, using Italian firm-level data, we seek to verify whether (i) functional and (ii) geographical closeness to the car-maker pushes suppliers' innovation. Following the literature (Sturgeon et al. (2008)), our working hypothesis is that firms' position along the supply chain influences the degree of involvement in the innovation process. The closer the firm, the greater the strength and complexity of the interactions that support innovation. Moreover geographical proximity stimulates firms' interaction along the supply chain and the exchange of tacit knowledge, thereby fostering innovation. We try to verify this hypothesis by combining two unique datasets: a firm-level survey on the Italian automotive supply chain conducted by the Turin Chamber of Commerce and the EPO Worldwide Patent Statistical Database (Patstat). In our data we are able to identify the universe of Italian firms producing automotive components by their location and by their position along the supply chain. We match firm-level data with Patstat data and retrieve the patent applications filed by each firm in our sample to measure innovation.

We find that innovation is higher for firms that are closer to the car-maker along the supply chain. The outsourcing boom in the automotive industry generated hierarchical value chains. At the top, big suppliers provide complex systems of components with high technological content. These linkages represent the bulk of direct interactions between car makers and suppliers. As a consequence, these firms innovate more than other firms along the supply chain. Moreover, after controlling for the functional position, we find some evidence that physical distance plays a role in explaining firms' innovation. Co-location of component suppliers and headquarters can be relevant for several reasons. Product development requires several months or years and the exchange of tacit knowledge needs continuous face-to-face interactions. Another possible explanation is the existence of knowledge spillovers, so that firms benefit from innovations generated by other firms located in the same area.

A methodological disclaimer is worth making. We cannot make a serious claim to causality between proximity and innovation due to the presence of serious endogeneity problems. Firms decide their own locations and it could be that ex-ante more innovative firms simply decide to locate close to a car-maker. We cannot observe what their innovation activity would have been if they had been randomly assigned to a different location. Nonetheless we think that our analysis is a step forward in the empirical literature on the Global Value Chain (GVC) in the automotive industry. First, using firm-level data, we provide micro estimates on the impact of innovation on component suppliers as predicted by the recent literature. Secondly, we measure innovation output using patents, while most of the existing literature proxies innovation using firms' self-reported measures of innovation or measures of innovation input such as R&D expenditure.

The structure of the paper is as follows: Section 2 briefly analyses the conceptual framework that guides our analysis. Section 3 depicts the main features of the Italian automotive industry. In Sections 4 and 5 we describe the data used in the empirical analysis and present the main results. Section 6 concludes.

2 The conceptual framework

In the last three decades automotive industry has been affected by relevant changes regarding both the organization of production among firms and the geographical distribution of manufacturing activities. The driving forces of these changes were the increasing technological complexity of the automotive products that fostered outsourcing of many manufacturing and service activities from car makers to suppliers, globalization that opened new markets especially in new emerging economies and the ICT revolution that made it possible to unbundle production processes all around the world. Accordingly, the conceptual framework of this paper refers to the theory of industrial organization applied to automotive industry (see a review of the literature in Cullino and Fabrizi (2005)) and to the theory of Global Value Chains (see Gereffi et al. (2005)) with a very interesting application to the automotive sector put forward by Sturgeon et al. (2008).

The increase in the technological complexity of the final product (the car) fostered a very deep functional reorganization of the automotive sector. Car makers concentrate more and more on the higher value added activity (such as design, engineering, R&D, sale and after-sale services). The need for more complex and higher technology components' systems drove car makers to outsource many activities. As a result, big systems' suppliers were increasingly involved not only in many production processes but also in innovative activities. A new organization of the innovation process emerged together with a new hierarchical division of labour among firms. The automotive supply chain has been organized along hierarchical levels: at the top the so called tier-1 suppliers make large scale activities, invest huge amounts of money into R&D activities to maintain products on the cutting-edge technology and coordinate smaller suppliers of single components. The smaller suppliers can be divided into different levels (tier-2, tier-3, etc.) according to the decreasing complexity of their products. In this framework, R&D and design processes have been reorganized: systems and components' suppliers are increasingly involved in the innovation process and become central actors of innovation.

