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The birth and development of the Italian automotive industry (1894-2015) and the Turin car cluster¹

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For Peer Review

1
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3
4 *Abstract*
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8 This paper describes the early genesis and later evolution of the Italian automotive
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10 industry employing the traditional agglomeration approach combined with Klepper's
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12 spinoff theory. It highlights the key role played by the Turin car cluster from the late 19th
13
14 century. We provide the first comprehensive database of Italian automobile companies
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16 from 1894 until 2015, based on original archival research. We use historical analysis and
17
18 econometric models to identify the factors contributing to the creation and success of the
19
20 automotive industry in Turin. More specifically, we investigate agglomeration
21
22 economies, and the part played by spinoffs and institutional factors with a special
23
24 emphasis on the role of local education. Our model confirms the existence of a spinoff
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26 effect, and especially the positive effect of inherited technical skills embedded in pilots.
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28 We find support for positive agglomeration effects at the regional level, technological
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30 complementarities with aeronautics, a metropolitan cluster effect and importance of local
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32 education. Basic and technical education seem to be particularly important initial
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34 institutional preconditions for further technical learning and scientific advancement, and
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36 would make an interesting research topic.
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4 **Keywords:** Industrial Dynamics, Business History, Cluster, Automobile, Spinoffs.
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7 **JEL Classification:** O31; O33; O14; L26; I25; N83; N84; N93; N94;
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For Peer Review

1. Introduction

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

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

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

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4 Klepper's evolutionary framework makes it "explicit that one needs to differentiate between
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7 firms in terms of the competencies they possess as soon as they enter the new industry ... the
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10 background of new entrants was decisive, in particular, whether new entrants had inherited
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13 (better) capabilities from parent companies in the same industry or not" (Boschma, 2015a, p.
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16 862). The process of parent company spinoffs to produce new entrants promotes the emergence
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19 of clusters which form on the basis of the competencies transferred from parent to offspring
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22 located in the same region. The spinoff process is seen as facilitating the transmission of
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24 entrepreneurial skills between parent companies and new entrants. The skills that promote
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27 entrepreneurship are derived from the new entrepreneur's previous experience of working in
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30 the parent company in the same or a similar sector. Industrial clustering is driven by the entry
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33 and exit of firms with different inherited capabilities and the ability of existing, early-
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36 established firms to generate a larger number of new firms, rather than by agglomeration
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39 economies (Buenstorf and Guenther, 2011; Buenstorf and Costa, 2018).
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48 This paper fills a gap in the literature by proposing a bridging between the traditional
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50 agglomeration approach and Klepper's view of the role of spinoffs, to explain the early genesis
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53 and later evolution of an industry. The focus is on the Italian automotive industry and the
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56 formation of the Turin car cluster in the late 19th century up to WWII.
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4 In the context of these contrasting views, the present paper makes four specific contributions.
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7 First, it provides evidence that the basic Klepper model does not hold for the case of the Turin
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10 cluster although Turin is the case that most closely resembles the Detroit (i.e., an automobile
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13 town) case discussed by Klepper. Geographical concentration and the evolution of production
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16 activities involves more complex explanations.
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21 Second, we capture the effect of institutional factors – specifically education and literacy, as
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24 early preconditions for the further accumulation of technical know-how in the cluster. Since
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27 the late 19th century, the Turin area has exhibited higher levels of education and literacy
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30 compared to other Italian cities involved in car production. We argue that these constitute the
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33 initial conditions for the acquisition of more specialized mechanics know-how and formation
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36 of a cohort of technical-school trained technicians. Some recent critical reappraisals of
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39 Klepper's work by Boschma (2015), Cusmano et al. (2015) and Morrison and Boschma (2019)²
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41
42 confirm that Klepper's account ignores the role of institutional factors.
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49 Third, we specify the type of knowledge and how it is transmitted through the spinoff process.
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52 Klepper's spinoff theory positions managerial competence at the core of the model. He argues
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59 ² The latter two papers in particular include a well-articulated analysis of the role of institutions in the evolution
60 of industrial clusters.

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4 also that “spinoffs are expected to be better able than inexperienced firms to *manage* the process
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7 of technological change by dint of their prior experience” (Klepper, 2007, p. 624, emphasis
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9
10 added). We challenge this view by testing the role of inherited technical rather than managerial
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13 skills. We provide evidence that car making firms founded by entrepreneurs with experience
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16 as pilots (not just fast drivers but technicians especially able to provide crucial feedback on the
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19 development and set up of the automobile) are more likely to survive compared to other firms,
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22 and to promote development of a cluster. In this context, pilots are considered selected
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27 “breeders” (Buenstorf and Klepper, 2009, 2010).

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31 Fourth, we consider the notion of related industries (Frenken et al., 2007) and apply it to the
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34 interaction between the automotive industry and the aviation sector (which show almost
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37 parallel development). The complementarities between these two sectors are seen as factors
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40 supporting the clustering of car production in Turin. Boschma and Wenting (2007) examine
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43 the role of related industries in the spatial development of the British car industry and Delgado,
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46 Porter and Stern (2010) show that clusters in regions with a large presence of other
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49 complementary industries experience higher new business formation and start-up employment
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52 growth, and better start-up firm survival. The present paper considers the role of related
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55 industries more broadly, by measuring the level of employment in the mechanical industries,
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4 and testing the specific complementarities between the automotive and aeronautics industries
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7 by examining each carmakers' product portfolio in terms of whether and how many automobile
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10 producers were diversifying into the growing aeronautics sector.

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14 In this paper, we use historical analysis combined with survival models to identify the different
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17 factors enabling the creation and success of the automotive industry in Turin. The analysis is
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20 based on original data from the new AUTOITA dataset of 396 Italian carmakers since 1894.
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23 AUTOITA was constructed by merging and comparing several different national and
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26 international archival sources, and provides unique and internationally comparable data on
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29 Italian car producers. This is the first systematic attempt to create an inclusive database of car
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32 producers in Italy.
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38 The paper is structured as follows. Section 2 provides a synthetic historical contextualization
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41 of the development of the Italian car-making industry. Section 3 presents complementary
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44 hypotheses on the development of the Turin car cluster. Section 4 describes the AUTOITA
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47 dataset and offers a quantitative, long term descriptive analysis of the Italian automobile
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50 industry. Section 5 presents the econometric model and the model results. Section 6 presents a
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53 summary of our findings.
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2. A brief history of the Italian automobile industry

The first Italian automobile manufacturer of cars which went on sale to the public was Enrico Bernardi. Bernardi & Miari Giusti was founded in 1894 in Padua by Bernardi and two engineers – Giacomo Miari and Francesco Giusti del Giardino. In 1896, it became Motori Bernardi, Miari, Giusti & Co. and up to the time of its closure in 1901, had various ownership structures and names. Bernardi & Miari Giusti was established to produce the first petrol engine Italian cars (very innovative at the time), initially three-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 4.1 for a detailed description of the AUTOITA dataset of Italian automobile companies). As in other countries, in Italy what constituted a car in terms of its basic design and method of propulsion varied. The main market for these early vehicles was composed originally of a small number of rich individuals – mostly aristocrats - and only later included financial and industry entrepreneurs.

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4 As a result, the earliest cars were luxurious and designed to be status symbols, and were used
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7 mostly for racing. Many were “unique pieces”. The manufacturers provided their customers
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10 with a frame, and the customer relied on specialized bodybuilders for the remaining
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13 construction, the bodywork, and the selection of accessories which pushed personalization to
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16 its extremes (Biffignandi, 2017, 2013). In this handicraft context, invested capital might be less
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19 than 10,000 lire (or equivalent to \$1,818 in 1900).³
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24 From the outset, FIAT which was founded in 1899 differed from its competitors (Castronovo,
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27 1999): (a) its initial activities were based on a large amount of invested capital (800,000 lire
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30 about \$440,000 in 2018), and (b) three years after its foundation, FIAT’s management (in
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33 particular Giovanni Agnelli) decided to focus on a less sophisticated product aimed at a wider
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36 audience. Instead of original bespoke designs for an elite clientele, FIAT wanted to reach a
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39 larger group of consumers using the best of the existing technology. FIAT’s strategy was to
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42 industrialize car production as quickly as possible (in the early 1900s Agnelli made several
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45 trips to the US to visit the Ford production plants – Castronovo, 1999). Initial production
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48 volumes were small but grew quickly from 50 in 1900 to 268 in 1904. FIAT’s growth was
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51 based on exports which accounted for more than half of its production (86% in 1909) during
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60 ³ Equivalent to about \$54,000 in 2018.

