Dipartimento
Economia e Statistica
Cognetti de Martiis

Working Paper Series

09/19

THE BIRTH AND DEVELOPMENT OF THE ITALIAN AUTOMOTIVE INDUSTRY (1894-2015) AND THE TURIN CAR CLUSTER

ALDO ENRIETTI, ALDO GEUNA,
CONSUELO R. NAVA and PIER PAOLO PATRUCCO

brick Bureau of Research on Innovation, Complexity and Knowledge

The Department of Economics and Statistics "Cognetti de Martiis" publishes research papers authored by members and guests of the Department and of its research centers. ISSN: 2039-4004

Department of Economics and Statistics "Cognetti de Martiis"
Campus Luigi Einaudi, Lungo Dora Siena 100/A, 10153 Torino (Italy)
www.est.unito.it

UNIVERSITÀ DEGLI STUDI DI TORINO

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

Aldo Enrietti[*]
Department of Economics and Statisitcs Cognetti de Martiis &
ISMEL, Polo del Novecento

Aldo Geuna[**]
Department of Economics and Statisitcs Cognetti de Martiis &
BRICK, Collegio Carlo Alberto

Consuelo R. Nava[***]
Department of Economics and Political Sciences

Pier Paolo Patrucco[****]
Department of Economics and Statisitcs Cognetti de Martiis &
BRICK, Collegio Carlo Alberto

March 2019

Acknowledgments

The original idea for this paper was made more concrete as a result of discussions between Aldo Geuna and Dan Breznitz during the latter's period as a visiting fellow at the Collegio Carlo Alberto. The authors also acknowledge useful comments and suggestion from Paolo Bianchini, 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.

[*] Department of Economics and Statistics Cognetti De Martiis, University of Turin, ISMEL, Polo del Novecento, E-mail: aldo.enrietti@unito.it

[**] Corresponding author - Department of Economics and Statistics Cognetti De Martiis, University of Turin, BRICK, Collegio Carlo Alberto, E-mail: aldo.geuna@unito.it

[***] Department of Economics and Political Sciences, University of Aosta Valley, E-mail: c.nava@univda.it

[****] Department of Economics and Statistics Cognetti De Martiis, University of Turin, BRICK, Collegio Carlo Alberto E-mail: pierpaolo.patrucco@unito.it

Abstract

By discussing the relation between the traditional Marshallian/Jacobian approach and Klepper's concept of spinoffs and their role, this paper tries to explain the early genesis and later evolution of the Italian automotive industry, based on the formation of the Torino's car cluster from the late nineteenth century. Historical analysis and econometric models are integrated to identify key factors that enabled the creation and success of the automotive industry in Turin. Specifically, we investigate agglomeration economies, the role of spinoffs and institutional factors such as the level and importance of local education. Based on original archival research, we built a new database of all Italian automobile companies. Replication of Klepper's (2007) and Boschma and Wenting's (2007) models shows no particular influence of the Turin cluster and no early entry advantages. Our model, which integrates and extends previous contributions, confirms the existence of a spinoffs effect, and in particular the positive effect of inherited technical skills embedded in pilots. We find support also, for positive agglomeration effects at the regional level and inter industry externalities from aeronautics, a metropolitan cluster effect and the significance of metropolitan education.

Keywords: Industrial Dynamics, Business History, Cluster, Automobile, Spinoffs.

JEL Classification: O31; O33; O14; L26; I25; N83; N84; N93; N94;

1. Introduction

The Marshallian tradition explains the concentration and development of economic activities in space in terms of agglomeration economies driven by technical externalities and knowledge spillovers. Industries and new firms agglomerate in well-defined geographical areas based on the co-location of pools of specialized workers and suppliers which allow proximate firms to access productive resources at lower cost. Additionally, agglomeration favors knowledge spillovers: firm knowledge circulates via labor mobility, user-producer interactions, informal communication, and local institutions that act as bridging organizations. Co-located firms can more easily access external knowledge and exploit the advantages of collective learning.

This traditional approach was challenged by the seminal work of Steve Klepper who argued that the spinoff process is the main driver of the formation and development of clusters and the local concentration of industry. The spinoff process is considered as facilitating the transmission of knowledge between parent companies and new entrants. The knowledge and 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. Moreover, more successful parent firms are able to generate a larger number of spinoffs which are more successful than other new firms. Therefore, cluster development and growth depend more on the ability of existing, early-established firms to generate a larger number of new firms than on co-location in a space.

We discuss the relations and missing links between the traditional Marshallian approach and Klepper's view of the role of spinoffs to explain the early genesis and later evolution of the Italian automotive industry through the formation of a car cluster in Turin from the late nineteenth century to WWII.

The paper makes three specific contributions. First, 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 nineteenth century, the Turin area has exhibited higher levels of education and literacy compared to other Italian regions involved in car production. We argue that these are initial conditions allowing the acquisition of more specialized mechanics know-how and the formation of a cohort of technical school trained technicians. In Klepper's account, the role of institutional factors is largely neglected which is confirmed in some recent reappraisals of his work by Ron Boschma (2015) and Morrison and Boschma (2017). Second, the paper considers Jacobian knowledge externalities (Jacobs, 1969) between the automotive industry and the aviation sector (which developed almost in parallel) as a factor supporting the clustering of car production in Turin. While this idea is not new in the cluster literature, for instance Boschma and Wenting (2007) examined the role of related industries in the spatial development of the British car industry, to our knowledge, previous work uses aggregate measures of industry concentration (e.g. employment, patents) to account for the presence of related industries. Our paper considers the microeconomic level and examines each carmakers' product portfolio in terms of whether, and how many car producers were diversifying in the rising aeronautics sector, and investigate the presence of inter-industry technical externalities. Third, we define the type of knowledge and how it is transmitted within the spinoff process. Klepper's spinoff theory positions managerial competence at the core of the model: "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, p. 616). 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, p. 624). In our paper, we test the role of inherited technical rather than managerial skills. In line with Buenstorf and Costa (2018) that propose that intra-industry flows of the technical knowledge embodied in employees support spinoff dynamics and the longevity of entrants, we hypothesize that that automobile pilots founders of car producing firms were carriers of special technological knowledge. The technical and tacit skills acquired, by pilots are considered key sources of technological competency diffusion (Eichenberger and Stadelmann, 2009; Jenkins and Tallman, 2015; Pinch et al., 2003). We test whether car making firms founded by entrepreneurs with experience both as pilots and at other carmakers are more likely to survive compared to other firms, and promote the development of a cluster. In this sense, pilots are considered selected "breeders" (Buenstorf and Klepper, 2009, 2010).

We combine historical analysis with survival models to identify the main factors enabling the creation and success of the automotive industry in Turin. The localization and persistence of the car industry in the Turin metropolitan area are framed within the current theoretical literature based on comparing the traditional Marshallian/Jacobian approach to Klepper's pioneering analysis of the role of spinoffs. We test Klepper's hypothesis of spinoffs as the drivers of industry clusters, and propose some new elements. The analysis is based on original data from a new dataset AUTOITA of 398 Italian carmakers since 1894. AUTOITA was constructed by merging and comparing several different archival sources which resulted in unique and internationally comparable data on Italian car producers.

The article is organized as follows. Section 2 provides a brief history of the Italian automobile industry, and section 3 discusses agglomeration economies and Klepper's contestation of Marshallian economies. Section 4 defines the main alternative research hypotheses; this represents a specific contribution related to understanding the birth, development, and clustering of industries. Section 5 describes the AUTOITA dataset and presents a descriptive analysis of the main variables. Section 6 presents the econometric methodology and the estimations in the context of our hypotheses.

2. A brief history of the Italian automobile industry

The first Italian automobile producer that manufactured cars for sale to the public was Enrico Bernardi. The company 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 & C and experienced various ownership structures and names up to the closure in 1901. Bernardi & Miari Giusti was established to produce the first petrol engined Italian cars (which was very innovative at the time), initially three-wheelers 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 to 1906 saw the foundation of 165 car manufacturers – see section 5.1 for a detailed description of the AUTOITA data on Italian automobile companies). As in other countries, there was variation in what was considered to be a car in terms of its basic design and method of propulsion. The main market for these early vehicles was composed originally of a small number of rich nobility, and only later by financial and industry entrepreneurs.