Globalization, the ICT revolution and the unbundling of the production processes affected the automotive industry (and its innovative activities) in a very deep way and reshaped also its spatial structure. A peculiar geographical organization of this industry has been emerging: the global dimension coexists with the regional and local ones. This is quite different from the spatial organization of other important high-volume, consumer-oriented manufacturing industries (for example, apparel and electronics industry), where production for world markets is concentrated in a few locations. According to Sturgeon et al. (2008), "*the automotive industry is therefore neither fully global ... nor is it tied to the narrow geography of nation states or specific localities*

... local, national and regional value chains in the automotive industry are "nested" within the global organizational structures and business relationships of the largest firms".

The dispersion of final assembly activities in a large number of sites all over the world (very close to the final markets) has been coupled with the persistence of a very few number of clusters historically specialized in the automotive sector. In these clusters the high value added and knowledge intensive activities concentrate (R&D, engineering, design, styling, etc.). Usually these clusters, called "motor city", are the urban areas where major car makers were born and grew up; in these places the R&D departments of the most important suppliers and other economic and institutional actors involved in the creation of specialized knowledge (universities, public and private research departments, etc.) are localized. In the "motor city" interactions and exchanges of knowledge (especially tacit and uncodifiable information) can be easy, frequent and very productive. Moreover, in the "motor city" we find, like in other urban contexts, agglomeration phenomena, knowledge spillovers, specialized labor markets (see Glaeser (2011)) that furtherly fosters the economic push towards concentration of knowledge intensive activities and actors.

This helps to explain the persistence over time of these clusters, despite the centrifugal forces that drives towards the dispersion of production activities all over the world. The persistence of the "motor city" can be better understood if we take into account the importance of tacit knowledge in the automotive industry, due to the shortage of robust, industry-wide standards and codification schemes. Two main factors can help to explain this shortage: one technical and one structural. On the technical side, the integrated and complex nature of vehicle design architecture (a car can be seen as a complex system of components' systems) means that changes in one component often have an impact on other components: characteristics such as noise, vibration, handling are deeply interrelated and it is difficult to quantify their interactions in advance. Moreover, the complexity of vehicles is continuously growing and this vanishes the efforts to fully codify the design process. On the structural side, given the high concentration of the automotive industry, major car makers and suppliers have a relevant market power so that they can impose idiosyncratic standards, information systems and business processes upon their suppliers, lowering standardization.

Before the great changes in the organization of the industry, exchanges of tacit information mostly occurred within the boundaries of the (highly integrated) car maker; face-to-face interactions and proprietary standards were at the base of information and knowledge exchange. The growing and necessary involvement of suppliers in innovation activities along the supply chain intensifies knowledge exchange between lead firms and the suppliers of complex parts and sub-systems. Co-location still matters, even if it is neither a sufficient nor a necessary condition. It matters also because of the temporal dimension of innovation: at any point in time every lead firm has a lot of innovation programs on its agenda and every program may take a lot of time (often many years) to be accomplished. Staying outside the cluster certainly does not help a supplier to get involved in these programs. To sum up, given the importance of tacit knowledge in the industry, its exchange and its development are eased by spatial proximity.

Due to the forces that have been reshaping the functional and geographical organization of the car industry we can expect that innovative activities are higher the closer are the firms to the final car maker along the value chain or to the "motor city". We will test this hypothesis for the Italian case, that is interesting because within the country we have the presence of an historical cradle of automotive industry (Turin),several assembly plants spread in many Italian regions and a few number of other specialized clusters of automotive suppliers. In particular we look at patenting as a proxy of innovation. Patenting indeed is a very meaningful measure in the context of the functional and spatial reorganization described before. The dispersion of innovative activities among firms along the supply chain implies that the flows of information and knowledge across the boundaries of a single firm must be managed in a different way. The protection of intellectual rights becomes more relevant than in the past; its importance grows as the boundaries among firms at the different tiers of the supply chain become more and more blurred. It becomes a prerequisite for horizontal as well as multi-level cooperation (Ploder et al. (2010)). Growing patenting activity over time correlates to the increasing number of innovative firms in the industry. This explain why in this industry patents represents a quite good instrument for identifying innovation drivers and co-patenting is a good indicator for cooperation in innovation.

3 The Italian automotive industry

The changes described in the previous sections deeply affected also the Italian automotive industry. In the 1970s Fiat was a highly vertically integrated company. Fiat substantially changed in the decades after in its organizational structure with the outsourcing of a large fraction of production and also of innovative processes.

