Industrial and Corporate Change, 2021, **00**, 1–25
DOI: https://doi.org/10.1093/icc/dtab058
Original Article

The birth and development of the Italian automotive industry (1894–2015) and the Turin car cluster

Aldo Enrietti[1,2], Aldo Geuna[3,4,5], Consuelo R. Nava[1] and Pier Paolo Patrucco[1,6,*]

[1]Department of Economics and Statistics Cognetti de Martiis, University of Torino, Lungodora Siena 100, Torino 10153, Italy. e-mail: consuelorubina.nava@unito.it, [2]ISMEL, Polo del Novecento, Torino, Italy. e-mail: aldo.enrietti@unito.it, [3]Department of Culture, Politics and Society, University of Torino, Lungodora Siena 100, Torino 10153, Italy, [4]Collegio Carlo Alberto, Torino. e-mail: aldo.geuna@unito.it, [5]CIFAR, MaRS Centre, West Tower, 661 University Ave., Toronto, ON M5G 1M1 Canada and [6]BRICK, Collegio Carlo Alberto, Torino. e-mail: pierpaolo.patrucco@unito.it

*Main author for correspondence.

Abstract

This paper describes the early genesis and later evolution of the Italian automotive industry employing the traditional agglomeration approach combined with Klepper's spinoff theory. It highlights the key role played by the Turin car cluster from the late 19th century. We provide the first comprehensive database of Italian automobile companies from 1894 until 2015, based on original archival research. We use historical analysis and econometric models to identify the factors contributing to the creation and success of the automotive industry in Turin. More specifically, we investigate agglomeration economies and the part played by spinoffs and institutional factors with a special emphasis on the role of local education. Our model confirms the existence of a spinoff effect and, especially, the positive effect of inherited technical skills embedded in pilots. We find support for positive agglomeration effects at the regional level, technological complementarities with aeronautics, a metropolitan cluster effect, and importance of local education. Basic and technical education seem to be particularly important initial institutional preconditions for further technical learning and scientific advancement and would make an interesting research topic.

JEL classification: O31, O33, O14, L26, I25, N83, N84, N93, N94

1. Introduction

There is agreement that clusters drive the evolution of both regions and industries; the initial formation of local concentration of firms seems to be crucial for the later development of an industry at both the regional and national levels. However, our understanding of the complex interaction of factors explaining both the emergence and evolution of industrial clusters is incomplete.

Building on the classical notion of agglomeration externalities (Marshall, 1920), scholars interested in cluster formation emphasize the idea that firms in the same industry, localized in the same geographic space, benefit from local knowledge spillovers, specialized local labor market pooling, and specialized local suppliers and buyers. The co-occurrence of these factors promotes firm clustering within an individual industry.

However, the Marshallian tradition has been questioned by Steve Klepper (2007, 2010, 2009) who proposes an industry life cycle approach to understand how industrial clusters emerge and evolve over time. Klepper's theory which is based on the role of organizational reproduction and inheritance rather than on localization economies challenges the Marshallian view.

Klepper's evolutionary framework makes it "explicit that one needs to differentiate between firms in terms of the competencies they possess as soon as they enter the new industry … the background of new entrants was decisive, in particular, whether new entrants had inherited (better) capabilities from parent companies in the same industry or not" (Boschma, 2015: 862). The process of parent company spinoffs to produce new entrants promotes the emergence of clusters that form on the basis of the competencies transferred from parent to offspring located in the same region. The spinoff process is seen as facilitating the transmission of entrepreneurial skills between parent companies and new entrants. The skills that promote entrepreneurship are derived from the new entrepreneur's previous experience of working in the parent company in the same or a similar sector. Industrial clustering is driven by the entry and exit of firms with different inherited capabilities and the ability of existing, early-established firms to generate a larger number of new firms, rather than by agglomeration economies (Buenstorf and Guenther, 2011; Buenstorf and Costa, 2018).

This paper fills a gap in the literature by proposing a bridging between the traditional agglomeration approach and Klepper's view of the role of spinoffs, to explain the early genesis and later evolution of an industry. The focus is on the Italian automotive industry and the formation of the Turin car cluster in the late 19th century up to WWII.

In the context of these contrasting views, the present paper makes four specific contributions. First, it provides evidence that the basic Klepper model does not hold for the case of the Turin cluster although Turin is the case that most closely resembles the Detroit (i.e., an automobile town) case discussed by Klepper. Geographical concentration and the evolution of production activities involve more complex explanations.

Second, we capture the effect of institutional factors—specifically education and literacy, as early preconditions for the further accumulation of technical know-how in the cluster. Since the late 19th century, the Turin area has exhibited higher levels of education and literacy compared to other Italian cities involved in car production. We argue that these constitute the initial conditions for the acquisition of more specialized mechanics know-how and formation of a cohort of technical-school-trained technicians. Some recent critical reappraisals of Klepper's work by Boschma (2015), Cusmano *et al.* (2015), and Morrison and Boschma (2019)[1] confirm that Klepper's account ignores the role of institutional factors.

Third, we specify the type of knowledge and how it is transmitted through the spinoff process. Klepper's spinoff theory positions managerial competence at the core of the model. He argues also that "spinoffs are expected to be better able than inexperienced firms to *manage* the process of technological change by dint of their prior experience" (Klepper, 2007: 624, emphasis added). We challenge this view by testing the role of inherited technical rather than managerial skills. We provide evidence that car-making firms founded by entrepreneurs with experience as pilots (not just fast drivers but technicians especially able to provide crucial feedback on the development and the setup of the automobile) are more likely to survive compared to other firms and to promote development of a cluster. In this context, pilots are considered selected "breeders" (Buenstorf and Klepper, 2009, 2010).

Fourth, we consider the notion of related industries (Frenken *et al.*, 2007) and apply it to the interaction between the automotive industry and the aviation sector (which show almost parallel development). The complementarities between these two sectors are seen as factors supporting the clustering of car production in Turin. Boschma and Wenting (2007) examine the role of related industries in the spatial development of the British car industry, and Delgado *et al.* (2010) show that clusters in regions with a large presence of other complementary industries experience higher new business formation and start-up employment growth, and better start-up firm survival. The present paper considers the role of related industries more broadly, by measuring the level of employment in the mechanical industries, and testing the specific complementarities between the automotive and aeronautics industries by examining each carmakers' product portfolio in terms

1 The latter two papers in particular include a well-articulated analysis of the role of institutions in the evolution of industrial clusters.

of whether and how many automobile producers were diversifying into the growing aeronautics sector.

In this paper, we use historical analysis combined with survival models to identify the different factors enabling the creation and success of the automotive industry in Turin. The analysis is based on original data from the new AUTOITA dataset of 396 Italian carmakers since 1894. AUTOITA was constructed by merging and comparing several different national and international archival sources and provides unique and internationally comparable data on Italian car producers. This is the first systematic attempt to create an inclusive database of car producers in Italy.

The paper is structured as follows. Section 2 provides a synthetic historical contextualization of the development of the Italian car-making industry. Section 3 presents complementary hypotheses on the development of the Turin car cluster. Section 4 describes the AUTOITA dataset and offers a quantitative, long-term descriptive analysis of the Italian automobile industry. Section 5 presents the econometric model and the model results. Section 6 presents a summary of our findings.

2. A brief history of the Italian automobile industry

The first Italian automobile manufacturer of cars that went on sale to the public was Enrico Bernardi. Bernardi & Miari Giusti was founded in 1894 in Padua by Bernardi and two engineers—Giacomo Miari and Francesco Giusti del Giardino. In 1896, it became Motori Bernardi, Miari, Giusti & Co. and up to the time of its closure in 1901, it had various ownership structures and names. Bernardi & Miari Giusti was established to produce the first petrol engine Italian cars (very innovative at the time), initially three-wheeled and then four-wheeled models. The first four-wheeled Italian petrol engine cars were produced in Italy in Turin by Michele Lanza in 1895.

The Italian automotive industry originated from a large number of mainly artisanal or small business companies (1894–1906 saw the foundation of 165 car manufacturers—see Section 4.1 for a detailed description of the AUTOITA dataset of Italian automobile companies). As in other countries, in Italy what constituted a car in terms of its basic design and method of propulsion varied. The main market for these early vehicles was composed originally of a small number of rich individuals—mostly aristocrats—and only later included financial and industry entrepreneurs.

As a result, the earliest cars were luxurious and designed to be status symbols and were used mostly for racing. Many were “unique pieces”. The manufacturers provided their customers with a frame, and the customer relied on specialized bodybuilders for the remaining construction, the bodywork, and the selection of accessories that pushed personalization to its extremes (Biffignandi, 2013, 2017). In this handicraft context, invested capital might be less than 10,000 lire (or equivalent to $1818 in 1900).[2]

From the outset, FIAT that was founded in 1899 differed from its competitors (Castronovo, 1999): (i) its initial activities were based on a large amount of invested capital (800,000 lire about $440,000 in 2018) and (ii) 3 years after its foundation, FIAT’s management (in particular Giovanni Agnelli) decided to focus on a less sophisticated product aimed at a wider audience. Instead of original bespoke designs for an elite clientele, FIAT wanted to reach a larger group of consumers using the best of the existing technology. FIAT’s strategy was to industrialize car production as quickly as possible (in the early 1900s Agnelli made several trips to the USA to visit the Ford production plants—Castronovo, 1999). Initial production volumes were small but grew quickly from 50 in 1900 to 268 in 1904. FIAT’s growth was based on exports that accounted for more than half of its production (86% in 1909) during the pre-WWI period 1904–1914 (FIAT Archivio Storico, 1996). The national market was limited: in 1906, the number of vehicles circulating in Italy was 6080 compared to about 16,000 in Germany, 40,000 in France, 63,000 in the UK, and 143,000 in the USA (Volpato, 1983). The first 20 years of the Italian automobile industry are a clear example of export-led growth.

2 Equivalent to about $54,000 in 2018.

The 1906–1907 economic crisis was the first watershed in the history of the Italian car industry, when the prospect of quick gains favored large stock speculation (Castronovo, 1999) and the consequent crash. In 1906, FIAT's stock prices reached 75 times their nominal value. Speculation encouraged the establishment of more firms: in 1907, there were 84 active automobile companies in Italy, and 6000 cars in circulation i.e., one car per 5500 inhabitants in Italy, compared to one in 981 in France, and one in 640 in England (Volpato, 1983). In 1907, there was a rapid collapse of the industry that resulted in a predominant although not monopolistic FIAT (in 1904 FIAT's share in national production was 8.7% and, in 1914, it was 35%).