As a result, the earliest cars were luxurious to satisfy their acquisition as status symbols, and to use for racing. Many were "unique pieces". The manufacturers provided customers with the frame, and the customer relied on specialized bodybuilders for the remaining construction, the choice of bodywork, and the selection of accessories all of which pushed personalization to its extreme (Biffignandi, 2017, 2013). In this handicraft context, invested capital could be less than 10,000 lire ($1.818 in 1900).[1]

FIAT which was founded in 1899, was from the outset, different from its competitors (Castronovo, 1999): (a) its initial activities were based on a large invested capital (800,000 lire about $440,000 in 2018), and (b) three 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 US to visit the Ford production plans – Castronovo, 1999). Initial production volumes were small but grew quickly from 50 in 1900 to 268 in 1904.

[1] Equivalent to about $54,730 in 2018.

FIAT’s growth was based on exports which 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 6,080 compared to about 16,000 in Germany, 40,000 in France, 63,000 in the United Kingdom and 143,000 in the United States (Volpato, 1983). In its first 20 years, the Italian automobile industry was a clear example of export led growth.

The 1906-1907 economic crisis was the first watershed in the history of Italian car industry, when the prospect of quick gains favored large stock speculation (Castronovo, 1999) and 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 6,000 cars in circulation i.e. one car per 5,500 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 which 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 automotive production and production of military-oriented vehicles increasing. Between 1914 and 1918 FIAT’s production grow by more than 356%, reaching a maximum of over 19,000 vehicles in 1917, and this compared to Lancia whose 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 focus on serial production rather than the French customization for the elite model. FIAT’s strategy resulted in a reduction to the range of models but increased production volume 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 the 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 five 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, 182,000 in the United Kingdom. Thus, Italy’s production was less than a third of its main competitors (Volpato, 1983).

The 1929 crisis represented for Italy a further moment of concentration in the sector. Small and medium size 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 (IRI) 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 OM (for industrial vehicles), and the SPA (for special vehicles). The 1929 crisis was also 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 government decided on a policy of a strong lira keeping the exchange rate to sterling 90 to 1 (Quota 90) in order to re-enter in 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 the opportunity to again exploit economies of scale. In 1950 FIAT production exceeded 100,000 units: in 1960 it exceeded 500,000 and in 1966 it exceeded one million (equivalent of 4,000 per day) (ANFIA).[2] This growth was linked closely to a strong domestic market which was growing more than in other countries: from 1959 to 1969, the number of cars sold increased by 2.1 times in Germany, by 2.4 in France, and by 4.6 in Italy. In 1958, Italy was recording car ownership rates of one car to every 24 inhabitants, about the same level as in France and the United Kingdom in 1930, and in 1965 it achieved one car for every 10 inhabitants, equaling the 1924 level in the United States (Biffignandi, 2013).

3. Agglomeration economies and Klepper's challenge

Whether and how the geographical concentration of economic activities affects the industry dynamics in general, and the birth and evolution of a particular industry in particular were studied by Alfred Marshall and Jane Jacobs. However, attention to these issues has been spurred by recent re-appreciation of the work of Steven Klepper related to industry clusters and the industry life cycle.[3] Elaborating upon the notion of intra-industry externalities (Marshall, 1920), scholars interested in economic geography, industrial dynamics and innovation have emphasized the idea that firms in the same industry clustered in geographic space benefit from local knowledge spillovers, labor market pooling and the presence of specialized suppliers, and promote firm clustering within a single

[2] In 1967 and 1968, FIAT was ranked first in Europe, ahead of VW, with 6.6% of world production, 15.7% of European production and 21.2% of CEE production. Source Associazione Nazionale Filiera Industrie Automobilistiche, various years.

[3] See for instance the Special Issue: Industry Evolution, Entrepreneurship, and Geography: Contributions in Honor of Steven Klepper, *Industrial and Corporate Change* (2015) 24 (4): 739-873, edited by Rajshree Agarwal, Guido Buenstorf, Wesley M. Cohen and Franco Malerba.

industry. There is a large literature (see for instance, Glaeser et al., 1992) devoted to developing the claim that geographic proximity can be a major driver of firm growth and formation of industrial clusters and districts because proximity favors different forms of contact among co-located firms.

Economic geographers revisited the Marshallian "industrial atmosphere" notion, using the "untraded interdependencies" (Storper, 1995) and "local buzz" (Bathelt et al., 2004) lenses which consider co-location as having possible unintended effects on learning and the accumulation of technical knowledge by embedded actors. The variety of the interdependencies among actors facilitates individual learning and spontaneous formation of industrial clusters.

However, the assumption that co-location on its own will support the cross-fertilization of ideas and the diffusion of skills left scholars interested in innovation who considered intentional networking as the driver of cluster formation and growth (Bathelt et al., 2011; Breschi and Malerba, 2005; Brenner et al. 2013) disappointed. The idea that firms would benefit from external economies simply by "being there" (Gertler, 1995, 2003) developed by focusing on the role of proximity as facilitating interactions.

We can identify various forms of proximity (Thompson and Fox Kean, 2005; Antonelli et al., 2011; D'Este et al., 2013): geographical but also cognitive (Noteboom et al., 2007), institutional (Giuliani, 2007; Graf, 2011), social (Breschi and Lissoni, 2009) proximity matter for explaining participation in clusters and networks, and their persistence. The circulation of knowledge becomes a crucial variable in cluster growth via collaborations between firms, collaborations between firms and scientific and training institutions, and mobility of human capital.

In its insistence on the positive effect of a variety of players constructing a network with the objective of sharing skills and technologies, this work was based implicitly on Jacobs's (1969) observation that firms clustered in space can benefit from industry variety and inter-industry externalities. Firms can acquire competences, abilities and technologies from other firms active in similar industries and proximate in the technology space which allow them to survive and grow faster. In turn, it is more likely that variety can trigger the emergence of new industries compared to the case of firms that are located in contexts characterized by the presence of a single sector. Based on the idea that diverse industries can introduce improvements by learning from each other, the notion of related variety and local related externalities (Boschma and Wenting, 2007; Frenken et al., 2007) captures the idea that different sectors should be located together in order to generate benefits and drive industry clustering. Jacobs also stressed the role played by large cities and institutional factors such as education and scientific institutions, financial players and politics in promoting the exploitation of inter-industry externalities.

In sum, in agglomeration approaches, industry clustering and growth may be associated to the either Marshallian or Jacobian economies: the former embodies the idea of geographical agglomeration and sectoral specialization supporting the formation of a local pool of technical skills and knowledge spillovers; and the latter embodies the idea of the advantages deriving from learning economies among firms in diverse sectors, and from institutional effects.

3.1 Klepper's contestation of Marshallian economies

The Marshallian tradition has been questioned by Klepper (2007, 2010; Buenstorf and Klepper, 2009). Klepper adopts an industry life cycle approach to understand how industrial clusters emerge and evolve over time. His 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 "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, p. 862). The process of parent company spinoffs to produce new entrants promotes the emergence of clusters which form on the basis of the competencies transferred from parents to their offspring located in the same region. Industrial clustering is driven by entry and exit of firms with different inherited capabilities rather than agglomeration economies.

Highlighting the role of legacy in his work on the formation of the United States automobile industry, Klepper (2007, p. 621) distinguishes among four types of new entrants: 1) "spinoffs if at least one of their founders had worked for or founded, or both, an automobile firm […]"; 2) "experienced entrepreneurs were new firms headed by someone who previously headed an active or recently sold off firm in another industry"; 3) "experienced firms, were preexisting firms that entered the automobile industry by adding automobiles to their product line", i.e. diversifiers; 4) "firms that were not classified as experienced firms, experienced entrepreneurs, or spinoffs were lumped into a residual category of inexperienced firms, reflecting their limited prior knowledge regarding automobiles".