In 1982 around 50 percent of the value of Fiat production was sub-contracted, in 2000 that percentage rose at 70; for design, these values are even greater, from 30 percent at the beginning of the 1980s to 72 percent in 2000 (Enrietti and Lanzetti (2003)). According to Zirpoli (2010), the outsourcing of design and R&D activities has been even excessive and gave the way to a huge loss of Fiat's competences expecially those regarding more complex systems. Suppliers were fostered to increase their innovative contribution, developing new high value competences, in a framework of growing cooperative linkages and continuing exchange of knowledge with the final assembler.

From the geographical perspective, in Italy the automotive industry developed in other provinces, beside Turin, typically those where Fiat plants set up: in the South of Italy (around Pomigliano d'Arco, Melfi and Termini Imerese), in Central Italy (around Cassino and Chieti sites) and in other districts in Northern Italy (Milan and Modena).

In 2008 the automotive industry contributed to 0.6 percent of total value added in Italy and to 3.7 percent of manufacturing. In 2007-09 motor vehicles and parts accounted on average nearly 7.5 percent of total export. In 2009 more than 175,000 persons were employed in the automotive manufacturing, with more than a half of these working at parts production and about 68,000 employed in cars manufacturing (the remaining worked in the so called coach-building). Between 1991 and 2009 the share of manufacturing on total employment has fallen, from 37.4 percent to 23.7 percent; the same happened for the automotive sector (so that its weight on total manufacturing has remained more or less stable at 4.2 percent), but with different dynamics between motor vehicles production (fallen from 62.8 percent to 39.1 percent of total automotive industry employment) and parts and components manufacturing, that increased its relevance.

Looking at the geographical distribution (at province NUTS3 level) of employees, the automotive industry in Italy is quite concentrated. There are a few manufacturing sites, those where Fiat plants are located; the supply chain concentrates in the same provinces (or those surrounding). Despite the relocation of most of Fiat production elsewhere in Italy (and abroad), in 2009 the Turin area still held a very important position, with almost one third and one fifth of the total amount of employees in motor vehicle and parts production, respectively. Turin's exports accounted for nearly 15 percent of total motor vehicles export and 30 percent of parts export.

It's even more important that the Turin area hosts not only motor vehicle manufacturing activities (in the historical plant of Mirafiori) and parts suppliers, but also the headquarters of Fiat, its main directories, some important design, engineering and style centres, such as Centro Ricerche Fiat (CRF, whose almost total employees are located in the Turin district) and General Motors Powertrain Europe's research department (specialized in gasoline engines; it employes nearly 400 people, almost all engineers graduated in Politecnico di Torino). Even tertiary level education has a significant automotive specialization: since the end of 1990s the Politecnico di Torino has a Degree course in automotive engineering (thanks to a collaboration with Fiat): it graduates engineers with strong technical-scientific and managerial competences in the automotive field; in spring 2011 Politecnico di Torino and Windsor University in Ontario (Canada) signed a collaborative agreement (with the support of Fiat and Chrysler) for establishing the International Joint Master Degree in Automotive Engineering, whose attendance started in 2011-12 academic year.

4 Data

The empirical analysis uses a few different dataset, two of them almost unexploited at firm-level in the automotive industry. Since 1997 the Turin Chamber of Commerce (CCIAAT henceforth) has been publishing an annual report on the Italian automotive sector named "Osservatorio sulla Filiera Autoveicolare". The CCIAAT compiles a list of all Italian firms in the automotive industry combining information from different sources (associations' reports and specialized websites) and from the Register of Enterprises kept by CCIAAT[1]. Every year they check out for expired, winding-up and in bankruptcy firms and they include those who, after an accurate analysis of their activities' description, work in the automotive chain. After the definition of the universe of firms operating in the automotive industry, they submit a questionnaire to a representative sample. The survey contains information about turnover, employment, exports and an accurate description of the activities performed by the firms. According to CCIAAT the sample is representative of the universe of corporate enterprises in the automotive chain[2]. The sample is representative even of the different functional activities: modules and systems suppliers (the so called OEM, that is above all big multinational firms, both Italian and foreign),

[1] Huge final assemblers are excluded (Fiat, PSA, Piaggio, etc.), while coach-builders and niche producers (even assemblers) are included. Only manufacturing and services' firms are included, while those who perform only commercial activities are excluded.