WWI represented another growth opportunity for the automotive sector and, especially, for FIAT with increased automotive production and production of military-oriented vehicles. Between 1914 and 1918, FIAT's production grew more than 356%, reaching a maximum of over 19,000 vehicles in 1917, while Lancia's production increased by "only" 94% to reach a maximum of 860 vehicles in 1918. Towards the end of WWI, FIAT accounted for some 80% of Italian national automotive production (FIAT Archivio Storico, 1996). The post-war years worked to reinforce FIAT's adoption of a "Make as Ford" strategy, and its focus on serial production, as opposed to France's customization of elite models. FIAT's strategy resulted in a reduced range of models but increased production volumes based on economies of scale. In 1919, the FIAT Lingotto factory was established in Turin as the first European factory designed and organized for mass production, and its assembly lines were set up to produce the "501". The 501 was the first Italian car to be manufactured in large volumes: by 1926 around 46,000, 501 had been produced. In the 5 years between 1925 and 1929, FIAT produced 190,000 cars, equivalent to 72% of total national production (Volpato, 1983). However, in international terms, both Italian production and Italian demand remained weak: in 1929, almost 52,000 cars were produced in Italy compared to 191,000 in France and 182,000 in the UK. Thus, Italy's production was less than a third of its main competitors (Volpato, 1983).

The 1929 crisis represented a further moment of sectoral concentration for Italy. Small and medium sized companies such as Ansaldo, Ceirano, Chiribiri, Diatto, Itala, and Scat closed down. Alfa Romeo and Isotta Fraschini were acquired by the Istituto per la Ricostruzione Industriale, the Italian state holding company created in 1933 to rescue and restructure private companies that were in financial trouble due to the 1929 crisis. FIAT absorbed Officine Meccaniche that produced industrial vehicles and SPA to produce special vehicles. The 1929 crisis saw the start of a historical period characterized by trade protection policies worldwide and, especially, against fascist Italy (in 1935 the League of Nations imposed sanctions on Italy following the invasion of Ethiopia). In the period 1926–27, the Italian government decided on a policy of a strong lira (Quota 90), maintaining an exchange rate with sterling of 90–1 in order to re-enter the Gold Exchange Standard. Italian automobile companies which for most of the 1920s had exported around 60% of their production suffered a significant drop in exports from 61% in 1927 to 41% in 1930 and 17% in 1933 (Biffignandi, 2013).

The end of WWII gave FIAT another opportunity to exploit economies of scale. In 1950, FIAT production exceeded 100,000 units, in 1960, it exceeded 500,000, and in 1966, it exceeded 1 million units (equivalent to 4000 per day). This growth was linked closely to a strong domestic market that was growing faster than the domestic markets in other countries: between 1959 and 1969, the number of cars sold increased 2.1 times in Germany, 2.4 times in France, and 4.6 times in Italy. In 1958, Italy was recording car ownership rates of one for every 24 inhabitants, about the same levels as in France and the UK in 1930, and in 1965, it reached one car for every 10 inhabitants, equaling 1924 levels in the USA (Biffignandi, 2013).

3. The birth and development of industrial clusters

Whether and how the geographical concentration of economic activities affects industry dynamics, in general, and the birth and evolution of a specific industry, in particular, have long been the objects of study in the fields of economic geography and industrial economics. A stronger focus on these issues was spurred recently by re-appreciations of Steven Klepper's work on industry clusters and the industry life cycle. In this paper, we test the traditional agglomeration economy hypotheses and Klepper's spinoff model and combine these explanations of local agglomeration with the idea of technological spinoffs and the role of local education to frame our understanding of the birth and development of industries and clusters.[3]

3.1 Localization economies

There is a vast literature on whether a specific geographic location is the main driver of industrial cluster formation.

Agglomeration approaches to industry clustering and evolution are linked to the effects of Marshallian economies (Marshall, 1920): geographical agglomeration and specialization within a single industry support the formation of a local pool of technical skills and knowledge spillovers that occur along the supplier–buyer supply chain. Production and knowledge externalities among firms co-located in the industrial, geographical, and social space generate a peculiar mix of cooperation and competition that support cluster growth (Zeitlin, 2008; Becattini *et al.*, 2009).

There is a vast literature on agglomeration and industry formation and its supporting factors including local demand conditions, specific institutions, the organizational and competitive structure of regional industries, and the role of social networks (Porter, 1990; Saxenian, 1994; Hannan *et al.*, 1995; Storper, 1995; Markusen, 1996; Sorenson and Audia, 2000; Stuart and Sorenson, 2003; De Vaan *et al.*, 2012; Baptista and Costa, 2012; Brenner *et al.*, 2013).

In this context, our analysis of the agglomeration drivers that made Turin the cradle of industrial development in Italy identifies the following elements. First, Turin had a long-term special cultural and political relationship with France that was home to early automobile industry developments. The creation in 1871 of the Frejus railroad tunnel facilitated these countries' trade relationships (Turin was the first major Italian city on the railroad connection to France). Second, the geographic location of Turin near major rivers and close to mountain waterfalls provided yearlong supplies of relatively cheap water power and later hydro-electricity (Ciccarelli and Fenoaltea, 2013). Third, Turin's heritage as the capital of the Savoy Kingdom and the first Italian capital resulted in availability of a specialized workforce based on the concentration of military production, train, and railroad construction and the metallurgical industry. Fourth, Turin was specialized in coach building as a result of being the first Italian capital and its special relationship with Paris (the main location of carriage production). The carpentry skills of artisan coach builders were especially important for the early development of the automobile industry.

3.2 Related industries and knowledge complementarities

The idea of related industries (Boschma and Wenting, 2007; Frenken *et al.*, 2007) highlights that the benefits of agglomeration can derive from local diversification in complementary or related industries through the cross-fertilization of ideas and transmission of technological solutions. Agglomeration economies arise among clusters of complementary industries i.e., industries based on similar technologies and skills, shared infrastructures, and similar demand and institutions. The presence of related industries in a specific location supports new firm formation because it enhances the opportunities to develop new products by accessing complementary inputs and technologies (Delgado *et al.*, 2010).

In the context of technological complementarities, the new industries of car-making and aeronautics developed almost in parallel that motivates our search for their possible complementarities. Aeronautics is particularly important since many carmakers were involved also in the aeronautics industry. A number of new automobile firms were established in the 1920s to transfer

3 Agglomeration economies and cluster effects can occur at different spatial scales. While agglomeration economies associated with economic scale, industrial population and economic institutions are related more to the regional level, specific cluster effects such as spin-offs and technological learning take place at a narrower level such as the province/county level (for an account of the differences in spatial scales, see De Vaan *et al.*, 2012; Frenken *et al.*, 2015). It is also true that the typical Marshallian factors—local skilled labor, input–output linkages, and technical externalities—have been widely employed to explain the formation and growth of small industrial districts in very narrow geographical spaces i.e., a few municipalities (Becattini *et al.*, 2009). In our empirical analysis, we try to differentiate between the effects at different spatial scales, to capture specific cluster effects at the provincial level. We thank an anonymous referee for this point.

and apply the technological competencies of by technicians who had worked in the aeronautics industry during WWI (Mantegazza, 2009).

We test the role played by related industries and technological complementarities in the formation and growth of the automobile clusters. First, we control for the number of local employees in related industries i.e., the aggregate mechanics sector. Second, we examine the role of access to new scientific and technological knowledge available in the aviation industry whose parallel development involved similar actors in Turin. We are particularly interested in carmakers that were also active in the aeronautic industry and the technologies involved.

In 1915, Italy had 22 active aviation companies; during 1915–1918, 17 new producers entered and airplane production rose from 400 in 1915 to 6500 in 1918 (in 1918, 24,000 engines were produced).[4] This development was accompanied by growth in scientific and technological aerodynamics knowledge crucial for aeronautics. In the same period, car production experienced a significant transformation with complete cars produced by a single producer rather than car bodies and engines being produced by different makers. The design of the car body became intrinsic to the automobile project, and knowledge in aerodynamics became relevant for car production. The aeronautics industry was located mainly in Milan, Varese, and Turin. In Turin, there was systematic interaction between the aeronautics and auto industries and important players (such as Chiribiri, SPA, ITALA, SCAT, Diatto, FIAT, and Lancia among others) diversified in both auto and aeronautic technologies (designing or producing the full plane or only engines and/or components). Those companies, active especially in the production of whole planes, were able to access and master the new knowledge base and most likely transferred this knowledge to automobile producers, giving them competitive advantage.

3.3 Klepper's spinoff model

Klepper's model of the special role of spinoffs for explaining local clustering is associated with a life cycle model that explains the survival probability in relation also to the period of entry to the industry. All other things being equal, in an industry (such as the automobile sector) experiencing falling prices, early entrants have a higher probability of survival since they are able to benefit from economies of scale. At the same time, if we follow Klepper and assume a constant distribution of competences among potential entrants, in an industry experiencing falling prices, entry will be associated with higher levels of competence that will become scarcer over time, making entry less frequent and increasing the survival of incumbents. Moreover, spinoffs are characterized by higher rates of survival based on their inherited (from their parents) competencies that make them fitter and more successful. Spinoff survival probability depends also on the parent company's years of survival; the longer established the parent, the more competences it will have accumulated and the more competences it will be able to transfer at least partially to its offspring.

3.4 Technological spinoffs

According to Buenstorf and Klepper (2009, 2010) studies of US industry types, the potential to attract new entry and spinoffs is higher in regions with larger stocks of potential entrant "breeders" (i.e., incumbents) in the same industry. In other words, spinoff probability increases in regions with larger numbers of parent companies potentially able to generate spinoff companies in the same industry.

Not all incumbents are able equally to generate spinoffs. For instance, in the Italian plastics injection mold clusters (Patrucco, 2005), a few selected incumbents display ever-increasing rates of spinoff firms, while many produce no spinoffs. Giuliani (2007) and Giuliani and Bell (2005) provide similar evidence for firms in wine clusters.

This paper aims to identify the potential role of breeder firms i.e., incumbents that emerge as the main sources of spinoff activity and drive the persistence of clusters. In particular, we are interested in whether entrepreneurs who were trained pilots can be considered a specific source of

4 Building on the Ferrari (2005) database, we developed an original and comprehensive dataset (AEROITA) including 100 firms active in the aeronautics industry in Italy between 1905 and 2018. This dataset provides fine-grained information on the characteristics of aeronautics companies in Italy and will be used for future studies on the origins and development of the aeronautics industry in Italy.

technical knowledge that could explain the persistence of spinoffs and cluster growth suggested by anecdotal evidence on the early automotive industry (Biffignandi, 2013). We depart from Klepper's focus on managerial mismatches[5] as the motivation for spinoffs and highlight spinoff activity as driven by the potential for exploitation of the unique technical skills embodied in pilots.[6] During the early stages of the industry, pilots were the one that were able to drive quickly a car and have the intuition of what needed to be done to have the right setup of the car. The number of kilometers done and their daily interaction with mechanics enable them to develop a special technical knowledge.