In this paper, we follow Boschma and Wenting (2007, pp. 225-226), who "distinguished between three types of entrants, according to the pre-entry experience of the entrepreneur: 1) a firm was classified as a spinoff, if the founder had previous experience in the automobile industry, either as founder or as employee of another motor company; 2) a firm was classified into the category of experienced firms when at least one of their founders had prior experience in a closely related industry (such as coach making and cycle making) or a semi-related industry (mechanical engineering); 3) firms that were not classified as spinoffs or experienced firms were assigned to the residual category of inexperienced firms."

4. The birth and development of industrial clusters

In this paper, we test the traditional Marshall and Jacobs agglomeration economy hypotheses, and Klepper's spinoffs model, and integrate 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.

4.1 Marshall economies

Traditional agglomeration economy models identify the following reasons why Turin became the cradle of industrial development in Italy. First, Turin had a long-term cultural and political special relationship with France which 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 water falls in the mountains allowed the supply of yearlong 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 the availability of a specialized workforce based on the concentration of military production, train and railroad construction, and the metallurgical industry. Fourth, Turin specialized in building carriages as a result both of its being the capital of a kingdom, 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.

4.2 Jacobs' externalities: Inter-industry economies and related externalities

The idea of Jacobs' (1969) externalities and related variety (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. We test this idea directly by examining the role of access to new scientific and technological knowledge available in the aviation industry whose parallel development involved similar actors in Turin.

In 1915, Italy has 22 active aviation companies; during 1915-1918, 17 new producers entered and airplane production rose from 400 in 1915 to 6,500 in 1918 (in 1918 24,000 engines were produced).[4] This industry development was accompanied by the development of scientific and technological aerodynamic knowledge crucial to aeronautics. In the same period, car production experienced significant transformation with cars being produced by a single car producer rather than the car body and engine being the responsibility of different makers. The design of the body became intrinsic to the automobile project, and knowledge in aerodynamics became relevant to car production. The aeronautic industry was located mostly in Milan, Varese and Turin. In Turin, we observe a 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 full vehicles, engines, 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 production, giving them competitive advantage.

4.3 Klepper's spinoff model

Klepper's model of the special role of spinoffs in explaining local clustering is associated to a life cycle model that explains 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 industry) experiencing falling prices, early entrants have a higher probability of survival since they will 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 to higher levels of competences which will become scarcer over time, making entry less frequent and increasing the survival of incumbents. If we relax Klepper's constant distribution of competences assumption and assume instead that among automobile cluster firms shared knowledge implies that over time newly founded companies will have higher levels of competences, then early entry advantage will be weaker. Moreover, spinoffs are characterized by higher rates of survival based on their inherited (from their parents) competencies which make them fitter and more successful.[5]

---

[4] Building on the Ferrari (2005) database, we developed an original and comprehensive dataset 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 further work investigating the origins and development of the aeronautics cluster in Italy.

[5] To an extent it can be argued that Klepper's thesis is based on a particular form of experience and learning economies similar to those highlighted by Edith Penrose (1959) in her work on firm growth; however, instead of these economies being at work within the same firm which derives new capabilities from previous experience, in Klepper's model they

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 it will be able to transfer at least partially, to its offspring.

4.5 Technological spinoffs

According to Buenstorf and Klepper (2009, 2010) in their studies of United States industry types, the potential to attract new entry and spinoffs is higher in regions with larger stocks of potential "breeders" (i.e. incumbents) of entrants in the same industry. In other words, the spinoff probability is higher 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 displayed ever increasing rates of spinoff firms, while many others produced no spinoffs. Giuliani (2007) and Giuliani and Bell (2005) provide similar evidence in relation to wine cluster firms.

Our aim in the present paper is to identify the potential role of special breeders i.e. incumbents that emerge eventually as the main spinoff activity actors that drive the persistence of clusters. In particular, we are interested in whether entrepreneurs trained as pilots can be considered a specific source of technical knowledge explaining the persistence of spinoffs and cluster growth as suggested by anecdotal evidence on the early automotive industry (Biffignandi, 2013). We depart from Klepper's focus on managerial mismatches as the motivation for spinoffs, and highlight spinoff activity as driven by the potential of exploitation of unique technical skills that were embodied into pilots. During the early stages of the industry evolution pilots were the only one that were able to drive quickly a car but also have the intuition of what needed to be done to have the right set up of the car and were the only ones that did enough kilometers to develop that special knowledge in their daily interaction with mechanics.

4.5 Local education institutions

Despite a long-standing tradition which links institutions to the formation and evolution of industrial clusters and districts (Dorfman, 1983; Saxenian, 1994; Carlsson, 1997; Cooke, 2001; Becattini et al.,

operate between firms, and the new generations of firms inherit their competencies from the previous experience of their parent firms.

2009), Klepper's work does not consider their influence for supporting cluster and industry evolution (Boschma, 2015; Frenken et al., 2015). Similarly, Boschma and Wenting's (2007) work on the United Kingdom automobile industry does not include regional institutions; they argue that neither the previous literature nor the history of the United Kingdom automobile industry points to the particular role of institutions in the emergence of the industry.

Here, 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 which drive the industry's subsequent growth, and the creation of human capital by industry/technical schools. In other words, the education level can be considered an institutional pre-condition which facilitates further and quicker upgrading of human capital via industry /technical training which in turn favors cluster development. In this respect, scientific and education 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). In the case of the Turin cluster, we observe the focus on education by the municipality and firms.

In the mid 1800s and early 1900s, literacy levels in Piedmont, and especially Torino were higher than in Lombardy and Milan and the rest of Italy (see data analysis below) and high relative to a large number of European regions. This was due perhaps 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 two years of elementary state funded education obligatory (in France it was not obligatory until the 1882 Loi Ferry). In 1911, 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 primary education financing till 1930s (De Fort, 1996). Thus, historical heritage, political will and economic development at the city level affected local investment in primary education

Due to Turin's initial advantage, industrial and technical education developed more successfully than in other locations. In 1845, the public Scuole di Meccanica e Chimica Applicate alle Arti were funded followed soon by another three technical school financed partially by the municipality (De Fort, 2000).[6] The Scuole Tecniche Operaie di S. Carlo 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 were obliged to pay a membership fee but

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

received a fee waiver for some 15%-30% of students), 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 of between 200 and 300 students per year up to 1880, the 400-500 in the following ten years to reach some 900 students in 1890-1891 and around 1,400 in 1916-17, two years after the introduction of a special course for designers, motor experts and automobile drivers (Robotti, 1998). Among the notable private schools were le Scuole Officine Serali (1887) which 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 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[7] which merged the previous 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 (Automobilismo, 1907). 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 the city in the period 1903-1907, was honorary president of both schools), akin to what today we would describe as a Public Private Partnership. Later in the development of the Turin cluster, an important role was played also by company training schools including among others FIAT's Scuola Allievi FIAT which opened in 1922, and Lancia's Scuola Aziendale Lancia which opened in 1924.

Finally, a very advanced technical education was provided by the Technical School for Engineers which was created in 1859; in 1862 it merged with the Royal Italian Industrial Museum, a hybrid museum/ high level technical school institution[8] which in 1906 became the Politecnico of Turin.

7 https://it.wikipedia.org/wiki/Istituto tecnico industriale statale Amedeo Avogadro

8 The Royal Italian Industrial Museum (based on the South Kensington Museum, the first industrial museum which was founded in 1856) 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 London Great Exhibition of 1862 (Giacomelli, 2010).

5. The Italian automobile industry: Descriptive analysis

5.1 The AUTOITA Dataset

While there are sound historical and qualitative accounts of the development of the Italian automobile industry, especially in the case of Turin, prior to the present papers, there are no systematic attempts to create an inclusive 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 and none of them include all producers since they are based on secondary sources of information. All three articles provide only brief descriptions of the data, and it is unclear which types of car producers are included. For instance, in Hannan et al. (1995), the focus is on producers that intended to commercialize cars for the mass market (excluding prototypes), and producers of sole commercial vehicles and racing cars. Kim et al. (2003) appears to use Hannan et al.'s (1995) data,[9] and report on 198 firms. Hannan et al.'s (1995) list of Italian firms is inaccurate,[10] and the data description refers to Georgano (1982) and Baldwin et al. (1982), two international car encyclopedias, as the primary sources of information. Finally, Antonelli (2001) analyzes 225 companies, using data from unspecified Museo dell'Automobile of Turin sources, and provides no detailed information on the unit of analysis.