[2] For example, in 2009 around 33 percent of firms in the universe participated in the survey. They accounted for almost 60 percent of total turnover of the industry according to estimates provided by the CCIAAT.

engineering and design firms (E&D), specialists (SPE, those who supply innovative and specific high value added components) and subcontractors (SUB, those who supply simpler and lower value added components).

We get from the CCIAAT two waves of the survey conducted in 2009 and 2010 on the performance registered in the previous year. Overall 1,333 out of 2,677 firms of the Italian automotive universe participate in at least one survey. For all firms, we get patent records from Patstat[3] using VAT code and the matching procedure developed for Italian firms by Marin (2011) who, following the NBER routines (NBER Patent Data Project), harmonized names and then matched applicants' names recorded in Patstat with the names of Italian firms from the AIDA-*Bureau van Dijk* database. Finally, residual information on employment comes from balance sheet data provided in "Centrale dei Bilanci" and "Cerved" by Cerved Group (Cebil henceforth)[4].

Our final sample counts 1,219 firms after data cleaning: we get rid of firms for which we were not able to recover employment neither in the CCIAAT survey nor in Cebil. We exclude from the sample three Fiat Group OEM and firms headquartered outside Piedmont but with employees in the region. For each firm in our final sample we observe the address, the position along the supply chain, the employment, whether it belongs to a group and the export status. The bulk of these information comes form the surveys and refers to years 2008 and 2009. Patent data instead goes back to 1979, therefore for each firm we are able to recover the whole innovation history. We represent the geographical distribution of our sample in Figure 1. As we expected firms in the supply chain are localized close to the Italian assembly plants both in the North and in the South of Italy.

We measure innovation using patent application. Panel (a) of figure 2, shows the evolution of patent applications submitted by firms since 1979. We report the total number of application for both firms that participate in the survey and the other identified in the universe. The number of applications increases over time for both groups. Panel (b) shows the evolution of the total number of patent applications presented by all firms. The dynamics is consistent with the increase in the complexity of the final product, the reorganization of innovation processes and the increasing role of suppliers in R&D activities. Both pictures provide evidence that our sample is representative also of innovation of the universe of firms in the automotive industry.

Looking at the summary statistics reported in Table 1, the average size (employement) of modules and system suppliers (OEM) is by far the biggest among all functional classes. OEM also tend to locate in the Turin area (*Core* in the Table) more often than ED, SPE and SUB. In the last column we report summury statistics for innovation: 14 per cent of the firms has ever applied for a patent between 1979 and 2009. The highest application rate is for OEM (42 percent). We also divide firms according to their distance from Fiat headquarters. Instead of using pre-established distance classes, we divide firms equally in groups according to observed distances. The main features of the resulting five quintiles are shown in Table 2. The rings

[3] The EPO Worldwide Patent Statistical Database (Patstat) is a single patent statistics raw database, held by the European Patent Office (EPO) and developed in cooperation with the World Intellectual Property Organisation (WIPO), the OECD and Eurostat. Patstat provides raw patent data coming from around 90 patent offices worldwide, including of course the most important and largest ones such as the European Patent Office (EPO) and the United States Patent and Trademark Office (USPTO).

[4] Cerved Group provides balance sheet data on almost all Italian corporations.

in figure 1 provide the graphical representation of the different classes. The observed quintiles correspond to meaningful distances in the automotive industry (Schmitt and Van Biesebroeck (2011)). The first one, in particular, corresponds to firms located no more than 12 km far from the car maker headquarters. This distance makes frequent daily deliveries possible. The last two quintiles, instead, identify firms located on average at more than 285 km. From this distance on, frequent and face-to-face relationships between suppliers and the car-maker becomes unlikely according to our talks with the top management of the purchasing department of Fiat Group.

The relationship between functional and geographical proximity and the propensity to innovate can be appreciated in table 3. Apart from OEM, firms in the last two quintiles, on average 285 and 627 km away, have ever applied for a patent less than the ones in the first and in the second quintiles.