3.5 Local education institutions

Klepper does not consider the influence of institutions on automotive cluster and industry evolution (Boschma, 2015; Frenken *et al.*, 2015). Similarly, Boschma and Wenting's (2007) work on the UK automobile industry does not include regional institutions; they argue that neither the previous literature nor the history of the UK automobile industry highlights a particular role of institutions in the emergence of the industry.

However, there is a long tradition of institutions being linked to the formation and evolution of industries and clusters (Dorfman, 1983; Saxenian, 1994; Bigelow *et al.*, 1997; Carlsson, 1997; Cooke, 2001; Becattini *et al.*, 2009). Also, the institutional characteristics of the context in which firms are embedded influence their entry and clustering into an industry, their survival, and their performance (Wenting and Frenken, 2011; De Vaan *et al.*, 2019; Menzel and Kammer, 2019; Antonietti and Boschma, 2020). In line with this work, we argue that local education institutions played a significant role in the development of the Turin automobile cluster. We consider education at the metropolitan (province) level as a shared asset enabling further economies of learning and accumulation of knowledge that drove the industry's subsequent growth and the creation of human capital in industry/technical schools. In other words, the education level can be considered an institutional pre-condition facilitating further and faster upgrading of human capital via industry/technical training that in turn favors cluster development. In this respect, scientific and educational institutions such as technical schools, polytechnics, and design schools have been described as driving industry clustering in the case of Route 128 and Silicon Valley (Dorfman, 1983; Saxenian, 1994). Also, Buenstorf *et al.* (2015) and Buenstorf and Geissler (2011) highlight the role of public research and scientific institutions in the early formation and later evolution of industry clusters.

In the mid-1800s and early 1900s, literacy levels in Piedmont and, especially, in Turin were higher than in Lombardy (and Milan) and other Italian regions (see data analysis below) and were high relative to a large number of European regions. This was due to the importance given to education by the Savoy Kingdom, and after Italian unification in 1861, by the municipality of Turin. In 1859, the Savoy Kingdom Casati Law made 2 years of elementary state-funded education obligatory (in France it was not obligatory until the 1882 Loi Ferry). In 1911, the Italian state Daneo-Credao law created an elementary state school system financed by central government (previously, primary education was managed and financed by the municipality) although some large cities such as Turin were responsible for funding primary education until the 1930s (De Fort, 1996).

Because of Turin's initial advantage, industrial and technical education in the city developed more successfully than in other locations. In 1845, the public Scuole di Meccanica e Chimica Applicate alle Arti (School of Applied Mechanics and Chemistry) was established and followed quickly by three technical schools financed partially by the municipality (De Fort, 2000).[7] The Scuole Tecniche Operaie di S. Carlo (Technical School for Factory Workers) established in 1848 and still active today was the first true industrial/technical school active in Turin. Founded by a mutual aid society to offer free education to its members (mostly Turin handicraft workers

5 The importance of organizational and trade skills is also highlighted by Cusmano *et al.*'s (2015) study on the ceramic tile industry in the Sassuolo district.

6 The role of pilots as repositories and vehicles of technical knowledge is examined in Eichenberger and Stadelman (2009) and Jenkins and Tallman (2015).

7 In the academic year 1864–65, some 500 students were enrolled in primary technical schools and another 500 in technical high schools (Baricco, 1865, cited in De Fort, 2000).

who were obliged to pay a membership fee although some 15%–30% of students received a fee waiver), the school was supported by private donations, workers societies, and a few industrial companies and received some financial help from the municipality and the government. It developed to become the reference institution for basic industrial education for between 200 and 300 students per year up to 1880, 400–500 in the following 10 years reaching some 900 students in 1890–1891, and around 1400 in 1916–17, 2 years after the introduction of a special course for designers, motor experts, and automobile drivers (Robotti, 1998). The most notable private schools include le Scuole Officine Serali (Technical Night School) (1887) that was founded and financed by private citizens to offer after work training to workers and training for unemployed people, and the Scuole Archimede (1878) founded and financed by the workers' mutual aid society Archimede for after hours work and holiday training of its members. Scuole Archimede later opened its training to the wider public. In 1900, the municipality created the Istituto Professionale Operaio—the Workers Professional Institute[8] that merged the technical schools (including the School of Drawing and Geometry, the first technical school in the city founded in 1805). In 1906, more than 300 students were enrolled at the Scuola per Meccanici e Conduttori di Automobili (School for Mechanics and Car Drivers) created by Ing. Marenco in 1905. This was the only such school in Italy and was of sufficiently high quality to attract foreign students. In 1903, the Scuola Popolare di Elettrotecnica (People's School for Electrical Work) was founded. Both of these schools were funded by private institutions, citizens, and the municipality (Senator S. Frola, mayor of Turin between 1903 and 1907, was honorary president of both schools), akin to what today we would describe as a public private partnership. The later development of the Turin cluster included an important role played by company training schools including among others Scuola Allievi FIAT (FIAT Training School) that opened in 1922 and Scuola AziendaleLancia (Lancia Corporate School) that opened in 1924.

Finally, the Technical School for Engineers that was created in 1859 provided tertiary level technical education; in 1862, it merged with the Royal Italian Industrial Museum, a museum/high level technical school[9] that in 1906 became the Politecnico of Turin.

Thus, historical heritage, political will, and economic development at the city level affected local investment in education.

4. The Italian automobile industry: descriptive analysis

4.1 The AUTOITA dataset[10]

While there are sound historical and qualitative accounts of the development of the Italian automobile industry, especially for the case of Turin, there have been no previous systematic attempts to build a database of car producers in Italy. Only three academic articles (Hannan *et al.*, 1995; Antonelli, 2001; Kim *et al.*, 2003) use quantitative data on Italy's automobile industry, but they do not include all producers and are based on secondary sources of information. These three studies offer only brief data descriptions and which car producer types are included is unclear.

Our inclusive and robust database of automobile producers in Italy is based on information from:

- Four international car encyclopedias (Doyle, 1959; Georgano, 1982, 2000; Baldwin *et al.*, 1982);
- Three Italian car encyclopedias (Biscaretti, 1959; Museo dell'Automobile, 1977; Bruni *et al.*, 2014);
- Detailed archival search at the Museo dell'Automobile of Turin and original archival work.

8 https://it.wikipedia.org/wiki/Istituto tecnicoindustriale statale Amedeo Avogadro.

9 The Royal Italian Industrial Museum (based on the South Kensington Museum—now Victoria and Albert Museum—the first industry museum that was founded in 1852) was established to house a collection of machines, industry models, and technological artifacts to support and diffuse technical-scientific education. The initial collection was based on donated technological artifacts, and some acquired by the Savoy King, from the Great London Exposition of 1862 (Giacomelli, 2010).

10 The AUTOITA dataset is available at the Documentation Center of the National Car Museum of Turin: https://www.museoauto.com/en/the-museum/documentation-centre/.

The original archival search included the annual Active Company Directory for Turin (Guida Paravia) and Milan (Guida Savallo)[11] for the years 1884–1945 and issues related to the three most important specialist magazines (*L'Automobile d'Italia; L'Automobile; Motori Cicli e Sport*) during the period 1900–1918.

The resulting AUTOITA database includes 396 companies. It includes all firms that produced at least one car (four wheeler, three wheeler, electric, and internal combustion engines); producers of prototypes that were never commercialized (due to lack of financial support or for technical reasons) but for which production plans were produced and attempts were made to sell the production (investment in advertising the products). We excluded sole producers of racing cars, trucks, buses, and other commercial vehicles. For 38 companies listed only in Biscaretti (1959), we were unable to find much information; for another 22 companies, we have information only included in Georgano (1982) and Doyle (1959) that is incomplete and not completely reliable. Our final sample is composed of 336 companies for that we have a rich set of information on year of entry/exit, location, type of automobile produced (electric, cyclecar, and four wheeler), all licenses involved, eventual object of merger and acquisition, entrepreneurs involved in creating the company and their background (incomplete information), and links to aeronautics production. Following Boschma and Wenting (2007), we classify companies according to entrepreneur's pre-entry techno-economic experience/inexperience and spinoff experience as follows: (i) spinoff with at least one founder with previous experience in the automobile industry; (ii) experienced entrepreneur with a history of working in a closely or partly related industry; and (iii) inexperienced firm, not fulfilling either of the above criteria categories. Given the historical development of Italy's automobile industry and its first phase when production of racing cars was particularly important, we created a spinoff subcategory for companies founded by pilots previously employed in another company (the most notable example is the case of Lancia Automobiles, one of Italy's oldest carmakers that was founded in Turin in 1906 by Vincenzo Lancia, a former pilot employed by FIAT).

Table 1 presents summary information comparing our sample to the UK case (Boschma and Wenting, 2007). Since our information on the UK sample is incomplete, this comparison is partial. Boschma and Wenting (2007) focus on automobile manufacturers defined as "producers being principally devoted to four-wheeled petrol-engined passengers cars", i.e., the car dominant design (DD) that emerged following a few years of industry development (e.g., in 1946 in Italy there was still one active producer of electric cars although the majority had exited the market by 1910). Boschma and Wenting deliberately exclude producers of racing cars, commercial vehicles, one-off specials, kit cars, three-wheelers, steam cars, electric cars, and prototypes. We define this as the DD sample. In the Italian case, we have a basic information (BI) sample that includes prototypes, electric cars, and three-wheeler car companies that tended to have shorter life spans. We were able to identify information on firm pre-entry background for 292 of the 336 firms in the BI sample, 39 (14%) of which are spinoffs. In the DD sample, the UK accounts for over twice as many companies as Italy, 628 vs. 240. Pre-entry information is available for 380 and 200 of these companies, with the UK sample having many more companies with missing pre-entry background information. Of the companies with complete pre-entry information, 64 (17%) are UK spinoffs and 37 (19%) are Italian spinoffs.

From the outset, the Italian automobile industry was geographically concentrated. In the industry's first 6 years (1894–1899), 18 DD companies entered, 8 (44%) in Milan, 5 (28%) in Turin, and the remainder spread across the country.[12] Turin did not become the capital of the automobile industry until the turn of the century: in the period 1900–1905, 60 companies were founded in Italy, 34 (57%) in Turin, and 10 (17%) in Milan. Overall, among the 240 companies included in the DD sample, 113 were located in Turin (47%) and 64 in Milan (27%). Figure 1 depicts the geographic concentration of the Italian DD sample across the three historical periods identified. In the case of the BI sample, concentration is less dense than in the DD sample although some two-thirds of the companies were established in the two most industrialized cities in Northern Italy.