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3 the pre-WWI period 1904-1914 (FIAT Archivio Storico, 1996). The national market was
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6 limited: in 1906, the number of vehicles circulating in Italy was 6,080 compared to about
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10 16,000 in Germany, 40,000 in France, 63,000 in the United Kingdom and 143,000 in the United
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13 States (Volpato, 1983). The first 20 years of the Italian automobile industry are a clear example
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17 of export led growth.
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21 The 1906-1907 economic crisis was the first watershed in the history of the Italian car industry,
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24 when the prospect of quick gains favored large stock speculation (Castronovo, 1999) and the
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27 consequent crash. In 1906, FIAT's stock prices reached 75 times their nominal value.
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31 Speculation encouraged the establishment of more firms: in 1907 there were 84 active
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34 automobile companies in Italy, and 6,000 cars in circulation i.e. one car per 5,500 inhabitants
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37 in Italy, compared to one in 981 in France and one in 640 in England (Volpato, 1983). In 1907
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41 there was a rapid collapse of the industry which resulted in a predominant although not
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44 monopolistic FIAT (in 1904 FIAT's share in national production was 8.7%, and in 1914 it was
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47 35%).
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52 WWI represented another growth opportunity for the automotive sector, and especially for
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55 FIAT with increased automotive production and production of military-oriented vehicles.
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59 Between 1914 and 1918, FIAT's production grew more than 356%, reaching a maximum of
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4 over 19,000 vehicles in 1917, while Lancia's production increased by "only" 94% to reach a
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7 maximum of 860 vehicles in 1918. Towards the end of WWI, FIAT accounted for some 80%
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10 of Italian national automotive production (FIAT Archivio Storico, 1996). The post-war years
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13 worked to reinforce FIAT's adoption of a "Make as Ford" strategy, and its focus on serial
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16 production, as opposed to France's customization of elite models. FIAT's strategy resulted in
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19 a reduced range of models but increased production volumes based on economies of scale. In
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23 1919, the FIAT Lingotto factory was established in Turin as the first European factory designed
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26 and organized for mass production, and its assembly lines were set up to produce the "501".
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30 The 501 was the first Italian car to be manufactured in large volumes: by 1926 around 46,000
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33 501 had been produced. In the five years between 1925 and 1929, FIAT produced 190,000
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36 cars, equivalent to 72% of total national production (Volpato, 1983). However, in international
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39 terms, both Italian production and Italian demand remained weak: in 1929, almost 52,000 cars
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43 were produced in Italy compared to 191,000 in France and 182,000 in the United Kingdom.
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47 Thus, Italy's production was less than a third of its main competitors (Volpato, 1983).
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51 The 1929 crisis represented a further moment of sectoral concentration for Italy. Small and
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54 medium sized companies such as Ansaldo, Ceirano, Chiribiri, Diatto, Itala and Scat closed
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57 down. Alfa Romeo and Isotta Fraschini were acquired by the Istituto per la Ricostruzione
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4 Industriale (IRI), the Italian state holding company created in 1933 to rescue and restructure
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7 private companies that were in financial trouble due to the 1929 crisis. FIAT absorbed Officine
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10 Meccaniche (OM) which produced industrial vehicles, and SPA to produce special vehicles.
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13 The 1929 crisis saw the start of a historical period characterized by trade protection policies
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16 worldwide, and especially against fascist Italy (in 1935 the League of Nations imposed
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19 sanctions on Italy following the invasion of Ethiopia). In the period 1926-27, the Italian
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22 government decided on a policy of a strong lira (Quota 90), maintaining an exchange rate with
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25 sterling of 90 to 1 in order to re-enter the Gold Exchange Standard. Italian automobile
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28 companies which for most of the 1920s had exported around 60% of their production suffered
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30
31 a significant drop in exports from 61% in 1927 to 41% in 1930 and 17% in 1933 (Biffignandi,
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37 2013).

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40 The end of WWII gave FIAT another opportunity to exploit economies of scale. In 1950, FIAT
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43 production exceeded 100,000 units: in 1960 it exceeded 500,000 and in 1966 it exceeded 1
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46 million units (equivalent to 4,000 per day). This growth was linked closely to a strong domestic
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49 market which was growing faster than the domestic markets in other countries: between 1959
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52 and 1969, the number of cars sold increased 2.1 times in Germany, 2.4 times in France, and
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57 4.6 times in Italy. In 1958, Italy was recording car ownership rates of one for every 24
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3 inhabitants, about the same levels as in France and the United Kingdom in 1930, and in 1965
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7 it reached one car for every 10 inhabitants, equaling 1924 levels in the United States
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10 (Biffignandi, 2013).
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19 **3. The birth and development of industrial clusters**

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22 Whether and how the geographical concentration of economic activities affects industry
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25 dynamics in general, and the birth and evolution of a specific industry in particular have long
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28 been the objects of study in the fields of economic geography and industrial economics. A
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31 stronger focus on these issues was spurred recently by re-appreciations of Steven Klepper's
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34 work on industry clusters and the industry life cycle. In this paper, we test the traditional
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37 agglomeration economy hypotheses and Klepper's spinoff model, and combine these
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40 explanations of local agglomeration with the idea of technological spinoffs and the role of local
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43 education, to frame our understanding of the birth and development of industries and clusters.⁴
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53 ⁴ Agglomeration economies and cluster effects can occur at different spatial scales. While agglomeration
54 economies associated with economic scale, industrial population and economic institutions are related more to
55 the regional level, specific cluster effects such as spin-offs and technological learning take place at a narrower
56 levelsuch as the province/county level (for an account of the differences in spatial scales, see De Vaan, Boschma
57 and Frenken, 2012; Frenken, Cefis and Stam, 2015). It is true also that the typical Marshallian factors – local
58 skilled labor, input-output linkages and technical externalities – have been employed widely to explain the
59 formation and growth of small industrial districts in very narrow geographical spaces i.e. a few municipalities
60 (Becattini et al., 2009). In our empirical analysis we try to differentiate between the effects at different spatial
scales, to capture specific cluster effects at the provincial level. We thank an anonymous referee for this point.

3.1 Localization economies

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

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

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

In this context, our analysis of the agglomeration drivers that made Turin the cradle of industrial development in Italy identifies the following elements. First, Turin had a long-term special cultural and political relationship with France which was home to early automobile industry developments. The creation in 1871 of the Frejus railroad tunnel facilitated these

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4 countries' trade relationships (Turin was the first major Italian city on the railroad connection
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7 to France). Second, the geographic location of Turin near major rivers and close to mountain
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10 waterfalls provided yearlong supplies of relatively cheap water power and later hydro-
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13 electricity (Ciccarelli and Fenoaltea, 2013). Third, Turin's heritage as the capital of the Savoy
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16 Kingdom and the first Italian capital, resulted in availability of a specialized workforce based
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19 on the concentration of military production, train and railroad construction and the
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21
22 metallurgical industry. Fourth, Turin was specialized in coach building as a result of being the
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25 first Italian capital and its special relationship with Paris (the main location of carriage
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28 production). The carpentry skills of artisan coach builders were especially important for the
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31 early development of the automobile industry.
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38 *3.2 Related industries and knowledge complementarities*

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42 The idea of related industries (Boschma and Wenting, 2007; Frenken et al., 2007) highlights
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45 that the benefits of agglomeration can derive from local diversification in complementary or
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48 related industries through the cross-fertilization of ideas and transmission of technological
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51 solutions. Agglomeration economies arise among clusters of complementary industries i.e.
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54 industries based on similar technologies and skills, shared infrastructures, and similar demand
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57 and institutions. The presence of related industries in a specific location supports new firm
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4 formation because it enhances the opportunities to develop new products by accessing
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7 complementary inputs and technologies (Delgado et al., 2010).
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11 In the context of technological complementarities, the new industries of car-making and
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14 aeronautics developed almost in parallel which motivates our search for their possible
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17 complementarities. Aeronautics is particularly important since many carmakers were involved
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20 also in the aeronautics industry. A number of new automobile firms were established in the
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23 1920s to transfer and apply the technological competencies of by technicians who had worked
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25
26 in the aeronautics industry during WWI.
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31 We test the role played by related industries and technological complementarities in the
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34 formation and growth of the automobile clusters. First, we control for the number of local
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37 employees in related industries i.e. the aggregate mechanics sector. Second, we examine the
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40 role of access to new scientific and technological knowledge available in the aviation industry
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43 whose parallel development involved similar actors in Turin. We are particularly interested in
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46 carmakers that were also active in the aeronautic industry and the technologies involved.
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52 In 1915, Italy had 22 active aviation companies; during 1915-1918, 17 new producers entered
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55 and airplane production rose from 400 in 1915 to 6,500 in 1918 (in 1918, 24,000 engines were
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4 produced).⁵ This development was accompanied by growth in scientific and technological
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6
7 aerodynamics knowledge crucial for aeronautics. In the same period, car production
8
9
10 experienced a significant transformation with complete cars produced by a single producer
11
12
13 rather than car bodies and engines being produced by different makers. The design of the car
14
15
16 body became intrinsic to the automobile project, and knowledge in aerodynamics became
17
18
19 relevant for car production. The aeronautics industry was located mainly in Milan, Varese and
20
21
22 Turin. In Turin, there was systematic interaction between the aeronautics and auto industries
23
24
25 and important players (such as Chiribiri, SPA, ITALA, SCAT, Diatto, FIAT and Lancia among
26
27
28 others) diversified in both auto and aeronautic technologies (designing or producing the full
29
30
31 plane or only engines and/or components). Those companies, active especially in the
32
33
34 production of whole planes, were able to access and master the new knowledge base and most
35
36
37 likely transferred this knowledge to automobile producers, giving them competitive advantage.
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48 *3.3 Klepper's spinoff model*

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57 ⁵ Building on the Ferrari (2005) database, we developed an original and comprehensive dataset (AEROITA)
58 including 100 firms active in the aeronautics industry in Italy between 1905 and 2018. This dataset provides fine-
59 grained information on the characteristics of aeronautics companies in Italy and will be used for future studies on
60 the origins and development of the aeronautics industry in Italy.