5 Results

In this section we intend to test the effects on innovative activity generated by proximity to the automotive center. We first estimate the following equation:

$$y_i = \alpha + \beta_{ED} ED_i + \beta_{SUB} SUB_i + \beta_{SPE} SPE_i + \sum_{k=2}^{5} \beta_k q_i^k + \varepsilon_i$$

where the dependent variable y_i is a dummy equal to one if firm i has ever applied for patenting between 1979 and 2009; q^2 to q^5 are four of the five distances quintiles we get to test our hypothesis securing an even number of observations by each distance class. The variables ED, SUB and SPE are dummies for the functional classification of firms as the omitted category is OEM. Column 5 in Table 4 reports estimation results. Theory predictions are convalidated: OEM represent the most innovative side of the Italian automotive sector and the more the Italian automotive firms are far away from the *center* the less they innovate. Enterprises within the 1st quintile do innovate more than the ones in the 4th and 5th quintiles i.e. firms operating at no less than 284 km from the center (e.g. Bologna, Verona, Firenze and Bari). ED, SUB and SPE probability to apply for patenting ranges from 24 to 30 percentage points less than OEM. Being in the fourth distance quintile further results in 6 ($t = -2,01$) percentage points of lower probability to apply for patenting. Even stronger is the reduction for being located in the fifth quintile: -10 ($t = -3,6$) percentage points. We then add a vector of firms controls X_i covering: i) a measure of firm size; ii) a dummy for exporting firms; iii) a dummy if a firm belongs to a group [5] and estimates are reported in column 6 of Table 4. Previous results remain undisputed although less sharp. The coefficient on the 4th quintile, althout negative, is no more significant and the size of the coefficients decreases.

As additional robustness check, we add as controls dummies for the four macro areas of the Country (North-West, North-East, Center and South) to take into account the wide socio-economic and institutional differences in Italy that can have an independent impact on firms

[5] All firm controls are time invariant and "ex-post" dating 2008 or 2009, not a first best. Due to data limitation we use, as a measure of firm size, a dummy set to one for firms with a number of workers above its functional class median

innovation. In table 5 we reports the estimated coefficients. The main patterns remain unchanged.

One limitation of our analysis is the high correlation between firm characteristics and distance from Fiat, that make difficult to distinguish the pure effect of location. In Figure 3 we show a negative correlation between the distance and several firm characteristics. We divide firms accordingly to their distance from the "motor city" in 20 quantiles. For each group of firms we compute the share of firms that have ever applied for a patent (panel (a)), the share of firms with employment above the median (panel (b)), the share of exporting firms (panel (c)) and those that belong to a group (panel (d)). The greater the distance, the lower the propensity to patent, the size of the firms, the probability to export and to belong to a group. All the variables considered are relevant in explaining innovation irrespective of the location of the firms. It could be that ex-ante more innovative firms decide to locate close to the car-maker. But another possible explanation is that ex-ante identical firms end up being very different ex-post because of their proximity to the car makers. Unfortunately we only observe size, export and groups ex-post, therefore we cannot interpret our estimates in a causal way. Nonetheless, all the coefficients on the distance quintiles remain negative as predicted by the theory providing supporting evidence on the impact of distance on innovative performance.

In order to overcome the problems of bad controls, we also run a slighlty different exercise for the period 2003-2009:

$$y_{it} = \alpha + \beta_{ED} ED_i + \beta_{SUB} SUB_i + \beta_{SPE} SPE_i + \sum_{k=2}^{5} \beta_k q_i^k + X_i + \delta_t + \varepsilon_{it}$$

where y_{it} is set to one if at year t firm i has applied for pateting (see Table 6). All regressions do include time dummies δ_t and time invariant firm controls. The idea is to consider only a sub-period as close as possible to the period in which the firms controls are observed. Under the assumption that these firms characteristics have not changed during the period, they can be considered *predetermined*. Although this exercise could suffer from several problems we end up with the same insights.

6 Conclusion

Innovation in the automotive industry is an important factor of competition. Innovative skills are no longer found only in the car maker. Suppliers at the different tiers of the automotive chain become central actors in R&D activities because knowledge covers a large array of fields such as software, electronics, avionics, chemistry and plastics. Tacit knowledge plays an important role, given the lack of standards. This makes functional and geographic proximity relevant despite the forces of globalization. This is what the GVC paradigm theorizes for the automotive industry: the dispersion of final assembly activities in a large number of sites all over the world together with the persistence of a very small number of "motor cities" specialized in innovative and high technology activities. Our work finds evidence of a strong correlation between proximity and innovation, even if we are not able to infer a causality nexus. We used patent applications filed by firms as a proxy for innovation. Further improvements could come from the use of other variables concerning patent applications, in particular references (citations) to prior-art patents as a proxy for cooperation among firms.