11 Note that 29 and 11 companies, respectively, are listed only in Guida Paravia and Guida Savallo.

12 We consider city and province; however, there is a very small number of cases of companies not located in a city.

Table 1. UK and Italian automobile industry

	UK	Italy	Italy (RS)
All		396	
Missing info		60 (15%)	
Basic Info (BI)		336	
Basic Info with pre-entry background ($BI_{p\text{-}eb}$)		292	
$BI_{p\text{-}eb}$ Spinoff		40 (14%)	
DD	628	240	
No pre-entry background	248 (39%)	40 (17%)	
DD with pre-entry background ($DD_{p\text{-}eb}$)	380	200	162
$DD_{p\text{-}eb}$ Spinoff	64 (17%)	37 (19%)	35 (22%)

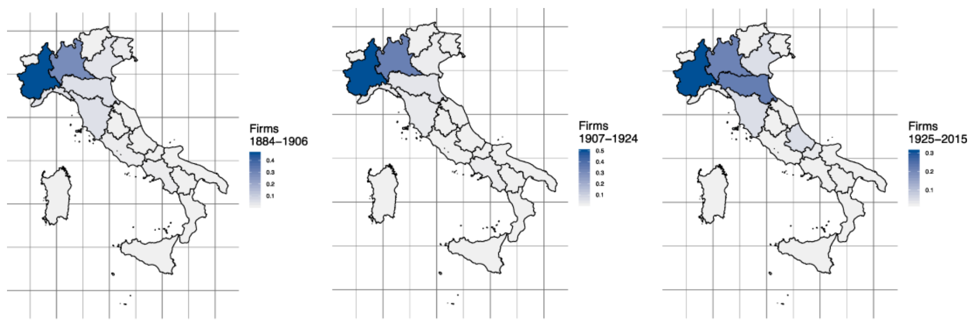

Figure 1. Geographical distribution according to cohorts of entry of the DD sample

In the first 10–20 years of the industry in particular, a large number of companies were founded and/or closed down and reopened under slightly different names, usually by new entrepreneurs who brought in new capital or occasionally by original founders exiting to create new firms focused on slightly different production. In most cases, the production plant and its machinery became the production facility of the new company. To emphasize the technological core of the companies, we constructed a reduced sample (RS) that shows the original company name and the subsequent transformations and assigns to each firm the original first entry year and the exit year of its final incarnation. For example, Alfa was created in 1910 and closed down in 1915 and, in that same year, the engineer Nicola Romeo bought the Alfa production plants and set up Nicola Romeo. The war years saw the company expand and diversify to refocus in 1918 on automobile production and the creation of Alfa Romeo that through various events survived as an independent brand until its acquisition by FIAT in 1986. The RS is used to check the robustness of the econometric estimations.

4.2 Entry, exit, and survival

Figure 2 presents yearly automobile manufacturer densities, entries, and exits for the DD sample that is the main sample used for our analysis. The patterns are similar for the BI and RS samples. The entry and exit dynamics of the 240 DD firms are characterized by three peaks for the number of firms active in the market—in 1906, 1913, and 1924 and respectively 67, 37 and 39 firms. The major decrease in the number of active firms after the 1906 peak is associated with the 1907 economic crisis and increasing numbers of failures and exits and reduced numbers of entries. After a short period of high entry and low exit rates during WWI, densities decreased significantly before a postwar recovery and another peak in 1924. In the succeeding 15 years, the industry consolidated (by the 1930s FIAT accounted for almost 75% of national production) with numerous mergers and acquisitions, failures, and higher mortality than new birth rates. We can identify three main periods for our analysis: 1894–1906, 1907–1924, and 1925–2015, with respective numbers of firms (following the DD definition) entering the industry in each period

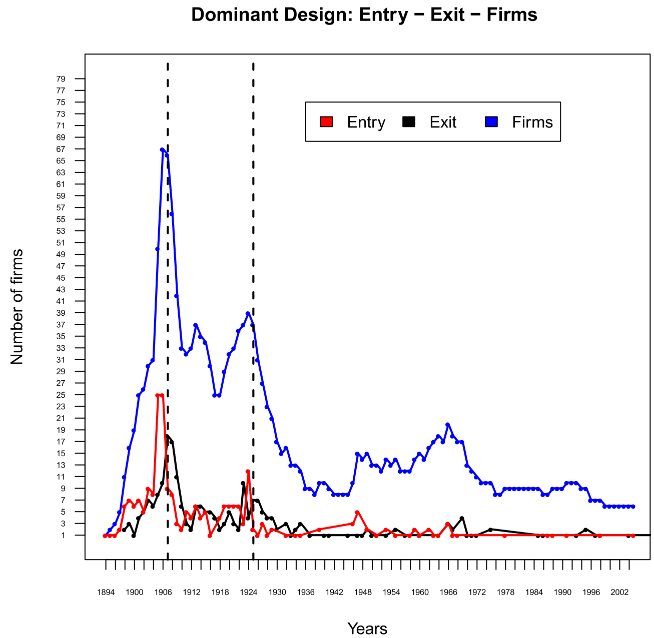

Figure 2. Entry, exit, and number of active firms per year

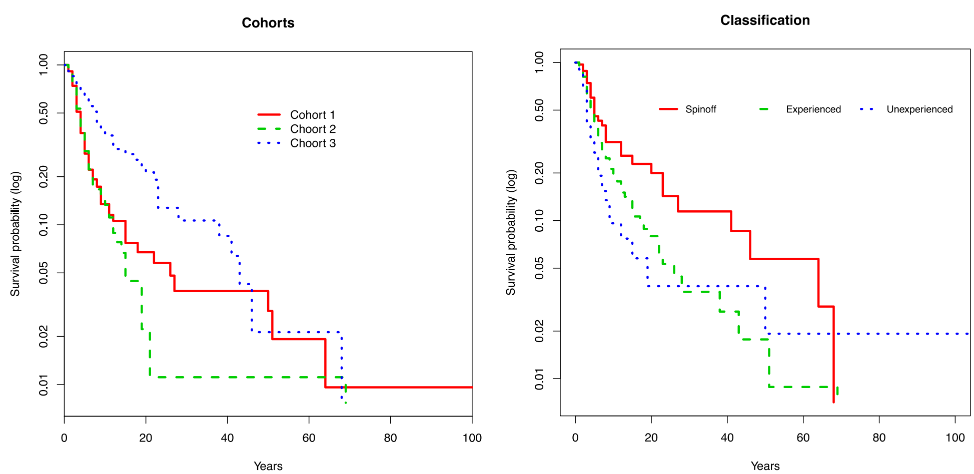

Figure 3. Kaplan–Meier survival curves (in log scale) by cohort (240 firms) and classification (200 firms). Differences in survival curves both cases are statistically significant (*P*-values 0.0018 and 0.028, respectively)

of 103, 90, and 47. In 2015, only five companies remained active in the market, FIAT, DR and three super-car producers: Covini Engineering, Lamborghini, and Pagani.

Klepper (2007, 2010) highlights the importance for firm survival of early entry in the industry. He argues that early entrants can make extra profits that allow higher levels of investment in innovation and technology and, therefore, higher growth and greater economies of scale. The Kaplan–Meier survival curves of the natural log of the percentage of entrants in each cohort that survive show a different pattern that contrasts with most previous work (see Figure 3a). In the first few years, the curves overlap but after 1925 the more recent entrants become dominant and few firms from the early cohorts survive (Alfa Romeo, FIAT, Lancia).

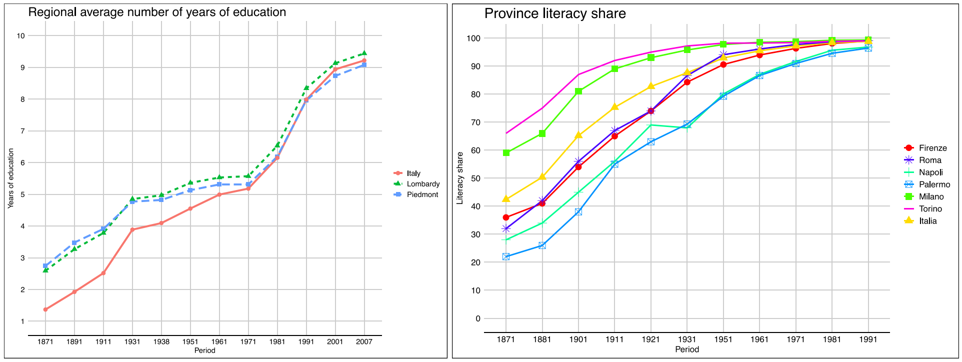

Figure 4. Education in Italy. Italy represents the average regional or province behavior given the population (selected provinces)

Klepper (2007) and Boschma and Wenting (2007) show also that the survival rates of automobile companies vary with the founder's pre-entry experience and that spinoffs with more experienced founders show higher rates of survival. Also, in the Italian case (see Figure 3b), we found that spinoffs tend to have better survival rates than either firms with inexperienced or experienced founders. The company that has dominated the market and survived to the present is the inexperienced company FIAT.

4.3 Education: regional and province analysis

We argue that education is central to the geographic localization of entrant firms and their survival rates. In this section, we analyze education attainment at the regional and provincial levels. We use information from Italian censuses (1871–2007) to build the variables *Reg-Education* and *Prov-Education*. The former measures the average number of years of education per inhabitant at the regional level. In the census years, provincial level education is not available (province is a geographical agglomeration similar to the metropolitan area); at the metropolitan level, we could only gather data on the literacy by share of inhabitants (*Prov-Education*). Figure 4 focuses on the Piedmont and Lombardy regions and the cities of Turin and Milan (which are relevant to the development of the Italian automobile industry) and compares them with other large and important cities such as Rome, Florence, Naples, and Palermo. In the first 30 years of the industry, education attainment was higher in Piedmont and Lombardy compared to the rest of Italy (about 1–1.5 years more education; 25%–60% more in relative terms). For the first two cohorts, education levels were higher in Piedmont than in Lombardy. After the 1920s, Lombardy overtakes Piedmont but at the metropolitan area level up to the end of WWII, Turin dominates Milan and all the other Italian cities in terms of literacy. This dynamic demonstrates the potentially important role of education in the development of the automobile industry and in Italian industrialization more generally. The first census that was held in 1871 predates the second Italian industrialization and provides some support for a causal effect of education on industrial development.