Our more 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);
- a detailed archival search at the Museo dell'Automobile of Turin and original archival work.

In the case of this last, we searched the annual Active Company Directory for Turin (Guida Paravia) and Milan (Guida Savallo)[11] for the period 1884-1945, and examined all the issues related to the three most important specialist magazines (*L'Automobile d'Italia; L'Automobile; Motori Cicli e Sport*) over the period 1900-1918.

[9] However, they cite two 1998 papers by Hannan et al. that do not include Italian data.

[10] On p. 514 they report 22 which is evidently an editing mistake since in the graph shown in figure 2 on p. 517, they present yearly densities for some 200 firms.

[11] Note that 29 and 11 companies were respectively listed only in Guida Paravia and Guida Savallo.

The resulting AUTOITA database includes 398 companies. We included: all firms that produced at least one car (4-wheeler, 3-wheeler, electric and internal combustion engines); producers of prototypes that were never commercialized (due to lack of financial support, or for technical reasons) but which put in place production plans and made attempts to sell their production (invested money in advertising their product). 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) which is incomplete and not fully reliable. Our final sample is 338 companies for which we have a rich set of information: year of entry/exit, location, type of automobile produced (electric, cyclecar, four-wheeler), all licenses used, 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) and Klepper (2007) we classified companies according to the entrepreneur's pre-entry techno-economic experience/inexperience and spinoff experience. 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 other companies' pilots (the most outstanding example is the case of Lancia Automobiles, one of Italy's oldest carmakers which was founded in Turin in 1906 by Vincenzo Lancia, a former pilot employed at FIAT).

Table 1: UK and Italian automobile industry

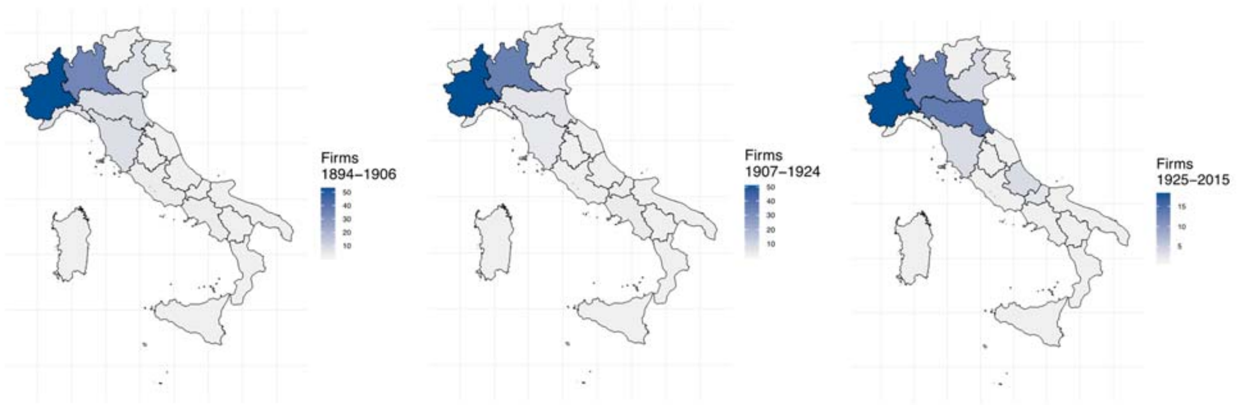
	UK	**ITALY**	**Italy (Reduced sample)**
All		398	
Missing info		60 (15%)	
Basic Info (BI)		338	
Basic Info with pre-entry background (BI_{p-eb})		292	
BI_{p-eb} Spinoff		40 (14%)	
Dominant Design (DD)	628	241	
No pre-entry background	248 (39%)	41 (17%)	
Dominant Design with pre-entry background (DD_{p-eb})	380	200	157
DD_{p-eb} Spinoff	64 (17%)	37 (19%)	35 (22%)

Table 1 presents summary information for our sample compared to the United Kingdom case (Boschma and Wenting, 2007). Since our information on the United Kingdom 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 which 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 dominant design (DD) sample. In the Italian case, we have a basic information (BI) sample that includes prototypes, electric cars and three-wheeler car companies which tended to have shorter life spans. We were able to identify information on firm pre-entry background for 292 of the 338 firms in the BI sample, 40 of which (14%) are spinoffs. In the DD sample the United Kingdom accounts for many more than twice as many companies as Italy, 628 vs. 241. Pre-entry information is available for respectively 380 and 200 of these companies with a similar share of companies with missing pre-entry background information. Of the companies with pre-entry information 64 (17%) are United Kingdom spinoffs and 37 (19%) are Italian spinoffs.

From the outset, the Italian automobile industry was heavily geographically concentrated. In the industry’s first six years (1894-1899), 18 DD companies entered, 8 (44%) in Milan, 5 (28%) in Turin and the remainder spread across the country.[12] Turin became the capital of the automobile industry only after 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 241 companies included in the DD sample, 113 were located in Turin (47%) and 64 in Milan (27%). Figure 1 depicts the geographical 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.

[12] We consider the city and the province, but only in a handful of cases the company was not located in the city

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

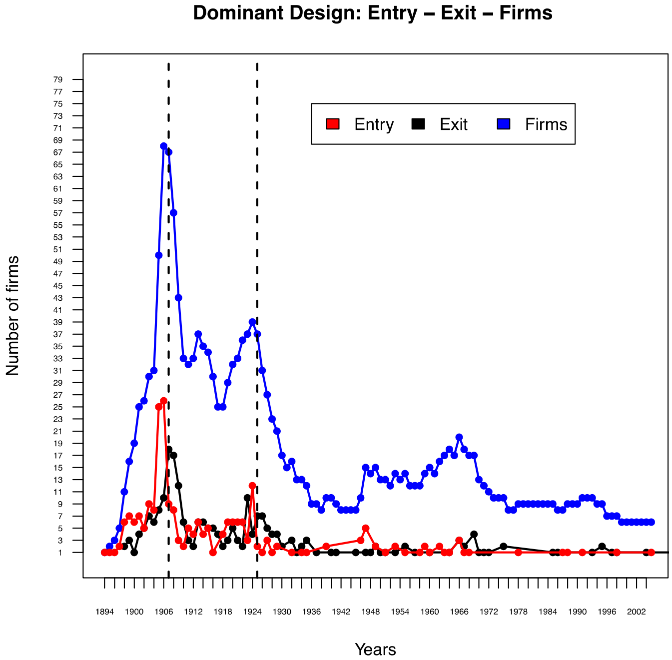


In the first 10 to 20 years of the industry in particular, a large number of companies were founded and/or closed down and reopened under slightly different names, usually by new entrepreneurs who brought in new capital, or occasionally by original founders exiting to create new firms focused on slightly different production. In most cases, the production plant and its machinery became the production facility of the new company. To emphasize the technological cores of the companies, we constructed a reduced sample (RS) which 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 plans 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 which through various events survived as an independent brand until its acquisition by FIAT in 1986. The reduced sample is used to check the robustness of the econometric estimations.

5.2 Entry, exit and survival

Figure 2 presents yearly automobile manufacturer densities, entries and exits for the DD sample which is the main sample use for our analysis. The patterns are similar for the BI and RS samples. The entry and exit dynamics of the 241 DD firms are characterized by three peaks for number of firms active in the market – in 1906, 1913 and 1924 and respectively 68, 37 and 39 firms. The major decrease in the number of active firms after the 1906 peak is associated to the 1907 economic crisis and increasing failures and exits and a reduced number of entries. After a short period of higher entry and lower exit rates during WWI, densities decreased significantly before recovering postwar and peaking again in 1924. In the succeeding 15 years, the industry consolidated (by the 1930s FIAT accounted for almost 75% of national production) with a number of mergers and acquisitions as well as 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 the respective number of firms (following the DD definition) entering the industry in each period 104, 90 and 47. In 2015, only five companies remained active in the market, FIAT and four super-car producers: Covini Engineering, DR, Lamborghini and Pagani.