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A Tables and Figures

Table 1: Summary Statistics

Functional Categories	Firms	Core[1]	Employement	Patent propensity[2]
OEM	50	58	557	42
ED	234	50	108	16
SUB	731	38	58	10
SPE	204	49	99	17
Total	1219	43	95	14

Source: CCIAAT, Patstat, Cebil.
[1] Share of firms located in the first two quintiles of distances in km from the automotive center.
[2] Share of firms applied for patenting at least once between 1979 and 2009.

Table 2: Distances [1]

Quintile	Mean	SDev	Median	Min	Max
1	7	3	5	1	12
2	31	18	25	12	83
3	155	37	149	85	221
4	285	34	284	222	353
5	627	210	581	358	1082
Total	212	245	132	1	1082

Source: CCIAAT.
[1] Quintiles of distances in km from the Automotive Center.

Table 3: Patent Propensity[1] by Quintiles of Distances and Functional Categories

	Quintiles				
Functional Categories	1	2	3	4	5
OEM	46	25	56	50	50
ED	24	22	7	15	6
SUB	14	13	12	8	6
SPE	20	9	32	17	9

Source: CCIAAT, Patstat.
[1] Share of firms applied for patenting at least once between 1979 and 2009.

Table 4: Innovation, GVC and Geography[1]

	(1)	(2)	(3)	(4)	(5)	(6)
ED	-0.2576***	-0.1915***			-0.2554***	-0.1942***
	[0.0740]	[0.0701]			[0.0743]	[0.0700]
SUB	-0.3160***	-0.2303***			-0.3035***	-0.2285***
	[0.0708]	[0.0676]			[0.0713]	[0.0677]
SPE	-0.2484***	-0.1939***			-0.2435***	-0.1943***
	[0.0747]	[0.0705]			[0.0750]	[0.0702]
Size		0.1099***		0.0966***		0.1097***
		[0.0195]		[0.0199]		[0.0201]
Group		0.1297***		0.1616***		0.1269***
		[0.0316]		[0.0311]		[0.0315]
Export		0.0800***		0.0877***		0.0743***
		[0.0180]		[0.0179]		[0.0186]
2nd Quintile			-0.0508	-0.0478	-0.0482	-0.0473
			[0.0329]	[0.0314]	[0.0328]	[0.0314]
3rd Quintile			-0.0455	-0.0260	-0.0341	-0.0162
			[0.0341]	[0.0319]	[0.0335]	[0.0320]
4th Quintile			-0.0752**	-0.0387	-0.0647**	-0.0320
			[0.0327]	[0.0306]	[0.0322]	[0.0305]
5th Quintile			-0.1243***	-0.0680**	-0.1047***	-0.0584**
			[0.0298]	[0.0283]	[0.0295]	[0.0283]
r2	0.035	0.114	0.014	0.102	0.045	0.118
N	1219	1219	1219	1219	1219	1219

Source: CCIAAT.
[1] Estimation method: OLS. Clustered standard errors in brackets.
*** Significant at the 1% level.
** Significant at the 5% level.
* Significant at the 10% level.

Table 5: Innovation, GVC and Geography[1,2]