5. Model estimation and discussion

Following Boschma and Wenting (2007) and Klepper (2007), we employ a survival model to study industry exit. We use the length of survival in the market to proxy for firm performance. We also employ a proportional hazard model (Cox Regression) to investigate survival time statistically (Lee, 1992; Audretsch and Mahmood, 1994). These types of methods are applied to survival models that study the time before the occurrence of some event (i.e., death of an automotive firm), according to problem-specific covariates (i.e., classification, cohorts, aeronautics, pilots, etc.). Cox regressions simultaneously control for covariate effects on survival time and assume that at a given time the dependent variable is a hazard function. The Cox regression estimates the relative risk based on a hazard function $h(t)$ in Equation (1).[13] We apply the following estimation model to describe the determinants of a market exit, given a set of selected predictor variables **X**:

$$h(t) = [h_0(t)]\, e^{X\beta'} \tag{1}$$

where $\boldsymbol{\beta}$ is the $1 \times r$ vector of the model coefficients, $\boldsymbol{X}$ is the $n \times r$ design matrix with r independent variables, and $h_0(t)$ is the baseline hazard function, i.e., the expected risk without control variables. Therefore, in a multiple Cox regression, e^{β_i} estimates the percentage change in the survival risk given a unit change in the i^{th} covariate, with $i = 1, \ldots, r$.

A positive estimate of the i^{th} explanatory variable, equivalent to $\beta_i > 0$ or $e^{\beta_i} > 1$, means that the exit probability (the hazard) in the next period is higher for higher values of X_i. In our analysis the event variable of the Cox regression indicates firm exit (i.e., it is set equal to 1). If the firm survives at the end of the observation period (i.e., 2015), the event variable assumes a value equal to 0, as in the case of FIAT.

We also employ (from model 3) a robust estimates approach based on clustered errors (see among others, Arellano, 1987). We assume that a cluster term in a Cox regression identifies clusters of correlated observations. In other words, with clustered errors, observations within the same group are assumed to be somehow correlated inducing correlation in the error term within the cluster but no error correlation among different groups. We cluster companies established in the metropolitan city of Turin and in the other provinces. Considering firm province as the cluster variable allows us to identify more than 10 clusters that is a suitable number of clusters of balanced size (see e.g., Wooldridge, 2003). This approach of introducing cluster-robust standard error estimations, in our case ensures better representation of the unobserved common features of firms belonging to the same cluster, and latent characteristics related to metropolitan city policies (e.g., development of technical education). Compared to a simple fixed effects control with dummies, this approach enables us to account for province heterogeneity and provides more robust estimates (Cameron and Douglas, 2015).

5.1 Variables

Based on the discussion in Section 3, we expect company survival to depend on localization economies, related industries and technological complementarities, pre-entry founder background (and mother company in the case of spinoffs), and local education at the regional and provincial levels. We control also for a cohort effect. The following variables are used in the model.

5.2 Localization economies

We constructed a series of variables to capture agglomeration economies at the regional level. At entry, each entrant is assigned to one of the 20 Italian regions.

- Regional population (*Reg-Pop*): we collected population numbers for each region from 1861–2011. For years with missing national census information, we reconstructed the measure using average population growth over the period.
- Regional gross domestic product (GDP): regional contribution to national GDP (*Reg-GDP*);
- Number of automobile firms in the region (*Reg-Comp*): for each year of entry, we computed the number of active firms in the region as a measure of local competition.

5.3 Related industries and technological complementarities

We use two proxies to capture agglomeration effects due to the colocation of related industries and technological complementarities.

13 A high hazard function indicates a high rate of mortality.

- Number of employees in related industries (*Empl-Related Ind*): for each year of entry in the automobile sector and for each region, we calculated the number of people working in the aggregate mechanics industry that is considered to be related to the automotive sector. The variable also captures supply side agglomeration economies.
- To measure (intra-firm) technological complementarities, we constructed the variable *Aeronautic* that identifies companies active in both the automobile and aeronautics industries in each year—14 in total.[14] A few automobile producers were involved only in airplane engine production; some focused only on plane components. We use three dummies—for automobile firms involved in construction only of plane components (*Components*), only of plane motors (*Motor*), and of the entire plane (*Aero*). Given the increasing complexity of the technological knowledge required to be active in all three segments, we expect a higher impact on the survival of automobile firms of companies active in the most complex aeronautics product i.e., the full plane. We were able to identify year of aeronautics industry entry and exit. However, the more recent development of the aeronautics sector means that only two firms began as aeronautics companies and differentiated into automobile production. Therefore, we cannot use company age to build a more complex time-dependent interaction between aeronautics and automobiles.

5.4 Founder's pre-entry background

For 200 companies in the DD sample, we can identify founder's pre-entry background that allowed us to construct the following firm variables:

- *Experienced* is a dummy variable equal to 1 if at least one of the firm's founders had prior experience in either a closely or partly related industry. *Experienced-within* is companies already active in the automobile industry, typically firms that had a name change following entry/exit of a partner and, perhaps, benefited from the injection of new capital but remained in the same production location.
- *Unexperienced* refers to firms for which we were unable to find clear evidence that the founder(s) had any previous relevant experience.
- *Spinoff* is a dummy variable equal to 1 if the firm is a spinoff from another automobile firm.
- *Pilots* is a dummy variable for the type of spinoff i.e., if the firm was founded by a pilot and equals 1 and 0 otherwise. We would expect spinoffs founded by pilots who we assume are special carriers of technological knowledge, and particularly in the first two periods of the industry (although interviews confirmed that in the 1950s pilots working as "testers" provided crucial input to the development of new engines in FIAT) will have a higher probability of survival.
- *Spinoff no pilots* is a dummy variable for spinoffs not founded by a pilot.
- *Year of mother prod* identifies for each spinoff, the age of the mother company at the time (year) the spinoff was established.

5.5 Local education

To capture the effect of local education on firm survival we use the variables *Reg-Education* and *Prov-Education*. Each entrant is assigned to one of the 20 Italian regions and one of the 80 provinces (metropolitan areas). Since it was impossible to construct a reliable time series for the number of students in technical education at the provincial level (Accornero, 2019), we introduced the dummy variable *Turin* for companies established in the metropolitan area (province) of Turin;[15] this controls for a specific metropolitan area effect if *Reg-Education* is included in the model. Inclusion of *Prov-Education* to control for basic education input at the provincial level,

14 In the BI sample 18 firms are active also in aeronautic firms.

15 Different institutional factors may have played a role in the development of the Turin cluster e.g., education policy implemented by Mayor S. Frola in the period 1903–1907, the 1906 municipal law to ensure special public grants to "providers and producers of transportation services" (Biffignandi, 2017), the supply of lower priced electrical energy by the Azienda Elettrica Municipalizzata (Municipal Electric Company—AEM Torino—founded in 1907) compared to the prices in other major cities, and municipal investment in the public transport network.

excludes the possibility of including the dummy variable *Turin* for reasons of collinearity, thus we use clustered standard errors to capture provincial level characteristics not already controlled for, i.e., technical education and other local institutions that might have supported the development of a local cluster and which are additional to local basic education.

Finally, we include *Cohort1* (1894–1906) and *Cohort2* (1907–1924) to control for year of entry.

5.6 Results and discussion

We start our analysis by replicating as closely as possible Boschma and Wenting's (2007) and Klepper's (2007) models[16] for the Italian automobile sector population and then present and discuss our model. Klepper's model when applied to the Italian data performs poorly; it confirms a higher survival probability for experienced companies but provides weak confirmation for the effect of spinoffs. The effect of the interaction between Turin cluster and spinoffs is not confirmed. We obtained more consistent results from the Boschma and Wenting model although the variables show lower levels of significance. Both experienced and spinoffs firms have a higher probability of surviving, and we found a negative effect of local competition.

Table 2 presents the estimated coefficients of the Cox regressions. In model 1, in addition to the variables capturing agglomeration economies, entry cohort, and type of firm that Boschma and Wenting (2007) include, we test the effect of local institutions and local education level on the exit probability. The local level of competition (*Reg-Comp*) is correlated positively to an increased exit probability while being an experienced or spinoff firm is associated with a higher survival probability. Demand side Marshallian agglomeration economies captured by regional GDP (*Reg-GDP*) are positively correlated to survival. Cohort effects are not significant. Both the *Turin* dummy and the regional education level (*Reg-Education*) are less than 1 and are significant after controlling for all the other variables. These results support the view that higher regional educational levels are associated with higher firm survival rates and that firms belonging to the Turin cluster benefit from local institutional effects not accounted for in previous studies.

Model 2 includes provincial (*Prov-Education)* rather than the regional level of education; its effect on the exit probability is not statistically significant. The dummy *Turin* is no longer significant most likely because Turin is the metropolitan city and had the highest levels of education in Italy before WWII (see Figure 4).

To avoid heteroskedasticity issues, model 3 employs a robust variance estimation based on firm province (i.e., robust clustered standard errors) and excludes the dummy for Turin. These robust standard error estimations provide more accurate coefficient estimates. We believe that the errors are correlated to province socioeconomic background rather than being completely uncorrelated. Thus, we introduce robust clustered standard errors to capture unobserved province policies/socioeconomic factors that might influence firm survival rates rather than using a fixed effects approach (see e.g., Cameron and Douglas, 2015). As in the previous model, a high level of regional competition is associated with earlier firm exit from the automotive sector, while the number of employees in related industries at the regional level (*Empl-Related Ind*) has a significant negative effect on the exit probability. The province education level has a negative and strongly significant effect on the exit hazard rate, confirming the positive role of metropolitan basic education on the survival of firms founded in the city.[17] Spinoff companies have a higher survival probability, while the age of mother firm that proxies for accumulated competence (*Year of mother prod*) has a negative but not significant effect on the spinoff's exit probability.

To better capture the importance of related variety and technological complementarities, in model 4, we introduce the covariate *Aeronautic* to capture the effect of intra-company related externalities. The dummy effect is negative (i.e., inducing a lower exit probability than in the case of non-aeronautics firms) and is highly statistically significant. This supports the idea that

16 See Appendix for details of the estimations.

17 We also ran model 3 including both provincial and regional level education; both variables turn out to be significant with province-level education having a strong negative effect on exit. Due to collinearity problems between Empl-Related Ind and Reg-Education, we prefer to present only the results with province-level education; the other regression results are available from the corresponding author.