1
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4 Klepper's model of the special role of spinoffs for explaining local clustering is associated to
5
6
7 a life cycle model which explains the survival probability in relation also to the period of entry
8
9
10 to the industry. All other things being equal, in an industry (such as the automobile sector)
11
12
13 experiencing falling prices, early entrants have a higher probability of survival since they are
14
15
16 able to benefit from economies of scale. At the same time, if we follow Klepper and assume a
17
18
19 constant distribution of competences among potential entrants, in an industry experiencing
20
21
22 falling prices, entry will be associated to higher levels of competence which will become
23
24
25 scarcer over time, making entry less frequent and increasing the survival of incumbents.
26
27
28 Moreover, spinoffs are characterized by higher rates of survival based on their inherited (from
29
30
31 their parents) competencies which make them fitter and more successful. Spinoff survival
32
33
34 probability depends also on the parent company's years of survival; the longer established the
35
36
37 parent, the more competences it will have accumulated and the more competences it will be
38
39
40 able to transfer at least partially to its offspring.
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52 *3.4 Technological spinoffs*

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56 According to Buenstorf and Klepper's (2009, 2010) studies of United States industry types, the
57
58
59 potential to attract new entry and spinoffs is higher in regions with larger stocks of potential
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1
2
3 entrant “breeders” (i.e. incumbents) in the same industry. In other words, spinoff probability
4
5
6
7 increases in regions with larger numbers of parent companies potentially able to generate
8
9
10 spinoff companies in the same industry.
11

12
13
14 Not all incumbents are able equally to generate spinoffs. For instance, in the Italian plastics
15
16
17 injection mold clusters (Patrucco, 2005), a few selected incumbents display ever increasing
18
19
20 rates of spinoff firms, while many produce no spinoffs. Giuliani (2007) and Giuliani and Bell
21
22
23 (2005) provide similar evidence for firms in wine clusters.
24
25

26
27
28 This paper aims to identify the potential role of breeder firms i.e. incumbents that emerge as
29
30
31 the main sources of spinoff activity and drive the persistence of clusters. In particular, we are
32
33
34 interested in whether entrepreneurs who were trained pilots can be considered a specific source
35
36
37 of technical knowledge which could explain the persistence of spinoffs and cluster growth
38
39
40 suggested by anecdotal evidence on the early automotive industry (Biffignandi, 2013). We
41
42
43
44 depart from Klepper’s focus on managerial mismatches⁶ as the motivation for spinoffs, and
45
46
47
48 highlight spinoff activity as driven by the potential for exploitation of the unique technical
49
50
51 skills embodied in pilots.⁷ During the early stages of the industry, pilots were the one that were
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57
58 ⁶ The importance of organizational and trade skills is highlighted also by Cusmano et al.’s (2015) study of the
59 ceramic tile industry in the Sassuolo district.

60 ⁷ The role of pilots as repositories and vehicles of technical knowledge is examined in Eichenberger and Stadelman
(2009) and Jenkins and Tallman (2015).

1
2
3 able to drive quickly a car and have the intuition of what needed to be done to have the right
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5
6
7 set up of the car. The number of kilometers done and their daily interaction with mechanics
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9
10 enable them to develop a special technical knowledge.
11
12
13

14 *3.5 Local education institutions*

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16
17
18 Klepper does not consider the influence of institutions on automotive cluster and industry
19
20
21 evolution (Boschma, 2015; Frenken et al., 2015). Similarly, Boschma and Wenting's (2007)
22
23
24 work on the United Kingdom automobile industry does not include regional institutions; they
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26
27
28 argue that neither the previous literature nor the history of the United Kingdom automobile
29
30
31 industry highlights a particular role of institutions in the emergence of the industry.
32
33

34
35
36 However, there is a long tradition of institutions being linked to the formation and evolution of
37
38
39 industries and clusters (Bigelow et al., 1997; Dorfman, 1983; Saxenian, 1994; Carlsson, 1997;
40
41
42 Cooke, 2001; Becattini et al., 2009). Also, the institutional characteristics of the context in
43
44
45
46 which firms are embedded influence their entry and clustering into an industry, their survival
47
48
49 and their performance (Wenting and Frenken, 2011; De Vaan, Frenken and Boschma, 2019;
50
51
52 Menzel and Kammer, 2019; Antonietti and Boschma, 2020). In line with this work, we argue
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54
55
56 that local education institutions played a significant role in the development of the Turin
57
58
59 automobile cluster. We consider education at the metropolitan (province) level as a shared asset
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2
3
4 enabling further economies of learning and accumulation of knowledge which drove the
5
6
7 industry's subsequent growth and the creation of human capital in industry/technical schools.
8
9

10 In other words, education level can be considered an institutional pre-condition facilitating
11
12
13 further and faster upgrading of human capital via industry /technical training which in turn
14
15
16 favors cluster development. In this respect, scientific and educational institutions such as
17
18
19
20 technical schools, polytechnics and design schools have been described as driving industry
21
22
23 clustering in the case of Route 128 and Silicon Valley (Dorfman, 1983; Saxenian, 1994). Also,
24
25
26
27 Buenstorf, Fritsch and Medrano (2015) and Buenstorf and Geissler (2011) highlight the role of
28
29
30 public research and scientific institutions in the early formation and later evolution of industry
31
32
33 clusters.
34
35

36
37 In the mid-1800s and early 1900s, literacy levels in Piedmont, and especially in Turin were
38
39
40 higher than in Lombardy (and Milan) and other Italian regions (see data analysis below) and
41
42
43
44 were high relative to a large number of European regions. This was due to the importance given
45
46
47 to education by the Savoy Kingdom, and after Italian unification in 1861, by the municipality
48
49
50 of Turin. In 1859, the Savoy Kingdom Casati Law made two years of elementary state funded
51
52
53 education obligatory (in France it was not obligatory until the 1882 Loi Ferry). In 1911, the
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56
57 Italian state Daneo-Credao law created an elementary state school system financed by central
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3
4 government (previously, primary education was managed and financed by the municipality)
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6
7 although some large cities such as Turin were responsible for funding primary education until
8
9
10 the 1930s (De Fort, 1996).

11
12
13
14 Due to Turin's initial advantage, industrial and technical education in the city developed more
15
16
17 successfully than in other locations. In 1845, the public Scuole di Meccanica e Chimica
18
19
20 Applicate alle Arti (School of Applied Mechanics and Chemistry) was established, followed
21
22
23 quickly by three technical schools financed partially by the municipality (De Fort, 2000).⁸ The
24
25
26 Scuole Tecniche Operaie di S. Carlo (Technical School for Factory Workers) established in
27
28
29 1848 and still active today, was the first true industrial/technical school active in Turin.
30
31
32 Founded by a mutual aid society to offer free education to its members (mostly Turin handicraft
33
34
35 workers who were obliged to pay a membership fee although some 15%-30% of students
36
37
38 received a fee waiver), the school was supported by private donations, workers societies and a
39
40
41 few industrial companies, and received some financial help from the municipality and the
42
43
44 government. It developed to become the reference institution for basic industrial education for
45
46
47 between 200 and 300 students per year up to 1880, 400-500 in the following ten years reaching
48
49
50 some 900 students in 1890-1891 and around 1,400 in 1916-17, two years after the introduction
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59 ⁸ In the academic year 1864-65 some 500 students were enrolled in primary technical schools and another 500 in
60 the technical high school (Baricco, 1865, cited in De Fort, 2000).

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3
4 of a special course for designers, motor experts and automobile drivers (Robotti, 1998). The
5
6
7 most notable private schools include le Scuole Officine Serali (Technical Night School) (1887)
8
9
10 which was founded and financed by private citizens to offer after work training to workers and
11
12
13 training for unemployed people, and the Scuole Archimede (1878) founded and financed by
14
15
16 the workers' mutual aid society Archimede for after hours work and holiday training of its
17
18
19 members. Scuole Archimede later opened its training to the wider public. In 1900, the
20
21
22 municipality created the Istituto Professionale Operaio – the Workers Professional Institute⁹
23
24
25 which merged the technical schools (including the School of Drawing and Geometry, the first
26
27
28 technical school in the city founded in 1805). In 1906, more than 300 students were enrolled
29
30
31 at the Scuola per Meccanici e Conduuttori di Automobili (School for Mechanics and Car
32
33
34 Drivers) created by Ing. Marengo in 1905. This was the only such school in Italy, and was of
35
36
37 sufficiently high quality to attract foreign students. In 1903, the Scuola Popolare di
38
39
40 Elettrotecnica (People's School for Electrical Work) was founded. Both of these schools were
41
42
43 funded by private institutions, citizens and the municipality (Senator S. Frola, mayor of Turin
44
45
46 between 1903 and 1907, was honorary president of both schools), akin to what today we would
47
48
49 describe as a public private partnership. The later development of the Turin cluster included an
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⁹ https://it.wikipedia.org/wiki/Istituto_tecnico_industriale_statale_Amedeo_Avogadro

1
2
3 important role played by company training schools including among others Scuola Allievi
4
5
6
7 FIAT (FIAT Training School) which opened in 1922, and Scuola Aziendale Lancia (Lancia
8
9
10 Corporate School) which opened in 1924.