	(1)	(2)	(3)	(4)	(5)	(6)
ED	-0.2568***	-0.1898***			-0.2552***	-0.1921***
	[0.0735]	[0.0697]			[0.0741]	[0.0698]
SUB	-0.3107***	-0.2255***			-0.2970***	-0.2210***
	[0.0704]	[0.0674]			[0.0712]	[0.0677]
SPE	-0.2454***	-0.1904***			-0.2401***	-0.1894***
	[0.0744]	[0.0703]			[0.0748]	[0.0701]
NE	0.0388	0.0474	0.1233***	0.0981***	0.1131***	0.0916***
	[0.0326]	[0.0308]	[0.0363]	[0.0342]	[0.0353]	[0.0339]
CE	-0.0001	0.0251	0.0915*	0.0775*	0.0809	0.0686
	[0.0476]	[0.0459]	[0.0488]	[0.0471]	[0.0496]	[0.0479]
MZ	-0.0994***	-0.0675***	-0.0181	-0.0296	-0.0204	-0.0272
	[0.0230]	[0.0243]	[0.0297]	[0.0319]	[0.0298]	[0.0316]
Size		0.1080***		0.0918***		0.1045***
		[0.0196]		[0.0199]		[0.0201]
Group		0.1331***		0.1645***		0.1307***
		[0.0316]		[0.0309]		[0.0314]
Export		0.0769***		0.0839***		0.0719***
		[0.0180]		[0.0178]		[0.0185]
2nd quintile			-0.0508	-0.0478	-0.0488	-0.0477
			[0.0330]	[0.0314]	[0.0328]	[0.0314]
3rd quintile			-0.0486	-0.0296	-0.0377	-0.0203
			[0.0340]	[0.0319]	[0.0335]	[0.0320]
4th quintile			-0.1402***	-0.0917***	-0.1248***	-0.0819***
			[0.0332]	[0.0316]	[0.0327]	[0.0317]
5th quintile			-0.1530***	-0.0889***	-0.1303***	-0.0780**
			[0.0336]	[0.0323]	[0.0329]	[0.0319]
r2	0.042	0.119	0.025	0.110	0.055	0.125
N	1219	1219	1219	1219	1219	1219

Source: CCIAAT, Patstat, Cebil

[1] Estimation method: OLS. Clustered standard errors in brackets. All regressions do include macroarea dummies.

[2] Dependent variable: dummy if a firm has applied for pateting between 1979 and 2008.

*** Significant at the 1% level.

** Significant at the 5% level.

* Significant at the 10% level.

Table 6: Innovation, GVC and Geography[1,2]

	(1)	(2)	(3)	(4)	(5)	(6)
ED	-0.1548***	-0.1270***			-0.1558***	-0.1292***
	[0.0480]	[0.0466]			[0.0480]	[0.0467]
SUB	-0.1605***	-0.1289***			-0.1583***	-0.1293***
	[0.0474]	[0.0462]			[0.0474]	[0.0463]
SPE	-0.1490***	-0.1257***			-0.1490***	-0.1271***
	[0.0479]	[0.0464]			[0.0478]	[0.0464]
Size		0.0381***		0.0330***		0.0384***
		[0.0063]		[0.0058]		[0.0064]
Group		0.0537***		0.0718***		0.0532***
		[0.0142]		[0.0148]		[0.0142]
Export		0.0134**		0.0161**		0.0130**
		[0.0061]		[0.0064]		[0.0066]
2nd Quintile			-0.0242*	-0.0231*	-0.0256**	-0.0250**
			[0.0132]	[0.0126]	[0.0130]	[0.0125]
3rd Quintile			-0.0192	-0.0141	-0.0167	-0.0114
			[0.0138]	[0.0130]	[0.0131]	[0.0126]
4th Quintile			-0.0249*	-0.0127	-0.0221*	-0.0111
			[0.0130]	[0.0122]	[0.0125]	[0.0119]
5th Quintile			-0.0339***	-0.0176	-0.0278**	-0.0145
			[0.0130]	[0.0127]	[0.0123]	[0.0123]
r2	0.032	0.067	0.004	0.050	0.035	0.069
N	7314	7314	7314	7314	7314	7314

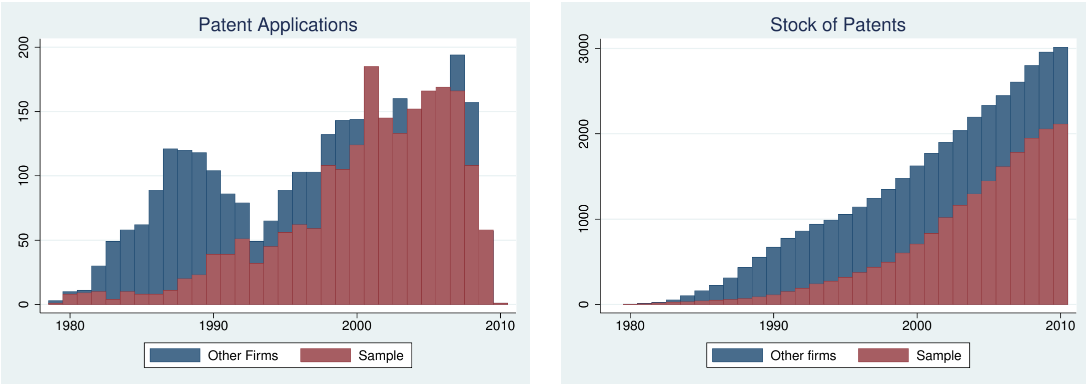
Source: CCIAAT.
[1] Estimation method: OLS. Clustered standard errors in brackets.
[2] Time dummies always included but not reported. Dependent variable: patent application dummy by year and firm.
*** Significant at the 1% level.
** Significant at the 5% level.
* Significant at the 10% level.