Table 2. Marginal effects e^{β} under Cox regression models for the exit (with robust clustered standard errors in parentheses)

Dependent variable exit from the automobile market					
Variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Agglomeration					
Reg-Pop					0.730*
					(0.187)
Reg-GDP	0.914**	1.001	1.012	1.008	
	(0.037)	(0.029)	(0.018)	(0.021)	
Reg-Comp	1.017*	1.023**	1.019***	1.028***	1.027***
	(0.010)	(0.011)	(0.004)	(0.006)	(0.006)
Empl-Related Ind.	1.055	0.968	0.978***	0.970*	0.976*
	(0.042)	(0.030)	(0.012)	(0.016)	(0.012)
Inter-Ind. Extern.					
Aeronautics				0.176***	0.173***
				(0.422)	(0.430)
Institutions					
Reg-Education	0.958***				
	(0.015)				
Prov-Education		0.347	0.306***	0.382**	0.490*
		(0.669)	(0.581)	(0.490)	(0.426)
Turin	0.697*	0.850			
	(0.207)	(0.208)			
Cohort					
Cohort 1	0.947	0.917	0.961	1.166	1.292
	(0.305)	(0.343)	(0.285)	(0.358)	(0.307)
Cohort 2	1.088	1.291	1.340	1.732***	1.887***
	(0.279)	(0.281)	(0.187)	(0.203)	(0.211)
Founder					
Experienced	0.694**	0.740*	0.727	0.710**	0.697**
	(0.181)	(0.180)	(0.205)	(0.148)	(0.198)
Experienced-within				0.654	0.652
				(0.305)	(0.301)
Spinoff	0.514**	0.576*	0.565***		
	(0.320)	(0.319)	(0.215)		
Pilot				0.615***	0.582***
				(0.119)	(0.121)
Spinoff no pilot				0.971	0.961
				(0.207)	(0.192)
Year mother prod.	1.002	0.996	0.996	0.982*	0.983*
	(0.015)	(0.015)	(0.011)	(0.007)	(0.007)
R^2	0.156	0.128	0.128	0.290	0.294
Observations	200	200	200	200	200

Two-tailed test, significance:
***<0.01.,
**<0.05.,
*<0.1.

companies that were active in both industries survived for longer other things being equal. Model 4 also includes a set of variables for firm founders. It shows that firms founded by founders with previous experience have a higher probability of survival compared to companies whose founders have no relevant previous experience; also, for firms with specific (most often short) previous experience in the car industry (e.g., firms whose shareholder composition and name changed but which were not new firms or spinoffs) the effect is not statistically significant indicating a very turbulent high entry and exit period that did not allow for the accumulation of special competences by those companies. The effect of spinoff companies founded by pilots (*Pilots*) indicates that companies (co)founded by pilots have higher chances of survival likely associated with the technological knowledge embedded in the pilots. In contrast, companies founded by other types of entrepreneurs (*Spinoff no pilot*) have only a slightly higher (not significant in this specification and weakly significant in other specifications not presented here) survival rate that suggests that the technological competences of the spinoff company rather than management competences mattered for the survival. In this specification, *Year of mother prod* becomes weakly significant supporting Klepper's idea of inherited competences. Finally, in contrast to previous findings, companies that entered the industry in the earlier period do not tend to survive for longer than followers. Only one company that entered in the first period (FIAT) was able to benefit from the economies of scale effect discussed by Klepper; the absence of scale economies for all the other firms in the first cohort results in a not statistically significant estimate. The Italian automobile market was significantly smaller than those in the UK and the USA, and much of the Italian growth potential was achieved in the first years via exports. When at the end of the 1920s, the export possibility disappeared, the domestic market was not sufficiently sizeable to sustain the growth of more companies due to cost decreases associated with the loss of scale economies.

In the final model 5, our preferred specification, instead of *Reg-GDP*, we include the log of regional population (*Reg-Pop*) to proxy for demand side agglomeration economies; the effect is negative and statistically significant, confirming the importance of agglomeration economies for firm survival. All the results are robust to the inclusion of regional population.

Our analysis provides partial support for the robust evidence in the literature for agglomeration economies and the role of spinoff dynamics. We also found some evidence of a small positive effect of spinoff survival on mother company's experience in the Italian market: this provides some support for the idea that success breeds success.

Our findings provide novel evidence:

- The local environment and metropolitan "atmosphere" captured by the *Turin* dummy (and the cluster error model at the provincial level) and, especially, province-level education (*Prov-Education*) have positive effects on firm survival rates, highlighting the effect of metropolitan institutions (some of which are linked to specific policies implemented by the local government as in the case of the Turin cluster) that previous studies do not account for.
- We measure inter-industry externalities and related variety in terms of employment in related industries and at the micro-level, using data on companies active in both the car and aeronautics industries and show that both are correlated with lower exit probability.
- We distinguish between spinoff companies founded by pilots and others and show that companies (co)founded by pilots have a lower exit probability than other spinoffs. We argue that pilots acquired important technical skills through learning by using which were decisive for designing "better" cars and supporting firm performance.
- In contrast to existing findings we found no early entry advantage. This might be because the Italian market was too small to allow exploitation of scale economies by more than one company (i.e., FIAT).

5.7 Robustness check

In the first and most turbulent period of the industry, a significant number of companies changed their names sometimes including a new partner that brought additional capital. In general, production plans remained mostly unchanged—with the exception perhaps of some expansion or refocusing of production. To check the robustness of our results, we collected all those companies that experienced a name change: e.g., Carrera Luigi & C founded in 1896, closed down in 1906 and then reopened as Officine e Fonderie Torinesi after merging with the steel maker Schlepfer & Co. before finally exiting the automobile market in 1910. This reduced the number of observations to 162; most of the 38 companies that merged were founded in the first two periods. Table 3 presents the main results for this RS. The models in Table 3 are based on clustered standard error estimations and the results are consistent with the previous estimations. With the exception of *Reg-Pop* and *Empl-Related Ind* that are no longer statistically significant due most likely to the reduced number of observations in the regression, the coefficients are

Table 3. Marginal effects e^{β} under Cox regression models for the exit—RS/Aeronautics (with robust clustered standard errors in parentheses)

Dependent variable exit from the automobile market				
Variables	**Model 6**	**Model 7**	**Model 8**	**Model 9**
Agglomeration				
Reg-Pop	0.758	0.755	0.763	0.769
	(0.285)	(0.246)	(0.255)	(0.237)
Reg-Comp	1.033***	1.031***	1.033***	1.031***
	(0.006)	(0.006)	(0.006)	(0.006)
Empl-Related Ind.	1.004	1.004	1.005	1.003
	(0.019)	(0.019)	(0.019)	(0.019)
Inter-Ind. Extern.				
Aeronautics	0.130***			
	(0.436)			
Aero		0.091***		
		(0.691)		
Aeron. no aero		0.145***		
		(0.327)		
Components			0.646**	
			(0.221)	
Aeron. no components			0.130***	
			(0.435)	
Motor				0.211***
				(0.203)
Aeron. no motors				0.102***
				(0.660)
Institutions				
Prov-Education	0.528*	0.541*	0.522*	0.536*
	(0.329)	(0.341)	(0.339)	(0.318)
Cohort				
Cohort 1	1.974*	1.992**	1.986**	1.907*
	(0.371)	(0.376)	(0.371)	(0.378)
Cohort 2	2.341***	2.375***	2.368***	2.281**
	(0.317)	(0.316)	(0.318)	(0.326)
Founder				
Experienced	0.640**	0.634**	0.645**	0.675**
	(0.193)	(0.182)	(0.187)	(0.194)
Experienced-within	0.951	0.944	0.946	0.968
	(0.564)	(0.550)	(0.571)	(0.546)
Pilot	0.525***	0.506***	0.526***	0.481***
	(0.199)	(0.185)	(0.198)	(0.170)
Spinoff no pilot	0.782	0.762	0.782	0.739
	(0.279)	(0.256)	(0.267)	(0.238)
Year mother prod.	0.987	0.988	0.988	0.991
	(0.009)	(0.010)	(0.009)	(0.010)
R^2	0.331	0.333	0.332	0.317
Observations	162	162	162	162

Two-tailed test, significance:
***<0.01.,
**<0.05.,
*<0.1.

similar to the previous estimations confirming the role of regional competition, province level education, previous experience in related industries, and pilots as special breeders for company survival.

Table 3 presents a finer-grained aeronautics specification that considers whether the company was producing the whole plane (*Aero*), only the motor (*Motor*), or only components (*Components*). The three dummy variables are associated with a lower exit probability, and as expected the higher survival probability is associated with the production of complete planes by those firms that were able to master the new technological knowledge.

6. Conclusions

The paper aimed to provide a systemic understanding of cluster formation and development by combining a more traditional approach to industry clustering that identifies agglomeration economies and technical externalities as the main drivers of local industrial development, with Klepper's understanding of the role of spinoffs.

The paper sheds new light on industry clustering and development by explaining the early genesis and later evolution of the Italian automotive industry based on the formation of a car cluster in Turin between the late 19th century and the end of WWII.

We rely on an original dataset that represents the first systematic long-term repository of knowledge about the industry in Italy and tested the following hypotheses about agglomeration economies and spinoffs as drivers of industry clustering.

First and more generally, the literature (Klepper, 2007, 2010; Boschma and Wenting, 2007) highlights the importance of early entry to the industry for firm survival. However, our results do not support the hypothesis of early entry advantages in survival dynamics most likely because the market was too small to support the growth of more than one large company able to benefit from scale economies. This suggests that early entry advantages are not a property of spinoffs per se but that spinoffs may benefit from threshold effects. Market scale effects should be integrated in future research on spinoffs and industry developments.

Furthermore, we investigated the following three, specific factors that were key to the creation and success of the automotive industry in Turin: institutions and education; technological complementarities and the role of related industries such as aeronautics; and inherited technical skills in spinoffs founded by pilots.

First, we accounted for the role of institutional effects, and in particular the role of education. We argue that education can be considered an initial precondition for further learning and technical and scientific advancements. In the early phase of the industry before the emergence of a DD, learning rather than scale economies was important. Further, given the limited size of the internal market and the effects of WWI on trade, with the exception of FIAT early entrants were unable to grow or to benefit from intra-firm scale economies, making local basic and technical education extremely important for firm survival. The positive effect of education as an institutional factor is consistent also with the emphasis in recent contributions (Sorenson and Audia, 2000; Sine and Lee, 2009; Antonietti and Boschma, 2020) on the role of social capital and social resources to support the formation and growth of industries. The availability of education institutions enabled the construction of social capital and values in addition to technical skills that offer entrepreneurs a context conducive to starting a new venture in a new developing sector.

Second, we stressed the positive effect of related industries and especially the technological complementarities between automotive and aeronautics and argued that they rely on related technical and scientific knowledge. Some carmakers also entered the emerging aeronautics industry and may have benefited from both cross-fertilization in terms of ideas, design, and technical skill, and from the larger scale deriving from involvement in different industries and markets.

Third, we distinguished the role of different types of spinoffs, looking in particular at the effect on cluster resilience of firms founded by entrepreneurs with particular technological competences acquired from working as pilots in other carmakers. Klepper's spinoff theory positions managerial competence at the core of the analysis: "Disagreements arise because incumbent *management* has a limited ability to recognize employees with superior ideas and/or abilities. When the disagreements are severe enough, employees leave to found spinoffs" (Klepper, 2007: 616, emphasis added). He argues also that "spinoffs are expected to be better able than inexperienced firms to *manage* the process of technological change by dint of their prior experience" (Klepper, 2007: 624, emphasis added).