11
12
13
14 Finally, the Technical School for Engineers which was created in 1859 provided tertiary level
15
16
17 technical education; in 1862 it merged with the Royal Italian Industrial Museum, a
18
19
20 museum/high level technical school¹⁰ which in 1906 became the Politecnico of Turin.

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23
24 Thus, historical heritage, political will and economic development at the city level affected
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27 local investment in education,

28 29 30 31 32 **4. The Italian automobile industry: Descriptive analysis**

33 34 35 36 **4.1 The AUTOITA Dataset**

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40 While there are sound historical and qualitative accounts of the development of the Italian
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42
43 automobile industry, especially for the case of Turin, there have been no previous systematic
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45
46 attempts to build a database of car producers in Italy. Only three academic articles (Hannan et
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48
49 al., 1995; Antonelli, 2001; Kim et al., 2003) use quantitative data on Italy's automobile industry
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57
58 ¹⁰ The Royal Italian Industrial Museum (based on the South Kensington Museum –now Victoria and Albert Museum- the
59 first industry museum which was founded in 1852) was established to house a collection of machines, industry models and
60 technological artifacts to support and diffuse technical-scientific education. The initial collection was based on donated
technological artifacts, and some acquired by the Savoy King, from the Great London Exposition of 1862 (Giacomelli, 2010).

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2
3 but they do not include all producers and are based on secondary sources of information. These
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7 three studies offer only brief data descriptions and which car producer types are included is
8
9
10 unclear.

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14 Our inclusive and robust database of automobile producers in Italy is based on information
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16
17 from:

- 21 • four international car encyclopedias (Doyle, 1959; Georgano, 1982, 2000; Baldwin et al.,
22
23 1982);
- 24
25
26
27
28 • three Italian car encyclopedias (Biscaretti, 1959; Museo dell'automobile, 1977; Bruni et
29
30 al., 2014);
- 31
32
33
34
35 • detailed archival search at the Museo dell'Automobile of Turin and original archival work.

36
37
38
39 The original archival search included the annual Active Company Directory for Turin (Guida
40
41 Paravia) and Milan (Guida Savallo)¹¹ for the years 1884 to 1945, and issues related to the three
42
43 most important specialist magazines (*L'Automobile d'Italia*; *L'Automobile*; *Motori Cicli e*
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48
49 *Sport*) during the period 1900-1918.

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

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4 The resulting AUTOITA database includes 396 companies. It includes all firms that produced
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6
7 at least one car (4-wheeler, 3-wheeler, electric and internal combustion engines); producers of
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9
10 prototypes that were never commercialized (due to lack of financial support, or for technical
11
12
13 reasons) but for which production plans were produced and attempts were made to sell the
14
15
16 production (investment in advertising the products). We excluded sole producers of racing cars,
17
18
19 trucks, buses and other commercial vehicles. For 38 companies listed only in Biscaretti (1959)
20
21
22 we were unable to find much information; for another 22 companies we have information only
23
24
25 included in Georgano (1982) and Doyle (1959) which is incomplete and not completely
26
27
28 reliable. Our final sample is composed of 336 companies for which we have a rich set of
29
30
31 information on year of entry/exit, location, type of automobile produced (electric, cyclecar,
32
33
34 four-wheeler), all licenses involved, eventual object of merger and acquisition, entrepreneurs
35
36
37 involved in creating the company and their background (incomplete information), and links to
38
39
40 aeronautics production. Following Boschma and Wenting (2007), we classify companies
41
42
43 according to entrepreneur's pre-entry techno-economic experience/inexperience and spinoff
44
45
46 experience as: 1) spinoff with at least one founder with previous experience in the automobile
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48
49 industry; 2) experienced entrepreneur with a history of working in a closely or partly-related
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52 industry; 3) inexperienced firm, not fulfilling either of the above criteria categories. Given the
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4 historical development of Italy's automobile industry and its first phase when production of
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7 racing cars was particularly important, we created a spinoff subcategory for companies founded
8
9
10 by pilots previously employed in another company (the most notable example is the case of
11
12
13 Lancia Automobiles, one of Italy's oldest carmakers which was founded in Turin in 1906 by
14
15
16
17 Vincenzo Lancia, a former pilot employed by FIAT).

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19
20
21 [TABLE 1 ABOUT HERE]
22

23 Table 1 presents summary information comparing our sample to the United Kingdom case
24
25 (Boschma and Wenting, 2007). Since our information on the United Kingdom sample is
26
27 incomplete this comparison is partial. Boschma and Wenting (2007) focus on automobile
28
29 manufacturers defined as "producers being principally devoted to four-wheeled petrol-engined
30
31 passengers cars", i.e. the car dominant design which emerged following a few years of industry
32
33 development (e.g. in 1946 in Italy there was still one active producer of electric cars although
34
35 the majority had exited the market by 1910). Boschma and Wenting deliberately exclude
36
37 producers of racing cars, commercial vehicles, one-off specials, kit cars, three-wheelers, steam
38
39 cars, electric cars and prototypes. We define this as the Dominant Design (DD) sample. In the
40
41 Italian case, we have a Basic Information (BI) sample which includes prototypes, electric cars
42
43 and three-wheeler car companies which tended to have shorter life spans. We were able to
44
45 identify information on firm pre-entry background for 292 of the 336 firms in the BI sample,
46
47 39 (14%) of which are spinoffs. In the DD sample the United Kingdom accounts for over twice
48
49 as many companies as Italy, 628 vs. 240. Pre-entry information is available for respectively
50
51 380 and 200 of these companies, with the United Kingdom sample having many more
52
53 companies with missing pre-entry background information. Of the companies with complete
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3 pre-entry information, 64 (17%) are United Kingdom spinoffs and 37 (19%) are Italian
4 spinoffs.
5
6

7
8 From the outset, the Italian automobile industry was geographically concentrated. In the
9 industry's first six years (1894-1899), 18 DD companies entered, 8 (44%) in Milan, 5 (28%)
10 in Turin and the remainder spread across the country.¹² Turin did not become the capital of the
11 automobile industry until the turn of the century: in the period 1900-1905, 60 companies were
12 founded in Italy, 34 (57%) in Turin and 10 (17%) in Milan. Overall, among the 240 companies
13 included in the DD sample, 113 were located in Turin (47%) and 64 in Milan (27%). Figure 1
14 depicts the geographic concentration of the Italian DD sample across the three historical
15 periods identified. In the case of the BI sample, concentration is less dense than in the DD
16 sample although some two-thirds of the companies were established in the two most
17 industrialized cities in Northern Italy.
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31
32 [FIGURE 1 ABOUT HERE]
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34

35 In the first 10 to 20 years of the industry in particular, a large number of companies were
36 founded and/or closed down and reopened under slightly different names, usually by new
37 entrepreneurs who brought in new capital, or occasionally by original founders exiting to create
38 new firms focused on slightly different production. In most cases, the production plant and its
39 machinery became the production facility of the new company. To emphasize the technological
40 core of the companies, we constructed a Reduced Sample (RS) which shows the original
41 company name and the subsequent transformations and assigns to each firm the original first
42 entry year and the exit year of its final incarnation. For example, Alfa was created in 1910 and
43 closed down in 1915, and in that same year the engineer Nicola Romeo bought the Alfa
44 production plants and set up Nicola Romeo. The war years saw the company expand and
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¹² We consider city and province; however, there is a very small number of cases of companies not located in a city

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2
3 diversify to refocus in 1918 on automobile production and the creation of Alfa Romeo which
4
5 through various events survived as an independent brand until its acquisition by FIAT in 1986.
6
7 The reduced sample is used to check the robustness of the econometric estimations.
8
9

10 11 *4.2 Entry, exit and survival* 12

13
14 Figure 2 presents yearly automobile manufacturer densities, entries and exits for the DD sample
15 which is the main sample used for our analysis. The patterns are similar for the BI and RS
16 samples. The entry and exit dynamics of the 240 DD firms are characterized by three peaks for
17 number of firms active in the market – in 1906, 1913 and 1924 and respectively 67, 37 and 39
18 firms. The major decrease in the number of active firms after the 1906 peak is associated to the
19 1907 economic crisis and increasing numbers of failures and exits and reduced numbers of
20 entries. After a short period of high entry and low exit rates during WWI, densities decreased
21 significantly before a postwar recovery and another peak in 1924. In the succeeding 15 years,
22 the industry consolidated (by the 1930s FIAT accounted for almost 75% of national
23 production) with numerous mergers and acquisitions, failures and higher mortality than new
24 birth rates. We can identify three main periods for our analysis: 1894-1906, 1907-1924 and
25 1925-2015, with respective numbers of firms (following the DD definition) entering the
26 industry in each period of 103, 90 and 47. In 2015, only five companies remained active in the
27 market, FIAT, DR and three super-car producers: Covini Engineering, Lamborghini and
28 Pagani.
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49 [FIGURE 2 ABOUT HERE]
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51 Klepper (2007, 2010) highlights the importance for firm survival of early entry in the industry.
52 He argues that early entrants can make extra profits which allow higher levels of investment in
53 innovation and technology, and therefore higher growth and greater economies of scale. The
54 Kaplan-Meier survival curves of the natural log of the percentage of entrants in each cohort
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1
2
3 that survive show a different pattern which contrasts with most previous work (see figure 3a).