Figure 1: Italian Automotive Firms[1]

Source: CCIAAT.

[1] Circles represent the quintiles of the distances distribution from the automotive center. See table 2 for more details.

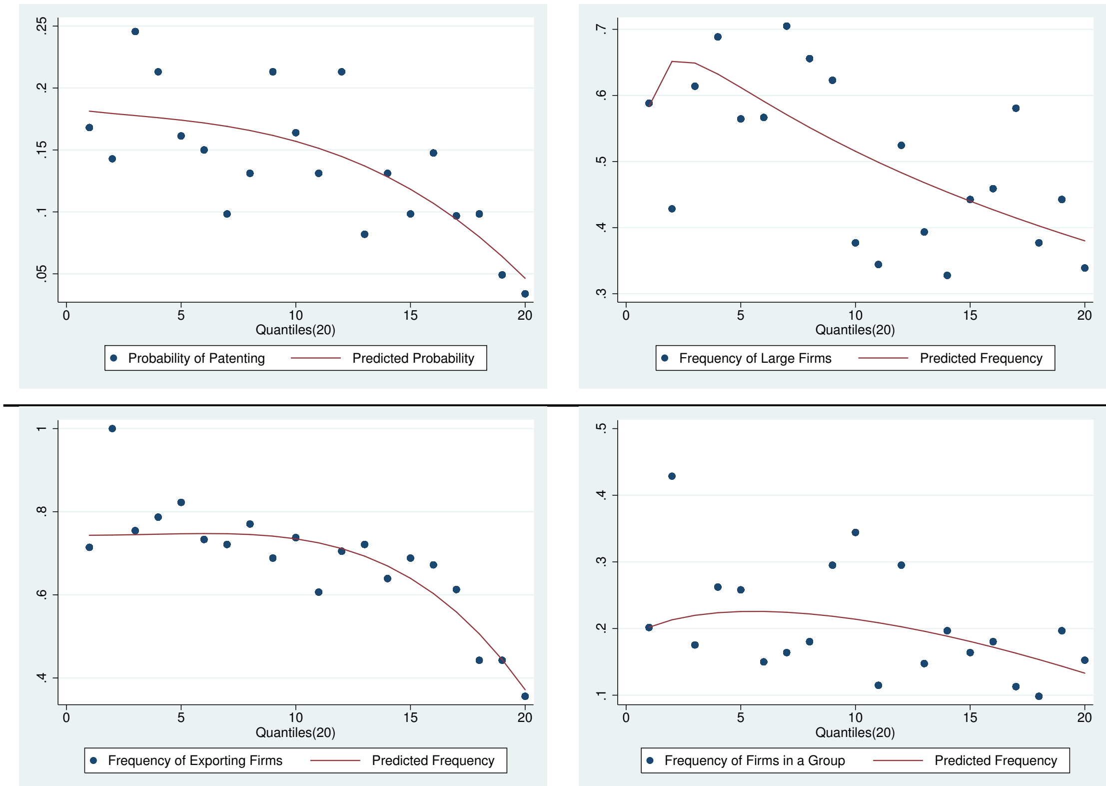
Figure 2: Evolution of Innovation Activity in the Automotive Industry[1]



Source: CCIAAT, Patstat.

[1] Automotive universe (pool of 2677 firms) from CCIAAT. Sample=compliant firms (1219); other firms=1458 automotive firms not compliant or omitted from the sample for other reasons.

Figure 3: Innovation Activity and Size/Export/Group Status of Firms by Distances [1]



Source: CCIAAT, Patstat, Cebil.

[1] x-axis: 20 quantiles of distances in km from the automotive center. In panel (a) patenting probability stands for estimated probability to apply for patenting in each quantile.