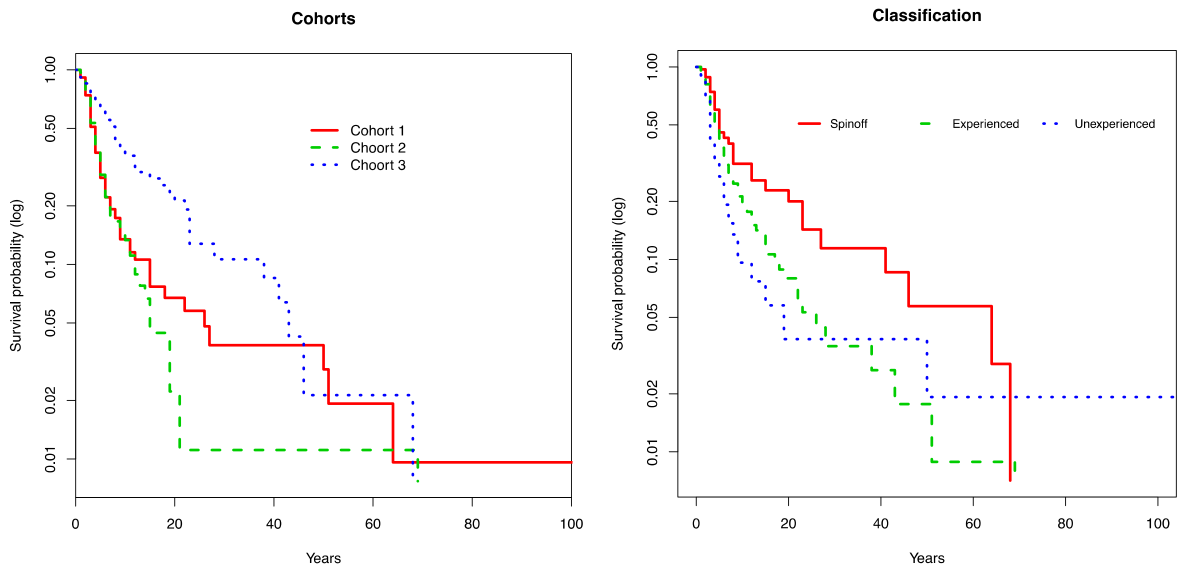
Figure 2: Entry, exit and number of active firms per year



Klepper (2007, 2010) highlights the importance for firm survival of early entry in the industry. He argues that early entrants can make extra profit which allows 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 that survive among each cohort show a different pattern that contrasts with most previous work (see figure 3a). In the first few years, the curves overlap but then after 1925 the more recent entrants become dominant and very few firms from the early cohorts survive (Alfa Romeo, FIAT, Lancia).

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 and spinoffs show higher rates of survival. In the case of Italy (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.

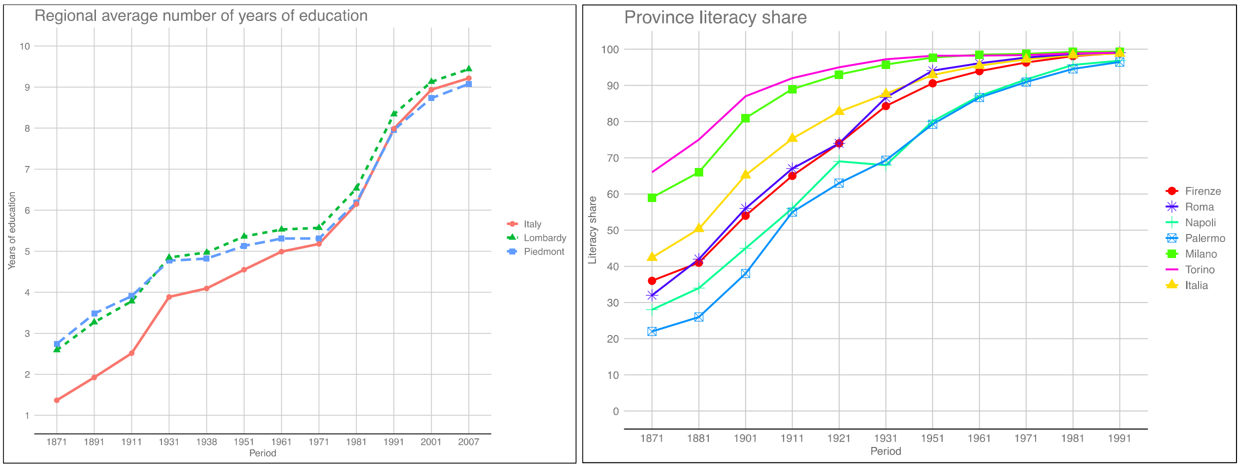
Figure 3: Kaplan-Meier survival curves (in log scale) by cohort (241 firms) and classification (200 firms). Differences in survival curves both cases are statistically significant (p-values 0.0018 and 0.028 respectively).



5.3 Education: Regional and Province analysis

Section 4 predicted 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); *Prov-Education* measures literacy by share of inhabitants. Figure 4 focuses on the Piedmont and Lombardy regions, and the cities of Turin and Milan (which are relevant to development of the Italian automobile industry) comparing 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 to 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 for 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 held in 1871 predates the second Italian industrialization and provides some support for the interpretation of a causal effect of education on industrial development.

Figure 4: Education in Italy. Italy represents the average regional or province behavior given the population.



6. 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 hazards model (Cox Regression) to investigate survival time statistically (Audretsch and Mahmood, 1994; Lee, 1992). These types of methods refer to survival models which 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 regression control simultaneously for covariate effects on survival time, and assume that the dependent variable is a hazard function at a given time. In line with the literature, we assume independent observations i.e. hazard ratios that are constant across time. The Cox regression estimates the relative risk based on a hazard function $h(t)$ in eq. (1).[13] We apply this estimation model to describe the determinants of an exit, given a set of selected predictor variables $\boldsymbol{X}$:

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

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

A positive estimate β_i of an explanatory variable, equivalent to $e^{\beta_i} > 1$, means that the exit probability (the hazard) in the next period is higher for higher values of X_i. Alternatively, a $\beta_i < 0$ or,

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

equivalently to $e^{\beta_i} < 1$, indicates that a firm with higher values of X_i has lower exit probability compared to other companies. Hence, 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 i.e. for 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, while there is no error correlation among different groups. We cluster companies established in the metropolitan city of Turin and the other provinces. This approach ensures better representation of unobserved common firm features, and latent characteristics related to metropolitan city policies. Compared to a simple control with dummies this approach allows better estimation of local heterogeneity.[14] To improve inference accuracy using this approach, and without introducing estimates of downward biased standard errors, we consider the firm's province as the clustering effect. This avoids having less than 10 clusters and ensures a suitable number of not unbalanced clusters (see e.g. Wooldridge, 2003).

6.1 Variables

Based on the theoretical discussion in Section 3, we expect company survival to depend on Marshall and Jacobs agglomeration economies, pre-entry founder background (and mother company in the case of spinoffs) and local education. We control also for a cohort effect. The following variables are used in the model.

<u>Marshallian and Jacobian economies</u>

Following Boschma and Wenting (2007) we construct a series of variables to capture agglomeration economies (Marshallian and Jacobian) at the regional level. At entry, each entrant is assigned to one of the 20 Italian regions and one of the 80 provinces.

• Marshallian economies:

[14] The estimator has been described as the Huber sandwich estimator, White's estimator and the Horvitz-Thompson estimator.

– population living in the region (*Reg-Pop*): we collected the number of people living in each region from the 1861 to 2011. For years with missing information in the national censuses we reconstructed the measure using the average population rate of growth over the period;
– regional GDP: regional contribution to national gross domestic product (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.

• Jacobian economies:

– number of employees in related industries (*Empl-Related Ind*): for each year of entry in the automobile sector and each region we calculated the number of people working in a related industry. The variable can also be interpreted as capturing supply side agglomeration economies;
– to measure inter-industry related externalities (intra-firm), we constructed the variable *Aeronautic* which identifies companies active in both the automobile and aeronautics industries in each year – a total of 14.[15] A few automobile producers were involved only in the production of airplane engines; some focused only on plane components. We use three dummies for automobile firms involved in the construction only of plane components (*Components*), only of plane motors (*Motor*), and 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 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 entry in and exit from the aeronautics industry. However, due to the more recent development of the aeronautic sector, only two firms began as aeronautics and differentiated into automobile production. Therefore, we cannot use company age to build a more complex time dependent interaction between aeronautics and automobiles.