4
5 In the first few years, the curves overlap but after 1925 the more recent entrants become
6
7 dominant and few firms from the early cohorts survive (Alfa Romeo, FIAT, Lancia).

8
9
10 Klepper (2007) and Boschma and Wenting (2007) show also that the survival rates of
11
12 automobile companies vary with the founder's pre-entry experience, and that spinoffs with
13
14 more experienced founders show higher rates of survival. Also for the Italian case (see figure
15
16 3b), we found that spinoffs tend to have better survival rates than either firms with
17
18 inexperienced or experienced founders. The company that has dominated the market and
19
20 survived to the present is the inexperienced company FIAT.
21
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24
25 [FIGURE 3 ABOUT HERE]
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27

28 4.3 Education: Regional and Province analysis 29

30
31 We argue that education is central to the geographic localization of entrant firms and their
32
33 survival rates. In this section, we analyze education attainment at the regional and provincial
34
35 levels. We use information from Italian censuses (1871-2007) to build the variables *Reg-*
36
37 *Education* and *Prov-Education*. The former measures the average number of years of education
38
39 per inhabitant at the regional level. In the census years, provincial level education is not
40
41 available (province is a geographical agglomeration similar to the metropolitan area); at the
42
43 metropolitan level we could only gather data on the literacy by share of inhabitants (*Prov-*
44
45 *Education*). Figure 4 focuses on the Piedmont and Lombardy regions, and the cities of Turin
46
47 and Milan (which are relevant to the development of the Italian automobile industry) and
48
49 compares them with other large and important cities such as Rome, Florence, Naples and
50
51 Palermo. In the first 30 years of the industry, education attainment was higher in Piedmont and
52
53 Lombardy compared to the rest of Italy (about 1 to 1.5 years more education; 25%-60% more
54
55 in relative terms). For the first two cohorts, education levels were higher in Piedmont than in
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1
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3 Lombardy. After the 1920s, Lombardy overtakes Piedmont but at the metropolitan area level
4
5 up to the end of WWII Turin dominates Milan and all the other Italian cities for literacy. This
6
7 dynamic demonstrates the potentially important role of education in the development of the
8
9 automobile industry and in Italian industrialization more generally. The first census which was
10
11 held in 1871 predates the second Italian industrialization and provides some support for a
12
13 causal effect of education on industrial development.
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15

16
17 [FIGURE 4 ABOUT HERE]
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19

20 21 **5. Model Estimation and Discussion** 22

23
24 Following Boschma and Wenting (2007) and Klepper (2007), we employ a survival model to
25
26 study industry exit. We use length of survival in the market to proxy for firm performance. We
27
28 also employ a proportional hazard model (Cox Regression) to investigate survival time
29
30 statistically (Audretsch and Mahmood, 1994; Lee, 1992). These types of methods are applied
31
32 to survival models which study the time before the occurrence of some event (i.e. death of an
33
34 automotive firm), according to problem specific covariates (i.e. classification, cohorts,
35
36 aeronautics, pilots, etc.). Cox regressions simultaneously control for covariate effects on
37
38 survival time and assume that at a given time the dependent variable is a hazard function. The
39
40 Cox regression estimates the relative risk based on a hazard function $h(t)$ in eq. (1).¹³ We apply
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¹³ A high hazard function indicates a high rate of mortality.

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4 the following estimation model to describe the determinants of a market exit, given a set of
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6
7 selected predictor variables \mathbf{X} :

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

14 where $\boldsymbol{\beta}$ is the $1 \times r$ vector of the model coefficients, \mathbf{X} is the $n \times r$ design matrix with r
15
16
17 independent variables, and $h_0(t)$ is the baseline hazard function, i.e. the expected risk without
18
19
20 control variables. Therefore, in a multiple Cox regression, e^{β_i} estimates the percentage change
21
22
23 in the survival risk given a unit change in the i^{th} covariate, with $i = 1, \dots, r$.

24
25
26
27
28 A positive estimate of the i^{th} explanatory variable, equivalent to $\beta_i > 0$ or $e^{\beta_i} > 1$, means that
29
30
31 the exit probability (the hazard) in the next period is higher for higher values of X_i . In our
32
33
34 analysis the event variable of the Cox regression indicates firm exit (i.e. it is set equal to 1). If
35
36
37 the firm survives at the end of the observation period (i.e. 2015), the event variable assumes a
38
39
40 value equal to 0, as in the case of FIAT.

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45 We also employ (from model 3) a robust estimates approach based on clustered errors (see
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47
48 among others, Arellano 1987). We assume that a cluster term in a Cox regression identifies
49
50
51 clusters of correlated observations. In other words, with clustered errors, observations within
52
53
54 the same group are assumed to be somehow correlated inducing correlation in the error term
55
56
57 within the cluster but no error correlation among different groups. We cluster companies
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3 established in the metropolitan city of Turin and in the other provinces. Considering firm
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6
7 province as the cluster variable allows us to identify more than 10 clusters which is a suitable
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9
10 number of clusters of balanced size (see e.g. Wooldridge, 2003). This approach of introducing
11
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13 cluster-robust standard error estimations, in our case ensures better representation of the
14
15
16 unobserved common features of firms belonging to the same cluster, and latent characteristics
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18
19 related to metropolitan city policies (e.g. development of technical education). Compared to a
20
21
22 simple fixed effects control with dummies, this approach enables us to account for province
23
24
25 heterogeneity and provides more robust estimates (Cameron and Douglas, 2015).
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31 *5.1 Variables*

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34 Based on the discussion in Section 3, we expect company survival to depend on localization
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36
37 economies, related industries and technological complementarities, pre-entry founder
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39
40 background (and mother company in the case of spinoffs) and local education at the regional
41
42
43 and provincial levels. We control also for a cohort effect. The following variables are used in
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46
47
48 the model.
49
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51 Localization economies

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54
55 We constructed a series of variables to capture agglomeration economies at the regional level.

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57
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59 At entry, each entrant is assigned to one of the 20 Italian regions.
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4 – regional population (*Reg-Pop*): we collected population numbers for each region from
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6 1861 to 2011. For years with missing national census information we reconstructed the
7
8 measure using average population growth over the period;
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12
13 – regional GDP: regional contribution to national gross domestic product (GDP) (*Reg-*
14
15 *GDP*);
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20 – number of automobile firms in the region (*Reg-Comp*): for each year of entry we
21
22 computed the number of active firms in the region as a measure of local competition.
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Related industries and technological complementarities

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31 We use two proxies to capture agglomeration effects due to the colocation of related industries
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33 and technological complementarities.
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- 37
38 – number of employees in related industries (*Empl-Related Ind*): for each year of entry
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40 in the automobile sector and for each region we calculated the number of people
41
42 working in the aggregate mechanics industry which is considered to be related to the
43
44 automotive sector. The variable also captures supply side agglomeration economies;
45
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47
48 – to measure (intra-firm) technological complementarities, we constructed the variable
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52 *Aeronautic* which identifies companies active in both the automobile and aeronautics
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3 industries in each year – 14 in total.¹⁴ A few automobile producers were involved only
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6 in airplane engine production; some focused only on plane components. We use three
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8
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10 dummies - for automobile firms involved in construction only of plane components
11
12
13 (*Components*), only of plane motors (*Motor*), and of the entire plane (*Aero*). Given the
14
15
16 increasing complexity of the technological knowledge required to be active in all three
17
18
19 segments, we expect a higher impact on the survival of automobile firms of companies
20
21
22 active in the most complex aeronautics product i.e. the full plane. We were able to
23
24
25 identify year of aeronautics industry entry and exit. However, the more recent
26
27
28 development of the aeronautics sector means that only two firms began as aeronautics
29
30
31 companies and differentiated into automobile production. Therefore, we cannot use
32
33
34 company age to build a more complex time dependent interaction between aeronautics
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37 and automobiles.
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Founder's pre-entry background

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48 For 200 companies in the DD sample we can identify founder's pre-entry background which
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51 allowed us to construct the following firm variables:
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60 ¹⁴ In the BI sample 18 firms are active also in aeronautic firms.