We challenged and integrated this view, testing the role of inherited technical rather than managerial skills. The technical and tacit skills acquired by pilots have been considered the key sources of technological diffusion (Eichenberger and Stadelmann, 2009; Jenkins and Tallman, 2015).

This is in line with Buenstorf and Costa (2018) who propose that it is intra-industry flows of technical rather than managerial knowledge that supports spinoff dynamics and entrant longevity. We provide evidence that carmakers founded by entrepreneurs with previous experience as pilots were more likely to survive compared to all other firms including other spinoffs.

We thus consider pilots to be selected "breeders" (Buenstorf and Klepper, 2009, 2010) or transmitters of assets (technical skills acquired through learning by using) between the mother company and the spinoff. We argue that in the earliest stages of development of the car industry, pilots as opposed to other technical specialists were the repositories of special technical knowledge. This distinguishes our findings from Klepper's model which focuses only on managerial mismatches as the motivation for spinning off.

These three factors are generally overlooked in analyses of clusters and industry developments. Our results suggest that they should be included and systematically addressed in future work on these topics.

Based on our analysis of the role of institutions in industry formation, it is clear that more research is needed along two complementary lines.

First, we need a better understanding and explanation of the role of technical/professional schools in Piedmont and other Italian regions in order to empirically identify their impact on the emergence of the Turin car cluster. Our current research involves systematic assessment of the early development in the mid-1800s and early 1900s of technical/professional schools in Italy. This should enable a qualitative account of their role in the formation of technical skills in the emerging industry and allow consistent integration of our data. This would be particularly interesting and would allow a better understanding of which type and level of education contributes the most to industrial development and would add to the current debate on the need for better and more diversified tertiary technical education to build the human capital needed to diffuse digital production in the 4th industrial revolution.

Second, we are interested in how the mobilization of political and public resources supported the emergence of the industry and the type of social and political capital that enhanced the effect of technical skills on the formation of an entrepreneurial system (Rugafiori, 1999) and the industry development. Different institutional factors complemented a technical education and may have played a role in the development of the Turin cluster. Castronovo (1995) suggests that (i) the local policies in Turin between the end of the 1800s and the first decade of the new century were aimed at attracting investment and encouraging industrial growth; (ii) the role of Turin's elite as a lobby and trait d'union between political and financial capital; (iii) the emergence between 1901 and 1906 of a growing interest among private investors in investing in the nascent automobile industry; and (iv) the regional regulatory framework which in the first decade of the 20th century was intended to ensure special public subsidies to suppliers and producers of transport services.

Future research could improve our understanding of the role of institutional factors in the dynamics of industry development and cluster formation.

Acknowledgments

The authors gratefully thank an anonymous referee of this Journal for the stimulating comments and suggestions, as well as Dan Breznitz for his inspiring thoughts as a visiting fellow at the Collegio Carlo Alberto. The authors also acknowledge useful comments from Carlo Bottai, Brendon Markey-Towler, and Stefano Musso and participants in the 2016 seminar at the Monk School of Global Affairs, Toronto University, the 2016 Schumpeter Conference, the 2016 Collegio Carlo Alberto Workshop, the DRUID 2017 and EARIE 2017 conferences and the 2018 Geoinno Conference. We thank Enrico Miletto, Donatella Sasso and Carlo Bottai for their archival research and Donatella Biffignandi, former Director of the Historical Archive of the Automobile Museum of Turin, for her help with the data collection. We are grateful for financial support from the Compagnia di San Paolo.

Funding

None declared.

References

Accornero, C. (2019), 'Istruzione tecnica e professionale e progresso industriale dalla fine dell'Ottocento al fascismo,' Mimeo, RENIR Project. https://renir.carloalberto.org/.

Antonelli, C. (2001), *The Microeconomics of Technological Systems*, Oxford University Press: Oxford.

Antonietti, R. and R. Boschma (2020), 'Social capital, resilience, and regional diversification in Italy,' *Industrial and Corporate Change*. dtaa052.

Arellano, M. (1987), 'Practitioners' corner: computing robust standard errors for within-groups estimators,' *Oxford Bulletin of Economics and Statistics*, **49**(4), 431–434.

Audretsch, D. B. and T. Mahmood (1994), 'The rate of hazard confronting new firms and plants in U.S. manufacturing,' *Review of Industrial Organization*, **9**, 41–56.

Baldwin, N., G. N. Georgano, M. Sedgwick and B. Laban (1982), *The World Guide to Automobile Manufacturers*. Facts on File: New York.

Becattini, G., M. Bellandi and L. De Propris (2009) *A Handbook of Industrial Districts*. Edward Elgar: Cheltenham.

Biffignandi, D. (2013), 'Nascita e sviluppo dell'industria automobilistica,' http://www.treccani.it/enciclopedia/nascita-e-sviluppo-dell-industria-automobilistica%28Il-Contributo-italiano-alla-storia-del-Pensiero:-Tecnica%29/.

Biffignandi, D. (2017), 'Torino tra ottocento e novecento,' http://www.museoauto.it/website/images/stories/articoli/varie/torinotra800e900.pdf.

Bigelow, L. S., G. R. Carroll, M.-D. L. Seidel and L. Tsai (1997), 'Legitimation, geographical scale, and organizational density: regional patterns of foundings of American automobile producers, 1885–1981,' *Social Science Research*, **26**(4), 377–398.

Biscaretti, C. (1959), *Elenco Costruttori Italiani dalle Origini*. Archivio del Museo dell'Automobile di Torino Giovanni Agnelli: Torino.

Boschma, R. (2015), 'Do spinoff dynamics or agglomeration externalities drive industry clustering? A reappraisal of Steven Klepper's work,' *Industrial and Corporate Change*, **24**(4), 859–873.

Boschma, R. and R. Wenting (2007), 'The spatial evolution of the British automobile industry: does location matter?' *Industrial and Corporate Change*, **16**(2), 213–238.

Brenner, T., U. Cantner and H. Graf (2013), 'Introduction: structure and dynamics of innovation networks,' *Regional Studies*, **47**(5), 647–650.

Bruni, A., M. Clarke, F. Paolini and O. Sessa (2014), *L'Automobile Italiana, Le Grandi Marche dalle Origini a Oggi*. Giunti: Firenze.

Buenstorf, G. and C. Costa (2018), 'Drivers of spin-off performance in industry clusters: embodied knowledge or embedded firms?' *Research Policy*, **47**(3), 663–673.

Buenstorf, G., M. Fritsch and L. F. Medrano (2015), 'Regional knowledge, organizational capabilities and the emergence of the West German laser systems industry, 1975–2005,' *Regional Studies*, **49**(1), 59–75.

Buenstorf, G. and M. Geissler (2011), 'The origins of entrants and the geography of the German laser industry,' *Papers in Regional Science*, **90**(2), 251–270.

Buenstorf, G. and C. Guenther (2011), 'No place like home? Relocation, capabilities, and firm survival in the German machine tool industry after World War II,' *Industrial and Corporate Change*, **20**(1), 1–28.

Buenstorf, G. and S. Klepper (2009), 'Heritage and agglomeration: the Akron tire cluster revisited,' *Economic Journal*, **119**, 705–733.

Buenstorf, G. and S. Klepper (2010), 'Submarket dynamics and innovation: the case of the US industry,' *Industrial and Corporate Change*, **19**(5), 1563–1587.

Cameron, A. C. and D. L. Miller (2015), 'A practitioner's guide to cluster-robust inference,' *Journal of Human Resources*, **50**(2), 317–372.

Carlsson, B. (ed.) (1997), *Technological Systems and Industrial Dynamics*. Kluwer Academic Publishers: Boston.

Castronovo, V. (1995), *Storia Economica d'Italia. Dall'Ottocento ai Giorni Nostri*. Einaudi: Torino.

Castronovo, V. (1999), *FIAT. Un Secolo di Storia Italiana*. Rizzoli: Milano.

Ciccarelli and Fenoaltea. (2013), 'Through the magnifying glass: provincial aspects of industrial growth in post-unification Italy,' *Economic History Review*, **66**(1), 57–85.

Cooke, P. (2001), 'Regional innovation systems, clusters, and the knowledge economy,' *Industrial and Corporate Change*, **10**(4), 945–974.

Costa, C. and R. Baptista (2012), 'Agglomeration Vs. Organizational Reproduction: The Molds Cluster in Portugal,' Papers in Evolutionary Economic Geography (PEEG) 1222. Utrecht University, Department of Human Geography and Spatial Planning, Group Economic Geography.

Cusmano, L., A. Morrison and E. Pandolfo (2015), 'Spinoff and clustering: a return to the Marshallian district,' *Cambridge Journal of Economics*, **39**(1), 49–66.

De Fort, E. (1996), *Storia della Scuola Elementare. Dall'Unità al Fascismo*. Il Mulino: Bologna.

De Fort, E. (2000), 'L'istruzione primaria e secondaria e le scuole tecnico-professionali,' in U. Levra (ed.) *Storia di Torino. La città nel Risorgimento*. Giulio Einaudi Editore: Torino, pp. 587–618.

De Vaan, M., R. Boschma and K. Frenken (2012), 'Clustering and firm performance in project-based industries: the case of the global video game industry, 1972–2007,' *Journal of Economic Geography*, **13**(6), 965–991.

De Vaan, M., K. Frenken and R. Boschma (2019), 'The downside of social capital in new industry creation,' *Economic Geography*, **95**(4), 315–340.

Delgado, M., M. E. Porter and S. Stern (2010), 'Clusters and entrepreneurship,' *Journal of Economic Geography*, **10**(4), 495–518.

Dorfman, N. S. (1983), 'Route 128: the development of a regional high-technology economy,' *Research Policy*, **12**, 299–316.

Doyle, G. R. (1959), *The World's Automobiles*. Temple: London.

Eichenberger, R. and D. Stadelmann (2009), 'Who is the best Formula 1 driver? An economic approach to evaluating talent,' *Economic Analysis and Policy*, **39**(3), 389–406.

Ferrari, P. (ed.) (2005), *L'Aeronautica Italiana: Una Storia del Novecento*. Franco Angeli: Milano.

FIAT Archivio Storico. (1996), *FIAT: Le Fasi della Crescita*. Paravia: Torino.

Frenken, K., E. Cefis and E. Stam (2015), 'Industrial dynamics and clusters: a survey,' *Regional Studies*, **49**(1), 10–27.

Frenken, K., F. Van Oort and T. Verburg (2007), 'Related variety, unrelated variety and regional economic growth,' *Regional Studies*, **41**, 685–697.

Georgano, G. N. (1982), *The New Encyclopedia of Motorcars: 1885 to the Present*. Dutton: Boston.

Georgano, G. N. (2000), *The Beaulieu Encyclopedia of the Automobile*. Routledge: London.