Founder's pre-entry background

For 200 companies in the DD sample we can identify the founder's pre-entry background which allows 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 are* companies already active in the automobile industry, typically firms that had a change of name following

[15] Note that in the BI sample the number of firms active also in aeronautic firms is 18.

the entry/exit of a partner, and perhaps benefited from the injection of new capital but remained in the same production location;

- *Unexperienced* refers to one firm for which we were unable to find clear evidence that the founder(s) had any previous experience;
- *Spinoff* is a dummy variable equal to 1 if the firm was 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, *Pilots* equals 1 and 0 otherwise (not pilot and/or not spinoff). We would expect spinoffs founded by pilots who we assume were special carriers of technological knowledge, and especially 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), would 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 the age of the company originating the spinoff (the mother).

<u>Local Education</u>

To capture the effect of local education on firm survival we use the variables *Reg-Education* and *Prov-Education*. Since it was impossible to construct a reliable time series for number of students in technical education at the provincial level (Accornero, 2019), we introduced the dummy variable *Torino* for the companies established in the metropolitan area of Turin; this controls for a specific metropolitan area effect when including *Reg-Education* in the model. When *Prov-Education* is introduced to control for basic education input at the provincial level we use the clustered model to capture the characteristics of Turin not controlled for such as technical education and other local institutions that might have supported the development of a local cluster.[16]

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

6.2 Results and Discussion

We start our analysis by replicating as closely as possible Boschma and Wenting's (2007) and Klepper's (2007) models for the Italian automobile sector population, and then present and discuss

[16] 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 electrical energy by the Azienda Elettrica Municipalizzata (Municipal Electric Company – AEM Torino – founded in 1907) at lower prices than in other major cities, and the municipal investment in the public transport network.

our model.[17] Klepper's model applied to the Italian data performs poorly; it confirms the higher survival probability related to experienced companies but provides weak confirmation of the effect of spinoffs. The effect of the interaction between the Torino cluster and spinoffs is not confirmed. We obtained more consistent results from the Boschma and Wenting model although we found lower significance of the variables. 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 regression in our models. In Model 1, in addition to the variables capturing agglomeration economies, entry cohort, and type of firm which Boschma and Wenting (2007) include, we tested the effect of local institutions and local education level on the exit probability. The local competition level is positively correlated to an increased exit probability while being an experienced or spinoff firm is associated to a higher probability of survival. Cohort effects are not significant. Both the Turin dummy (*Torino*) and regional education level (*Reg-Education*) are less than 1 and are significant after controlling for all other variables highlighting the importance of a local institutional effect not considered in the previous literature. Model 2 includes provincial (*Prov-Education)* instead of regional level of education; its effect on the exit probability is not statistically significant. The dummy *Torino* is no longer significant, likely due to the fact that Turin is the metropolitan city and had the highest educational levels in Italy up to WWII (see figure 4). To avoid heteroskedasticity issues Model 3 employs a robust variance estimation based on the firm's province (i.e. robust clustered standard errors) and excludes the dummy for Torino. These robust standard error estimations provide more accurate estimates of the model coefficients and cluster the error terms. Estimates of two of the coefficients of agglomeration economies are statistically significant in this specification: number of employees in related industries (*Empl-Related Ind*) at the regional level has a negative effect on the exit probability, and high levels of regional competition induce earlier firm exit from the automotive sector. The provincial education level has a negative and significant effect on the hazard rate, confirming the role of local in institutions. Spinoffs companies have a higher survival probability, but the age of the mother firm (proxy for accumulated competences) does not affect the exit probability of the spinoff. Model 4 includes the *aeronautic* covariate 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 companies that were active in both industries survived for longer all else being equal. Model 4 also includes a set of variables on firm founders. It shows that firms with previous experience in some other than the car industry have a higher

[17] See appendix A for details of the estimations.

probability of survival compared to companies with no previous experience of any kind; 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 which did not allow the accumulation by those companies of special competences. The effect of spinoff companies founded by pilots (*Pilots*) and others (*Spinoff no pilot*) indicates that companies (co)founded by pilots had higher survival rates likely associated to the technological knowledge embedded in the pilots. 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 of 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 the United Kingdom and United States markets, and much of the Italian growth potential was achieved in the first years via exports. When the export possibility disappeared at the end of the 1920s, the domestic market was not sufficiently sizeable to sustain the growth of more companies due to cost decreases associated to loss of scale economies. Finally, in model 5 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. All the results are robust to the inclusion of regional population.

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					0.707*
					(0.273)
Reg-GDP	0.916**	1.001	1.004	1.010	
	(0.036)	(0.029)	(0.029)	(0.029)	
Reg-Comp	1.018*	1.024**	1.030***	1.030***	1.028***
	(0.010)	(0.011)	(0.010)	(0.010)	(0.010)
Empl-Related Ind.	1.054	0.968	0.970*	0.971*	0.984*
	(0.042)	(0.030)	(0.028)	(0.028)	(0.023)
Inter-Ind. Extern.					
Aeronautics				0.170***	0.165***
				(0.325)	(0.326)
Institutions					
Reg-Education	0.958***				
	(0.015)				
Prov-Education		0.328	0.288**	0.382**	0.509*
		(0.685)	(0.655)	(0.680)	(0.673)
Torino	0.696*	0.853			
	(0.207)	(0.208)			
Cohort					
Cohort 1	0.937	0.911	0.949	1.288	1.403
	(0.301)	(0.339)	(0.334)	(0.343)	(0.313)
Cohort 2	1.083	1.282	1.327	1.845***	1.990***
	(0.278)	(0.281)	(0.277)	(0.288)	(0.276)
Founder					
Experienced	0.699*	0.752	0.739	0.726***	0.710**
	(0.184)	(0.182)	(0.181)	(0.195)	(0.197)
Experienced-within				0.677	0.670
				(0.219)	(0.219)
Spinoff	0.536**	0.555**	0.548***		
	(0.242)	(0.243)	(0.243)		
Pilot				0.500***	0.479***
				(0.299)	(0.299)
Spinoff no pilot				0.787	0.796*
				(0.275)	(0.275)
Year mother prod.	0.997	0.993	0.993	0.996	0.997
	(0.013)	(0.013)	(0.013)	(0.014)	(0.013)
R^2	0.156	0.126	0.126	0.296	0.302
Observations	200	200	200	200	200

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

Our analysis provides partial support for the findings in the literature by providing robust evidence of both Marshall and Jacobs agglomeration economies and the role of spinoff dynamics. However, our findings are novel:

- the local environment and local "atmosphere" (captured by *Torino*) and especially provincial education level (*Prov-Education*) have positive effects on firm survival rates, with the latter being much more important and significant, and highlighting the effect of local institutions which previous studies do not take into account;
- 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 exist probability;
- we distinguish between spinoff companies founded by pilots and others and show that companies (co)founded by pilots had a lower exit probability than other spinoffs. We argue that pilots learned technological skills that 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 the exploitation of scale economies by more than one company, FIAT.

6.3 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. la Carrera Luigi & C founded in 1896, closed down in 1906 then reopened as Officine e Fonderie Torinesi after merging with the steel maker Schlepfer & C before finally exiting the automobile market in 1910. This reduced the number of observations to 162; most of the 38 companies that experienced a merger were founded in the first two periods. Table 3 presents the main results for this reduced sample. The models in table 3 are based on clustered standard errors estimations and the results are consistent with the previous estimations. With the exception of *Empl-Related Ind* which is no longer statistically significant, the coefficients of agglomeration economies are similar to the previous estimations, confirming the role of regional competition and regional population. Similarly, the level of provincial education is correlated to a reduced exit probability, and

Experienced, *Pilot* and *Spinoff no pilot* indicate that the related companies had higher probabilities of survival.