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

- *Year of mother prod* identifies for each spinoff, the age of the mother company at the time (year) the spinoff was established.

Local Education

To capture the effect of local education on firm survival we use the variables *Reg-Education* and *Prov-Education*. Each entrant is assigned to one of the 20 Italian regions and one of the 80 provinces (metropolitan areas). Since it was impossible to construct a reliable time series for the number of students in technical education at the provincial level (Accornero, 2019), we introduced the dummy variable *Turin* for companies established in the metropolitan area (province) of Turin;¹⁵ this controls for a specific metropolitan area effect if *Reg-Education* is included in the model. Inclusion of *Prov-Education* to control for basic education input at the provincial level, excludes the possibility of including the dummy variable *Turin* for reasons of collinearity, thus we use clustered standard errors to capture provincial level characteristics not already controlled for, i.e. technical education and other local institutions that might have supported the development of a local cluster and which are additional to local basic education.

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

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4 Finally, we include *Cohort1* (1894-1906) and *Cohort2* (1907-1924) to control for year of entry.
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10 11 *5.2 Results and Discussion* 12 13 14

15 We start our analysis by replicating as closely as possible Boschma and Wenting's (2007) and
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18 Klepper's (2007) models¹⁶ for the Italian automobile sector population, and then present and
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20
21 discuss our model. Klepper's model when applied to the Italian data performs poorly; it
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23
24 confirms a higher survival probability for experienced companies but provides weak
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27 confirmation for the effect of spinoffs. The effect of the interaction between Turin cluster and
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30 spinoffs is not confirmed. We obtained more consistent results from the Boschma and Wenting
31
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33 model although the variables show lower levels of significance. Both experienced and spinoffs
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36 firms have a higher probability of surviving, and we found a negative effect of local
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39 competition.
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46 Table 2 presents the estimated coefficients of the Cox regressions. In model 1, in addition to
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48
49 the variables capturing agglomeration economies, entry cohort, and type of firm which
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51
52 Boschma and Wenting (2007) include, we test the effect of local institutions and local
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54
55 education level on the exit probability. The local level of competition (*Reg-Comp*) is correlated
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60 ¹⁶ See appendix A for details of the estimations.

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4 positively to an increased exit probability while being an experienced or spinoff firm is
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6
7 associated to a higher survival probability. Demand side Marshallian agglomeration economies
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10 captured by regional GDP (*Reg-GDP*) are positively correlated to survival. Cohort effects are
11
12
13 not significant. Both the *Turin* dummy and the regional education level (*Reg-Education*) are
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16 less than 1 and are significant after controlling for all the other variables. These results support
17
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19 the view that higher regional educational levels are associated to higher firm survival rates, and
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21
22 that firms belonging to the Turin cluster benefit from local institutional effects not accounted
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24
25 for in previous studies.
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31 Model 2 includes provincial (*Prov-Education*) rather than regional level of education; its effect
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34 on the exit probability is not statistically significant. The dummy *Turin* is no longer significant
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36
37 most likely because Turin is the metropolitan city and had the highest levels of education in
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40 Italy before WWII (see figure 4).
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45 To avoid heteroskedasticity issues, model 3 employs a robust variance estimation based on
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48 firm province (i.e. robust clustered standard errors) and excludes the dummy for Turin. These
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50
51 robust standard error estimations provide more accurate coefficient estimates. We believe that
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54 the errors are correlated to province socioeconomic background rather than being completely
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57 uncorrelated. Thus, we introduce robust clustered standard errors to capture unobserved
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4 province policies/socioeconomic factors which might influence firm survival rates rather than
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7 using a fixed effects approach (see e.g. Cameron and Douglas, 2015). As in the previous model,
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10 a high level of regional competition is associated to earlier firm exit from the automotive sector
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12
13 while number of employees in related industries at the regional level (*Empl-Related Ind*) has a
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16 significant negative effect on the exit probability. Province education level has a negative and
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19 strongly significant effect on the exit hazard rate, confirming the positive role of metropolitan
20
21
22 basic education on the survival of firms founded in the city.¹⁷ Spinoff companies have a higher
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25 survival probability, while age of mother firm which proxies for accumulated competence
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27
28 (*Year of mother prod*) has a negative but not significant effect on the spinoff's exit probability.
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34 To better capture the importance of related variety and technological complementarities, in
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37 model 4 we introduce the covariate *Aeronautic* to capture the effect of intra-company related
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40 externalities. The dummy effect is negative (i.e. inducing a lower exit probability than in the
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42
43 case of non-aeronautics firms) and is highly statistically significant. This supports the idea that
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46 companies that were active in both industries survived for longer other things being equal.
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51 Model 4 also includes a set of variables for firm founders. It shows that firms founded by
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58 ¹⁷ We also ran model 3 including both provincial and regional level education; both variables turn out to be
59 significant with province level education having a strong negative effect on exit. Due to collinearity problems
60 between *Empl-Related Ind* and *Reg-Education* we prefer to present only the results with province level education;
the other regression results are available from the corresponding author.

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4 founders with previous experience have a higher probability of survival compared to
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7 companies whose founders have no relevant previous experience; also, for firms with specific
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10 (most often short) previous experience in the car industry (e.g. firms whose shareholder
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13 composition and name changed but which were not new firms or spinoffs) the effect is not
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15
16 statistically significant indicating a very turbulent high entry and exit period which did not
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18
19 allow for the accumulation of special competences by those companies. The effect of spinoff
20
21
22 companies founded by pilots (*Pilots*) indicates that companies (co)founded by pilots have
23
24
25 higher chances of survival likely associated to the technological knowledge embedded in the
26
27
28 pilots. In contrast, companies founded by other types of entrepreneurs (*Spinoff no pilot*) have
29
30
31 only a slightly higher (not significant in this specification and weakly significant in other
32
33
34 specifications not presented here) survival rate which suggests that the technological
35
36
37 competences of the spinoff company rather than management competences mattered for the
38
39
40 survival. In this specification *Year of mother prod* becomes weakly significant supporting
41
42
43 Klepper's idea of inherited competences. Finally, in contrast to previous findings, companies
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45
46 that entered the industry in the earlier period do not tend to survive for longer than followers.
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50 Only one company that entered in the first period (FIAT) was able to benefit from the
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53 economies of scale effect discussed by Klepper; the absence of scale economies for all the
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3 other firms in the first cohort results in a not statistically significant estimate. The Italian
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6 automobile market was significantly smaller than those in the United Kingdom and the United
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10 States, and much of the Italian growth potential was achieved in the first years via exports.
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13 When at the end of the 1920s the export possibility disappeared, the domestic market was not
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16 sufficiently sizeable to sustain the growth of more companies due to cost decreases associated
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19
20 to loss of scale economies.
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23
24 In the final model 5, our preferred specification, instead of *Reg-GDP* we include the log of
25
26
27 regional population (*Reg-Pop*) to proxy for demand side agglomeration economies; the effect
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29
30 is negative and statistically significant, confirming the importance of agglomeration economies
31
32
33 for firm survival. All the results are robust to the inclusion of regional population.
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38 [TABLE 2 ABOUT HERE]
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41 Our analysis provides partial support for the robust evidence in the literature for agglomeration
42
43 economies and the role of spinoff dynamics. We also found some evidence of a small positive
44
45 effect of spinoff survival on mother company's experience in the Italian market: this provides
46
47 some support for the idea that success breeds success.
48

49
50 Our findings provide novel evidence:
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- 52
53 • the local environment and metropolitan “atmosphere”, captured by the *Turin* dummy
54
55 (and the cluster error model at the provincial level) and especially province level
56
57 education (*Prov-Education*) have positive effects on firm survival rates, highlighting
58
59 the effect of metropolitan institutions (some of which are linked to specific policies
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3 implemented by the local government as in the case of the Turin cluster) which previous
4
5 studies do not account for;

- 6
7
8 • we measure inter-industry externalities and related variety in terms of employment in
9
10 related industries and at the micro level, using data on companies active in both the car
11
12 and aeronautics industries and show that both are correlated with lower exit probability;
- 13
14 • we distinguish between spinoff companies founded by pilots and others, and show that
15
16 companies (co)founded by pilots have a lower exit probability than other spinoffs. We
17
18 argue that pilots acquired important technical skills through learning by using, which
19
20 were decisive for designing “better” cars and supporting firm performance;
- 21
22 • in contrast to existing findings we found no early entry advantage. This might be
23
24 because the Italian market was too small to allow exploitation of scale economies by
25
26 more than one company (i.e. FIAT).
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34 5.3 Robustness check