Giacomelli, L. (2010), 'Il Regio Museo industriale Italiano in Torino,' in E. Castelnuovo and E. Pagella (eds), *Torino: Prima Capitale d'Italia*. Istituto della Enciclopedia Italiana: Rome, pp. 117–124.

Giuliani, E. (2007), 'The selective nature of knowledge networks in clusters: evidence from the wine industry,' *Journal of Economic Geography*, **7**, 139–168.

Giuliani, E. and M. Bell (2005), 'The micro-determinants of meso-level learning and innovation: evidence from a Chilean wine cluster,' *Research Policy*, **34**(1), 47–68.

Hannan, M. T., G. R. Carroll, E. A. Dundon and J. C. Torres (1995), 'Organizational evolution in a multinational context: entries of automobile manufactures in Belgium, Britain, France, Germany and Italy,' *American Sociological Review*, **60**, 509–528.

Jenkins, M. and S. Tallman (2015), 'The geography of learning: Ferrari Gestione Sportiva 1929–2008,' *Journal of Economic Geography*, **16**(2), 1–24.

Kim, T.-Y., S. D. Dobrev and L. Solari (2003), 'Festina Lente: learning and inertia among Italian automobile producers 1896–1981,' *Industrial and Corporate Change*, **12**, 1279–1301.

Klepper, S. (2007), 'Disagreements, spinoffs, and the evolution of Detroit as the capital of the U.S. automobile industry,' *Management Science*, **53**, 616–631.

Klepper, S. (2010), 'The origin and growth of industry clusters: the making of Silicon Valley and Detroit,' *Journal of Urban Economics*, **67**, 15–32.

Lee, E. T. (1992), *Statistical Methods for Survival Data Analysis*. John Wiley & Sons: New York.

Mantegazza, A. (2009), 'Il Settore Aeronautico del Nord-Ovest,' www.storiaindustria.it.

Markusen, A. (1996), 'Sticky places in slippery space: a typology of industrial districts,' *Economic Geography*, **72**(3), 293–313.

Marshall, A. (1920), *Principles of Economics*, Revised edn. Macmillan: London.

Menzel, M.-P. and J. Kammer (2019), 'Industry evolution in varieties of capitalism: a comparison of the Danish and US wind turbine industries,' *Industrial and Corporate Change*, **28**(6), 1381–1403.

Morrison, A. and R. Boschma (2019), 'The spatial evolution of the Italian motorcycle industry (1893–1993): Klepper's heritage theory revisited,' *Industrial and Corporate Change*, **28**(3), 613–634.

Museo dell'Automobile. (1977), *Marche Italiane Scomparse*. Archivio Museo dell'Automobile di Torino Giovanni Agnelli: Torino.

Patrucco, P. P. (2005), 'The emergence of technology systems: knowledge production and distribution in the case of the Emilian plastics districts,' *Cambridge Journal of Economics*, **29**, 37–56.

Porter, M. E. (1990), *The Competitive Advantage of Nations*. Free Press: New York.

Robotti, D. (ed.) (1998), *Scuole d'Industria a Torino. Cento e Cinquant'anni delle Scuole Tecniche San Carlo*. Centro Studi piemontesi: Torino.

Rugafiori, P. (1999), 'Alle origini della Fiat. Imprese e imprenditori in Piemonte (1870–1900),' in C. Annibaldi e G. Berta (eds), *Grande Impresa e Sviluppo Italiano. Studi per i Cento Anni della Fiat*. IL Mulino: Bologna, pp. 135–183.

Saxenian, A. (1994), *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*. Harvard University Press: Cambridge, MA.
Sine, W. D. and B. H. Lee (2009), 'Tilting at windmills? The environmental movement and the emergence of the U.S. wind energy sector,' *Administrative Science Quarterly*, **54**(1), 123–155.
Sorenson, O. and P. G. Audia (2000), 'The social structure of entrepreneurial activity: geographic concentration of footwear production in the United States, 1940–1989,' *American Journal of Sociology*, **106**(2), 424–462.
Storper, M. (1995), 'The resurgence of regional economies, ten years later: the region as a nexus of untraded interdependencies,' *European Urban and Regional Studies*, **2**, 191–221.
Stuart, T. and O. Sorenson (2003), 'The geography of opportunity: spatial heterogeneity in founding rates and the performance of biotechnology firms,' *Research Policy*, **32**(2), 229–253.
Volpato, G. (1983), *L'Industria Automobilistica Internazionale*. CEDAM: Padova.
Wenting, R. and K. Frenken (2011), 'Firm entry and institutional lock-in: an organizational ecology analysis of the global fashion design industry,' *Industrial and Corporate Change*, **20**(4), 1031–1048.
Wooldridge, J. M. (2003), 'Cluster-sample methods in applied econometrics,' *The American Economic Review*, **93**(2), 133–138.
Zeitlin, J. (2008), 'Industrial districts and regional clusters,' in G. Jones and J. Zeitlin (eds), *The Oxford Handbook of Business History*. Oxford University Press: Oxford, pp. 219–243.

Appendix

The Klepper (2007) and Boschma and Wenting (2007) model estimation

Based on the Italian data, Table A1 replicates Models 1, 2, 3, and 5 in Klepper (2007), and Table A2 replicates models 1–5 in Boschma and Wenting (2007). The former group of models are based on Gompertz's specification of the hazard function and the latter exploit Cox proportional hazard regression.

In Models 1 and 2, the negative and statistically significant effect on the exit probability of the *Experienced* firms is confirmed; only in models 1 and 3 do *Spinoff* firms have a negative and statistically significant effect, and this is confined to Turin firms. This contrasts with Klepper's findings. Among the coefficient estimates only *Cohort1*t* is negative and significant, while *Cohort 1* and *Cohort 2* in the proportional terms are positive and significant for Italy, which contrasts to Klepper's (2007) results for the superior performance of firms in the Detroit area. Models 1 and 2 (Table A1) test the Turin effect that is never statistically significant when using Klepper's specification. Finally, the age of mother production firm has a negative effect on the exit probability only in model 5 although the value is close to zero that contrasts to Klepper's model.

Second, we compare the results in Table A2 with the evidence in Boschma and Wenting (2007). We find similar effects on the exit probability with respect to two variables groups:

- agglomeration economies: the level of competition in each region has a positive effect on exit (in our case only in models 1 and 5). *Empl-Related Ind.* is never statistically significant for the exit probability in the Italian case but not the UK case. This might be due to the strong correlation of *Empl-Related Ind.* to population;
- specialization: both *Experienced* firms and *Spinoffs* exhibit a lower exit probability than *inexperienced* firms in both the Italian and British samples. In Boschma and Wenting (2007), the spinoff effect is not always significant.

In the Italian automotive sector, years of mother firm production has no exit prediction power that contrasts to Boschma and Wenting's findings. Also, the entry period is interpreted in a different way. In Boschma and Wenting (2007), only firms in the first entry cohort have a lower exit probability, while in Italy both the first (only in model 1) and the second cohorts have an increased exit probability, consistent with the survival curves in Figure 2a.

Note that using Boschma and Wenting's (2007) model specification, we represent a maximum of 12% of the total variability of the exit probability of Italian automotive firms This suggests the need for further analyses to explain this effect that is discussed only partially in Klepper (2007).

Table A1. Klepper's models—a comparison with the Italian industry. Coefficient estimates β of the survival models with Gompertz's specification are reported (standard error in parenthesis)

	Dependent variable			
	Exit from the automobile market			
Variables	MODEL 1	MODEL 2	MODEL 3	MODEL 5
Constant	−0.004	−0.004	−0.001	−0.0004
	(0.013)	(0.013)	(0.013)	(0.013)
T	0.098***	0.098***	0.103***	0.097***
	(0.02615)	(0.026)	(0.027)	(0.025)
Turin	0.119	0.122		
	(0.153)	(0.164)		
Experienced	−0.280**	−0.281**	−0.276	−0.207
	(0.071)	(0.180)	(0.177)	(0.168)
Spinoff	−0.538**	−0.524	−0.197*	
	(0.238)	(0.318)	(0.439)	
Cohort 1	0.866***	0.867***	0.833***	0.827***
	(0.265)	(0.265)	(0.266)	(0.265)
Cohort 2	0.876***	0.877***	0.875***	0.875***
	(0.266)	(0.266)	(0.266)	(0.266)
*Cohort 1 * t*	−0.040**	−0.040**	−0.043***	−0.045**
	(0.017)	(0.017)	(0.017)	(0.017)
*Cohort 2 * t*	−0.013	−0.013	−0.017	−0.019
	(0.021)	(0.018)	(0.018)	(0.018)
Spinoff Torino		−0.027	−0.123	
		(0.33088)	(0.416)	
Year mother prod.			−0.021	−0.027*
			(0.017)	(0.013)
Log Likelihood	−589.589	−589.587	−589.0697	−589.6315
AIC	1197.18	1199.175	1198.139	1195.236
Observations	200	200	200	200

Two-tailed test, significance:
***< 0.01.,
**< 0.05.,
*< 0.1.

Table A2. Boschma and Wenting's models. A comparison using the Italian industry database. Coefficient estimates β of the Cox regression model are reported (standard errors in parenthesis)

	Dependent variable				
	Exit from the automobile market				
Variables	**MODEL 1**	**MODEL 2**	**MODEL 3**	**MODEL 4**	**MODEL 5**
Empl-Related Ind.	−0.032	−0.014	−0.012	−0.012	−0.021
	(0.020)	(0.023)	(0.023)	(0.023)	(0.019)
Reg-Pop	−0.237	−0.307	−0.354	−0.354	−0.298
	(0.264)	(0.260)	(0.253)	(0.253)	(0.252)
Reg-Comp	0.014**	0.006	0.012	0.013	0.020**
	(0.007)	(0.008)	(0.008)	(0.009)	(0.008)
Cohort 1		0.435*	0.267	0.265	
		(0.259)	(0.265)	(0.270)	
Cohort 2		0.626***	0.501**	0.500**	
		(0.239)	(0.246)	(0.247)	
Experienced			−0.325*	−0.325*	−0.295*
			(0.180)	(0.180)	(0.175)
Spinoff			−0.618**	−0.613**	−0.686***
			(0.241)	(0.326)	(0.320)
Year mother prod.				−0.0004	−0.001
				(0.016)	(0.015)
Observations	200	200	200	200	200
R^2	0.055	0.089	0.119	0.119	0.098
Max. Possible R^2	1.000	1.000	1.000	1.000	1.000
Log Likelihood	−849.221	−845.628	−842.240	−842.240	−844.610
Wald Test	11.370***	16.910***	23.560***	23.540***	19.920***
LR Test	11.367***	18.553***	25.329***	25.330***	20.590***

Two-tailed test, significance:.
***<0.01.,
**<0.05.,
*<0.1.