Table 3: Marginal effects e^{β} under Cox regression models for the exit – Reduced sample/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	0.736*	0.735*	0.741*	0.756*
	(0.281)	(0.280)	(0.281)	(0.278)
Reg-Comp	1.035***	1.034***	1.035***	1.033***
	(0.011)	(0.011)	(0.011)	(0.011)
Empl-Related Ind.	1.006	1.005	1.007	1.004
	(0.025)	(0.025)	(0.025)	(0.025)
Inter-Ind. Extern.				
Aeronautics	0.117***			
	(0.426)			
Aero		0.089***		
		(0.781)		
Aeron. no aero		0.129***		
		(0.471)		
Components			0.646*	
			(1.012)	
Aeron. no components			0.118***	
			(0.426)	
Motor				0.220***
				(0.390)
Aeron. no motors				0.104***
				(0.775)
Institutions				
Prov-Education	0.523*	0.533*	0.518*	0.536*
	(0.669)	(0.670)	(0.668)	(0.665)
Cohort				
Cohort 1	2.158**	2.167**	2.171**	1.986*
	(0.384)	(0.383)	(0.384)	(0.377)
Cohort 2	2.492***	2.515***	2.521***	2.341**
	(0.331)	(0.332)	(0.332)	(0.327)
Founder				
Experienced	0.642**	0.637**	0.647**	0.681**
	(0.201)	(0.202)	(0.202)	(0.201)
Experienced-within	0.942	0.936	0.938	0.968
	(0.352)	(0.352)	(0.352)	(0.352)
Pilot	0.448***	0.439***	0.449***	0.432***
	(0.335)	(0.339)	(0.334)	(0.335)
Spinoff no pilot	0.677*	0.668*	0.676*	0.665**
	(0.279)	(0.281)	(0.279)	(0.283)
Year mother prod.	0.997	0.997	0.997	0.997
	(0.017)	(0.017)	(0.017)	(0.017)
R^2	0.344	0.345	0.345	0.315
Observations	162	162	162	162

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

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

7. Conclusions

This paper discussed how a more traditional approach to industry clustering and growth which identifies agglomeration economies and technical externalities as the main drivers of local industrial development, can be combined with Steve Klepper's understanding of the role of spinoffs. In particular, it sheds new light by explaining the early genesis and later evolution of the Italian automotive industry based on the formation of a car cluster in Turin starting in the late nineteenth century to the end of WWII. We built a novel and unique dataset of Italian carmakers from 1894 to 2015, merging data from six international sources and integrating them with data from in-depth archival research.

Relying upon this original dataset, we tested hypotheses about agglomeration economies and spinoffs as drivers of industry clustering. We investigated three specific factors that enabled the creation and success of the automotive industry in Turin.

First, we accounted for the role of institutional effects, namely education. We argue that it can be considered an initial precondition for further learning and technical and scientific advancements. In the early phase of the industry when the dominant design had yet to emerge, learning rather than scale economies were 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 and to benefit from intra-firm scale economies, making local basic and technical education extremely important for firm survival.

Second, we stressed the positive effect of inter-industry externalities related to automotive and aeronautics, and argued that they relied on related technical and scientific knowledge, and that cross-fertilization benefited the development of the car cluster in Turin.

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. We identified pilot entrepreneur firms as "selected breeders", or transmitters of assets (technical skills) between the mother company and the spinoff. We emphasized spinoffs by pilots compared to other technical specialists, as motivated by the need for specific technical skills that in the earliest stages of development of the car industry. This differentiates our analysis from Klepper's model which focuses only on managerial mismatches as the motivation for spinning off.

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 Dynamics of Knowledge Internalization: The case of FIAT in the mechanical engineering cluster, in C. Antonelli, The Microeconomics of Technological Systems, Oxford, Oxford University Press.

Antonelli, C., Patrucco, P.P, and Quatraro, F. (2011), Productivity growth and pecuniary knowledge externalities: An empirical analysis of agglomeration economies in European regions, Economic Geography 87 (1), 23-50.

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 Mahmood, T. (1994), The rate of hazard confronting new firms and plants in U.S. manufacturing, Review of Industrial Organization, 9, 41-56.

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

Bathelt, H., Feldman M. P., and Kogler, D. F. (eds.) (2011), Beyond Territory: Dynamic Geographies of Knowledge Creation, Diffusion and Innovation. London: Routledge.

Bathelt, H., Malmberg, A. and Maskell, P. (2004), Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation, Progress in Human Geography, 28 (1), 31-56.

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

Biffignandi, D. (2017), Torino tra ottocento e novecento, http://www.museoauto.it/website/images/stories/articoli/varie/torino-tra-800-e-900.pdf

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/

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

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

Boschma, R. (2015), Towards an evolutionary perspective on regional resilience, Regional Studies

Brenner, T., Cantner, U., Graf, H. (2013), Introduction: Structure and dynamics of innovation networks, Regional Studies 47(5), 647-650.

Breschi, S. and Lissoni, F. (2009), Mobility of skilled workers and co-invention networks: An anatomy of localized knowledge flows, Journal of Economic Geography, 9(4), 439-468.

Breschi, S. and Malerba, F. (eds.) (2005), Clusters, networks and innovation, Oxford: Oxford University Press.

Bruni, A., Clarke, M., Paolini, F. and Sessa, O. (2015), L'Automobile Italiana, Le Grandi Marche dalle Origini a Oggi, Firenze, Giunti.

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

Buenstorf, G. and Klepper, S. (2009), Heritage and Agglomeration: The Akron Tire Cluster Revisited, Economic Journal, Vol. 119, 705-733.

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

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

Castronovo, V. (1999) FIAT, un secolo di storia italiana, Rizzoli.

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.

D'Este, P., Guy, F., and Iammarino, S. (2013) Shaping the formation of university-industry research collaborations: what type of proximity does really matter? Journal of Economic Geography.

De Fort, E. (2000) L'istruzione primaria e secondaria e le scuole tecnico-professionali, in U. Levra Storia di Torino Volume 6 La città nel Risorgimento, Giulio Einaudi Editore, Torino.

De Fort, E. (1996), Storia della scuola elementare. Dall'Unità al fascismo, Bologna, Il Mulino.

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, London, Temple.

Eichenberger, R. and Stadelmann, D. (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, Milano, Franco Angeli.

FIAT Archivio Storico (1996), FIAT: le fasi della crescita, Paravia, Torino.

Frenken, K., Cefis, E. and Stam, E. (2015), Industrial dynamics and clusters: A survey, Regional Studies, 49(1), 10-27.

Frenken, K., Van Oort, F., and Verburg, T. (2007), Related variety, unrelated variety and regional economic growth, Regional Studies, 41, 685-697.

Georgano, G.N. (2000), The Beaulieu Encyclopedia of the Automobile (ed. N. Georgano), Routledge.

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

Gertler, M. S. (1995), Being there proximity, organization, and culture in the development and adoption of advanced manufacturing technologies, Economic Geography, 71(1), 1-26.

Gertler, M. S. (2003), Tacit knowledge and the economic geography of context, or the undefinable tacitness of being (there), Journal of Economic Geography, 3(1), 75-99.

Giacomelli, L. (2010), Il Regio Museo industriale italiano in Torino, in Castelnuovo, E. and Pagella, E. (eds.), Torino: Prima capitale d'Italia, Roma: Istituto della Enciclopedia italiana, 117-124.

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

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

Glaeser, E. L., Kallal, H., Scheinkman, J. and Shleifer, A. (1992), Growth in cities, Journal of Political Economy, 100, 1126-1152.

Graf, H. (2011), Gatekeepers in regional networks of innovators, Cambridge Journal of Economics, 35(1), 173-198.

Hannan, M.T., Carroll, G.R., Dundon, E.A. and Torres, J.C., 1995, Organizational Evolution in a Multinational Context: Entries of automobile manufactures in Belgium, Britain, France, Germany and Italy, American Sociological Review, 60, 509-528.

Jacobs, J. (1969), The Economy of Cities, London, Jonathan Cape.

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

Kim, T-Y, Dobrev, S.D. and Solari, L. (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, Storiaindustria.it

Marshall, A. (1920), Principles of Economics (Revised ed.). London, Macmillan.

Morrison, A. and Boschma, R. (2017), The spatial evolution of the Italian motorcycle industry (1893–1993): Klepper's heritage theory revisited, Papers in Evolutionary Economic Geography 17 (7), Urban and Regional Research Centre, Utrecht University.