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37 In the first and most turbulent period of the industry, a significant number of companies
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39 changed their names sometimes including a new partner that brought additional capital. In
40
41 general, production plans remained mostly unchanged – with the exception perhaps of some
42
43 expansion or refocusing of production. To check the robustness of our results, we collected all
44
45 those companies that experienced a name change: e.g. Carrera Luigi & C founded in 1896,
46
47 closed down in 1906 then reopened as Officine e Fonderie Torinesi after merging with the steel
48
49 maker Schlepfer & Co. before finally exiting the automobile market in 1910. This reduced the
50
51 number of observations to 162; most of the 38 companies that merged were founded in the first
52
53 two periods. Table 3 presents the main results for this reduced sample. The models in table 3
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55 are based on clustered standard error estimations and the results are consistent with the previous
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57 estimations. With the exception of *Reg-Pop* and *Empl-Related Ind* which are no longer
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3 statistically significant due most likely to the reduced number of observations in the regression,
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5 the coefficients are similar to the previous estimations confirming the role of regional
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7 competition, province level education, previous experience in related industries and pilots as
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9 special breeders for company survival.
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12 [TABLE 3 ABOUT HERE]
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15 Table 3 presents a finer-grained aeronautics specification which considers whether the
16
17 company was producing the whole plane (*Aero*), only the motor (*Motor*), or only components
18
19 (*Components*). The three dummy variables are associated to a lower exit probability, and as
20
21 expected the higher survival probability is associated to the production of complete planes by
22
23 those firms that were able to master the new technological knowledge.
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30 **6. Conclusions**

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32 The paper aimed to provide a systemic understanding of cluster formation and development by
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34 combining a more traditional approach to industry clustering which identifies agglomeration
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36 economies and technical externalities as the main drivers of local industrial development, with
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38 Klepper's understanding of the role of spinoffs.
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42 The paper sheds new light on industry clustering and development by explaining the early
43
44 genesis and later evolution of the Italian automotive industry based on the formation of a car
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46 cluster in Turin between the late 19th century and the end of WWII.
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50 We rely on an original dataset which represents the first systematic long-term repository of
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52 knowledge about the industry in Italy, and tested the following hypotheses about agglomeration
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54 economies and spinoffs as drivers of industry clustering.
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58 First and more generally, the literature (Klepper, 2007, 2010; Boschma and Wenting, 2007)
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60 highlights the importance of early entry to the industry for firm survival. However, our results

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3 do not support the hypothesis of early entry advantages in survival dynamics most likely
4 because the market was too small to support the growth of more than one large company able
5 to benefit from scale economies. This suggests that early entry advantages are not a property
6 of spinoffs *per se* but that spinoffs may benefit from threshold effects. Market scale effects
7 should be integrated in future research on spinoffs and industry developments.
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12 Furthermore, we investigated the following three, specific factors that were key to the creation
13 and success of the automotive industry in Turin: institutions and education; technological
14 complementarities and the role of related industries such as aeronautics; and inherited technical
15 skills in spinoffs founded by pilots.
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18
19 First, we accounted for the role of institutional effects, and in particular the role of education.
20 We argue that education can be considered an initial precondition for further learning and
21 technical and scientific advancements. In the early phase of the industry before the emergence
22 of a dominant design, learning rather than scale economies was important. Further, given the
23 limited size of the internal market and the effects of WWI on trade, with the exception of FIAT
24 early entrants were unable to grow or to benefit from intra-firm scale economies, making local
25 basic and technical education extremely important for firm survival. The positive effect of
26 education as an institutional factor is consistent also with the emphasis in recent contributions
27 (Antonietti and Boschma, 2020; Sine and Lee, 2009; Sorenson and Audia, 2000) on the role of
28 social capital and social resources to support the formation and growth of industries. The
29 availability of education institutions enabled the construction of social capital and values in
30 addition to technical skills which offer entrepreneurs a context conducive to starting a new
31 venture in a new developing sector.
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55 Second, we stressed the positive effect of related industries and especially the technological
56 complementarities between automotive and aeronautics, and argued that they rely on related
57 technical and scientific knowledge. Some carmakers also entered the emerging aeronautics
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3 industry and may have benefited from both cross-fertilization in terms of ideas, design and
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5 technical skill, and from the larger scale deriving from involvement in different industries and
6
7 markets.
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11 Third, we distinguished the role of different types of spinoffs, looking in particular at the effect
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13 on cluster resilience of firms founded by entrepreneurs with particular technological
14
15 competences acquired from working as pilots in other carmakers. Klepper's spinoff theory
16
17 positions managerial competence at the core of the analysis: "Disagreements arise because
18
19 incumbent *management* has a limited ability to recognize employees with superior ideas and/or
20
21 abilities. When the disagreements are severe enough, employees leave to found spinoffs"
22
23 (Klepper, 2007, p. 616, emphasis added). He argues also that "spinoffs are expected to be better
24
25 able than inexperienced firms to *manage* the process of technological change by dint of their
26
27 prior experience" (Klepper, 2007, p. 624, emphasis added).
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32 We challenged and integrated this view, testing the role of inherited technical rather than
33
34 managerial skills. The technical and tacit skills acquired by pilots have been considered key
35
36 sources of technological diffusion (Eichenberger and Stadelmann, 2009; Jenkins and Tallman,
37
38 2015. This is in line with Buenstorf and Costa (2018) who propose that it is intra-industry flows
39
40 of technical rather than managerial knowledge that supports spinoff dynamics and entrant
41
42 longevity. We provide evidence that carmakers founded by entrepreneurs with previous
43
44 experience as pilots were more likely to survive compared to all other firms including other
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46 spinoffs.
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51 We thus consider pilots to be selected "breeders" (Buenstorf and Klepper, 2009, 2010) or
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53 transmitters of assets (technical skills acquired through learning by using) between the mother
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55 company and the spinoff. We argue that in the earliest stages of development of the car industry
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57 pilots as opposed to other technical specialists, were the repositories of special technical
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3 knowledge. This distinguishes our findings from Klepper's model which focuses only on
4 managerial mismatches as the motivation for spinning off.
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8 These three factors are generally overlooked in analyses of clusters and industry developments.
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10 Our results suggest that they should be included and systematically addressed in future work
11 on these topics.
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16 Based on our analysis of the role of institutions in industry formation it is clear that more
17 research is needed along two complementary lines.
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23 First, we need a better understanding and explanation of the role of technical/professional
24 schools in Piedmont and other Italian regions in order empirically to identify their impact on
25 the emergence of the Turin car cluster. Our current research involves systematic assessment of
26 the early development in the mid-1800s and early 1900s of technical/professional schools in
27 Italy. This should enable a qualitative account of their role in the formation of technical skills
28 in the emerging industry and allow consistent integration of our data. This would be
29 particularly interesting and would allow a better understanding of which type and level of
30 education contributes most to industrial development and would add to current debate on the
31 need for better and more diversified tertiary technical education to build the human capital
32 needed to diffuse digital production in the 4th industrial revolution.
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4 Second, we are interested in how the mobilization of political and public resources supported
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7 the emergence of the industry, and the type of social and political capital that enhanced the
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10 effect of technical skills on the formation of an entrepreneurial system (Rugafiori 1999) and
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13 the industry development. Different institutional factors complemented a technical education
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15
16 and may have played a role in the development of the Turin cluster. Castronovo (1995) suggests
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19 that: a) the local policies in Turin between the end of the 1800s and the first decade of the new
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21
22 century were aimed at attracting investment and encouraging industrial growth; b) the role of
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25 Turin's elite as a lobby and trait d'union between political and financial capital; c) the
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28 emergence between 1901 and 1906 of a growing interest among private investors in investing
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31 in the nascent automobile industry; d) the regional regulatory framework which in the first
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34 decade of the 20th century was intended to ensure special public subsidies to suppliers and
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37 producers of transport services.
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44 Future research could improve our understanding of the role of institutional factors in the
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47 dynamics of industry development and cluster formation.
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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 Gompertz's specification of the hazard function and the latter exploit Cox proportional hazard regression.

In Models 1 and 2 the negative and statistically significant effect on the exit probability of the *Experienced* firms is confirmed; only in models 1 and 3 do *Spinoff* firms have a negative and statistically significant effect, and this is confined to Turin firms. This contrasts with Klepper's findings. Among the coefficient estimates only *Cohort1*t* is negative and significant while *Cohort 1* and *Cohort 2* in the proportional terms are positive and significant for Italy, which contrasts to Klepper's (2007) results for the superior performance of firms in the Detroit area. Models 1 and 2 (table 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.

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4 Second, we compare the results in table A.2 with the evidences in Boschma and Wenting
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7 (2007). We find similar effects on the exit probability with respect to two variables groups:

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

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

52 Note that using Boschma and Wenting's (2007) model specification, we represent a maximum
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of 12% of the total variability of the exit probability of Italian automotive firms. This suggests

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the need for further analyses to explain this effect which is discussed only partially in Klepper
(2007).