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

Nooteboom, B., van Haverbeke, W.P.M., Duijsters, G.M., Gilsing V.A. and Oord, A. v.d. (2007), Optimal cognitive distance and absorptive capacity, Research Policy 36 (7), 1016-1034.

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.

Penrose, E. T. (1959), The Theory of the Growth of the Firm, London: Basil Blackwell. Porter M. (1990), The Competitive Advantage of Nations, New York, Macmillan.

Pinch, N., Henry, S., Jenkins, M. and Tallman, S. (2003), From 'industrial districts' to 'knowledge clusters': A model of knowledge dissemination and competitive advantage in industrial agglomerations, Journal of Economic Geography 3 (4), 373–388

Robotti, D. (ed.) (1998), Scuole d'industria a Torino. Cento e cinquant'anni delle Scuole tecniche San Carlo, Centro Studi piemontesi, Torino.

Saxenian, A. (1994), Regional Advantage: Culture and Competition in Silicon Valley and Route 128. Cambridge, MA.: Harvard University Press.

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.

Thompson, P. and Fox Kean, M. (2005), Patent citations and the geography of knowledge spillovers: A reassessment, American Economic Review, 95 (1), 450-460.

Volpato, G. (1983), L'industria automobilistica internazionale, Padova, CEDAM.

Wooldridge, J. M. (2003), Cluster-Sample Methods in Applied Econometrics, The American Economic Review, 93 (2), 133-138.

Appendix A

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

Based on the Italian data, table A.1 replicates models 1, 2, 3, and 5 in Klepper (2007), and table A.2 replicates models 1-5 in Boschma and Wenting (2007). The former group of models are based on the Gompertz's specification of the hazard function.[18] and the latter exploit the 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 A.1) test the Turin effect which is never statistically significant when using Klepper's specification. Finally, age of mother production firm has a negative effect on the exit probability only in model 5 although the value is close to zero which contrasts to Klepper's model.

Second, we compare the results in table A.2 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 United Kingdom case. This might be due to the strong correlation of *Empl-Related Ind.* to population (see figure A.1);
- 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 which 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,

[18] The Gompertz's specification of the hazard of firm exit at age t, is slightly different from (1) and takes the following form:

$$h(t) = e^{(\alpha_0 + \boldsymbol{X}\boldsymbol{\alpha}')t} e^{\beta_0 + \boldsymbol{Z}\boldsymbol{\beta}'}$$

where $\boldsymbol{X}$ and $\boldsymbol{Z}$ represent firm covariates. In particular, the first exponential term expresses a hazard rate monotonically affected by the age and by the selected variables in $\boldsymbol{X}$. The second exponential defines a hazard rate proportionally affected by the independent variables in $\boldsymbol{Z}$ at all ages.

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 15% of the total variability (see the R^2 in table A.2) of the exit probability of Italian automotive firms. This suggests the need for further analyses to explain this effect which is discussed only partially in Klepper (2007).

Table A:1: Klepper's models – a comparison with the Italian industry. Coefficient estimates $\boldsymbol{\beta}$ 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 (0.013)	-0.004 (0.013)	-0.005 (0.013)	-0.010 (0.013)
t	0.098*** (0.02615)	0.098*** (0.026)	0.100*** (0.027)	0.079*** (0.020)
Torino	0.119 (0.153)	0.122 (0.164)		
Experienced	-0.280** (0.071)	-0.281** (0.180)	-0.256 (0.179)	-0.028 (0.151)
Spinoff	-0.538** (0.238)	-0.524 (0.318)	-0.536* (0.322)	
Cohort 1	0.866*** (0.265)	0.867*** (0.265)	0.869*** (0.267)	0.9716*** (0.265)
Cohort 2	0.876*** (0.266)	0.877*** (0.266)	0.885*** (0.267)	0.911*** (0.267)
*Cohort 1 * t*	-0.040** (0.017)	-0.040** (0.017)	-0.038*** (0.017)	-0.033** (0.017)
*Cohort 2 * t*	-0.013 (0.021)	-0.013 (0.018)	-0.013 (0.018)	-0.008 (0.0175)
Spinoff Torino		-0.027 (0.33088)	0.073 (0.375)	
Year mother prod.			-0.002 (0.012)	-0.005* (0.012)
Log Likelihood	-589.589	-589.587	-589.8512	-592.1549
AIC	1197.18	1199.175	1199.704	1200.31
Observations	200	200	200	200

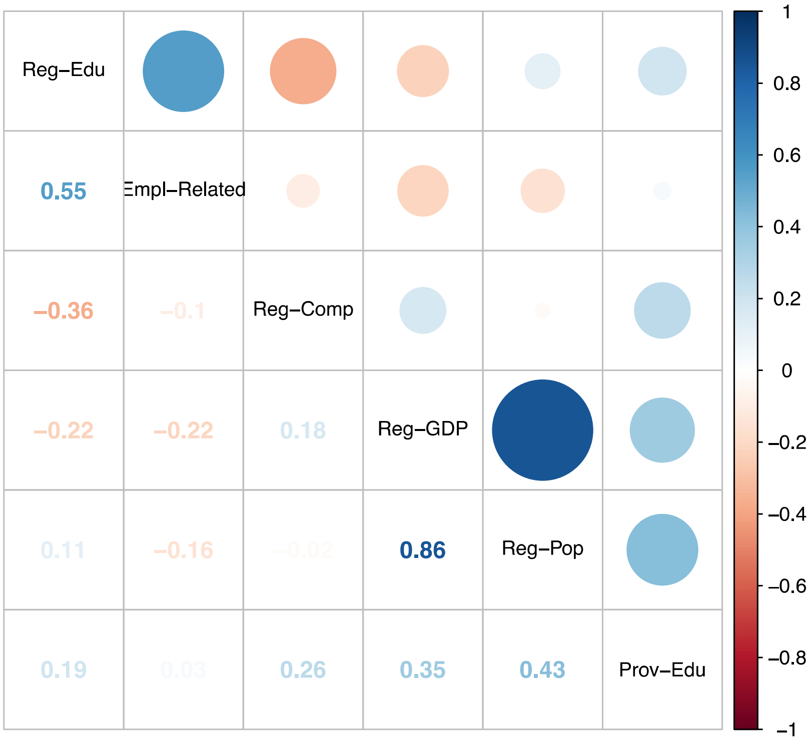
Two-tailed test, significance: ***< 0.01, **< 0.05, *< 0.1

Table A.2: Boschma and Wenting's models. A comparison using the Italian industry database. Coefficient estimates $\boldsymbol{\beta}$ 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	-0.353	-0.299
	(0.264)	(0.260)	(0.253)	(0.252)	(0.250)
Reg-Comp	0.014**	0.006	0.012	0.012	0.020***
	(0.007)	(0.008)	(0.008)	(0.008)	(0.007)
Cohort 1		0.435*	0.267	0.261	
		(0.259)	(0.265)	(0.266)	
Cohort 2		0.626***	0.501**	0.496**	
		(0.239)	(0.246)	(0.247)	
Experienced			-0.325*	-0.317*	-0.284
			(0.180)	(0.182)	(0.177)
Spinoff			-0.618**	-0.610**	-0.686***
			(0.241)	(0.243)	(0.236)
Year mother prod.				-0.004	-0.005
				(0.012)	(0.012)
Observations	200	200	200	200	200
R^2	0.055	0.089	0.119	0.119	0.099
Max. Possible R^2	1.000	1.000	1.000	1.000	1.000
Log Likelihood	-849.221	-845.628	-842.240	-842.197	-844.535
Wald Test	11.370***	16.910***	23.560***	23.570***	19.990***
LR Test	11.367***	18.553***	25.329***	25.416***	20.740***
Score (Logrank) Test	11.495***	17.393***	24.168***	24.202***	20.300***

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

les


Reg–Edu
0.55
Empl–Related
−0.36
−0.1
Reg–Comp
−0.22
−0.22
0.18
Reg–GDP
0.11
−0.16
0.86
Reg–Pop
0.19
0.26
0.35
0.43
Prov–Edu
1
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
−1