[TABLES A1, A2 ABOUT HERE]

For Peer Review

TABLES

Table 1: UK and Italian automobile industry

	UK	ITALY	Italy (Reduced sample)
<i>All</i>		396	
<i>Missing info</i>		60 (15%)	
Basic Info (BI)		336	
Basic Info with pre-entry background (BI _{p-eb})		292	
BI _{p-eb} Spinoff		40 (14%)	
Dominant Design (DD)	628	240	
<i>No pre-entry background</i>	248 (39%)	40 (17%)	
Dominant Design with pre-entry background (DD _{p-eb})	380	200	162
DD _{p-eb} Spinoff	64 (17%)	37 (19%)	35 (22%)

Table 2: Marginal effects e^{β} under Cox regression models for the exit

(with robust clustered standard errors in parentheses)

<i>Dependent Variable</i>					
<i>Exit from the automobile market</i>					
<i>Variables</i>	<i>MODEL 1</i>	<i>MODEL 2</i>	<i>MODEL 3</i>	<i>MODEL 4</i>	<i>MODEL 5</i>
Agglomeration					
<i>Reg-Pop</i>					0.730* (0.187)
<i>Reg-GDP</i>	0.914** (0.037)	1.001 (0.029)	1.012 (0.018)	1.008 (0.021)	
<i>Reg-Comp</i>	1.017* (0.010)	1.023** (0.011)	1.019*** (0.004)	1.028*** (0.006)	1.027*** (0.006)
<i>Empl-Related Ind.</i>	1.055 (0.042)	0.968 (0.030)	0.978*** (0.012)	0.970* (0.016)	0.976* (0.012)
Inter-Ind. Extern.					
<i>Aeronautics</i>				0.176*** (0.422)	0.173*** (0.430)
Institutions					
<i>Reg-Education</i>	0.958*** (0.015)				
<i>Prov-Education</i>		0.347 (0.669)	0.306*** (0.581)	0.382** (0.490)	0.490* (0.426)
<i>Turin</i>	0.697* (0.207)	0.850 (0.208)			
Cohort					
<i>Cohort 1</i>	0.947 (0.305)	0.917 (0.343)	0.961 (0.285)	1.166 (0.358)	1.292 (0.307)
<i>Cohort 2</i>	1.088 (0.279)	1.291 (0.281)	1.340 (0.187)	1.732*** (0.203)	1.887*** (0.211)
Founder					
<i>Experienced</i>	0.694** (0.181)	0.740* (0.180)	0.727 (0.205)	0.710** (0.148)	0.697** (0.198)
<i>Experienced-within</i>				0.654 (0.305)	0.652 (0.301)
<i>Spinoff</i>	0.514** (0.320)	0.576* (0.319)	0.565*** (0.215)		
<i>Pilot</i>				0.615*** (0.119)	0.582*** (0.121)
<i>Spinoff no pilot</i>				0.971 (0.207)	0.961 (0.192)
<i>Year mother prod.</i>	1.002 (0.015)	0.996 (0.015)	0.996 (0.011)	0.982* (0.007)	0.983* (0.007)
R²	0.156	0.128	0.128	0.290	0.294
Observations	200	200	200	200	200
Two-tailed test, significance:				***< 0.01, **< 0.05, *< 0.1	

Table 3: Marginal effects e^{β} under Cox regression models for the exit –
 Reduced sample/Aeronautics (with robust clustered standard errors in parentheses)

<i>Dependent Variable</i>				
<i>Exit from the automobile market</i>				
<i>Variables</i>	<i>MODEL 6</i>	<i>MODEL 7</i>	<i>MODEL 8</i>	<i>MODEL 9</i>
Agglomeration				
<i>Reg-Pop</i>	0.758 (0.285)	0.755 (0.246)	0.763 (0.255)	0.769 (0.237)
<i>Reg-Comp</i>	1.033*** (0.006)	1.031*** (0.006)	1.033*** (0.006)	1.031*** (0.006)
<i>Empl-Related Ind.</i>	1.004 (0.019)	1.004 (0.019)	1.005 (0.019)	1.003 (0.019)
Inter-Ind. Extern.				
<i>Aeronautics</i>	0.130*** (0.436)			
<i>Aero</i>		0.091*** (0.691)		
<i>Aeron. no aero</i>		0.145*** (0.327)		
<i>Components</i>			0.646** (0.221)	
<i>Aeron. no components</i>			0.130*** (0.435)	
<i>Motor</i>				0.211*** (0.203)
<i>Aeron. no motors</i>				0.102*** (0.660)
Institutions				
<i>Prov-Education</i>	0.528* (0.329)	0.541* (0.341)	0.522* (0.339)	0.536* (0.318)
Cohort				
<i>Cohort 1</i>	1.974* (0.371)	1.992** (0.376)	1.986** (0.371)	1.907* (0.378)
<i>Cohort 2</i>	2.341*** (0.317)	2.375*** (0.316)	2.368*** (0.318)	2.281** (0.326)
Founder				
<i>Experienced</i>	0.640** (0.193)	0.634** (0.182)	0.645** (0.187)	0.675** (0.194)
<i>Experienced-within</i>	0.951 (0.564)	0.944 (0.550)	0.946 (0.571)	0.968 (0.546)
<i>Pilot</i>	0.525*** (0.199)	0.506*** (0.185)	0.526*** (0.198)	0.481*** (0.170)
<i>Spinoff no pilot</i>	0.782 (0.279)	0.762 (0.256)	0.782 (0.267)	0.739 (0.238)
<i>Year mother prod.</i>	0.987 (0.009)	0.988 (0.010)	0.988 (0.009)	0.991 (0.010)
R²	0.331	0.333	0.332	0.317
Observations	162	162	162	162

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

Table A:1: Klepper's models – a comparison with the Italian industry. Coefficient estimates β of the survival models with Gompertz's specification are reported (standard error in parenthesis).

<i>Dependent Variable</i>				
<i>Exit from the automobile market</i>				
<i>Variables</i>	<i>MODEL 1</i>	<i>MODEL 2</i>	<i>MODEL 3</i>	<i>MODEL 5</i>
<i>Constant</i>	-0.004 (0.013)	-0.004 (0.013)	-0.001 (0.013)	-0.0004 (0.013)
<i>t</i>	0.098*** (0.02615)	0.098*** (0.026)	0.103*** (0.027)	0.097*** (0.025)
<i>Turin</i>	0.119 (0.153)	0.122 (0.164)		
<i>Experienced</i>	-0.280** (0.071)	-0.281** (0.180)	-0.276 (0.177)	-0.207 (0.168)
<i>Spinoff</i>	-0.538** (0.238)	-0.524 (0.318)	-0.197* (0.439)	
<i>Cohort 1</i>	0.866*** (0.265)	0.867*** (0.265)	0.833*** (0.266)	0.827*** (0.265)
<i>Cohort 2</i>	0.876*** (0.266)	0.877*** (0.266)	0.875*** (0.266)	0.875*** (0.266)
<i>Cohort 1 * t</i>	-0.040** (0.017)	-0.040** (0.017)	-0.043*** (0.017)	-0.045** (0.017)
<i>Cohort 2 * t</i>	-0.013 (0.021)	-0.013 (0.018)	-0.017 (0.018)	-0.019 (0.018)
<i>Spinoff Torino</i>		-0.027 (0.33088)	-0.123 (0.416)	
<i>Year mother prod.</i>			-0.021 (0.017)	-0.027* (0.013)
Log Likelihood	-589.589	-589.587	-589.0697	-589.6315
AIC	1197.18	1199.175	1198.139	1195.236
Observations	200	200	200	200
Two-tailed test, significance:			***< 0.01, **< 0.05, *< 0.1	

Table A.2: Boschma and Wenting's models. A comparison using the Italian industry database. Coefficient estimates β of the Cox regression model are reported (standard errors in parenthesis).

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

Two-tailed test, significance:

***< 0.01, **< 0.05, *< 0.1

FIGURES

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

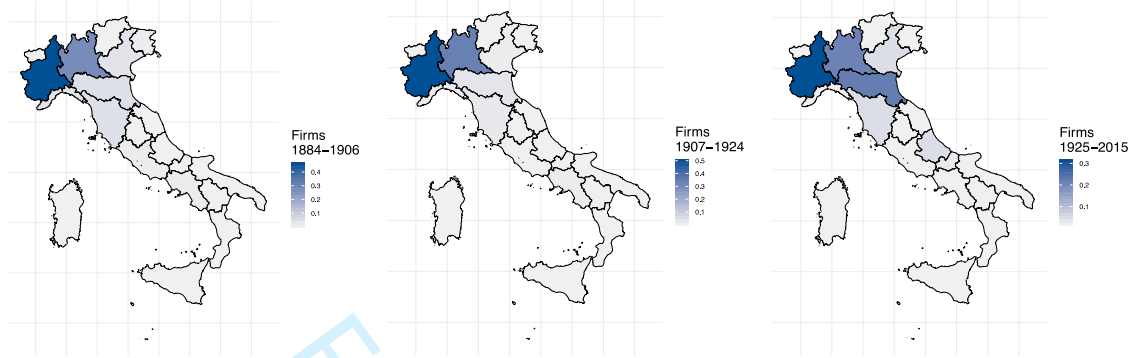


Figure 2: Entry, exit and number of active firms per year

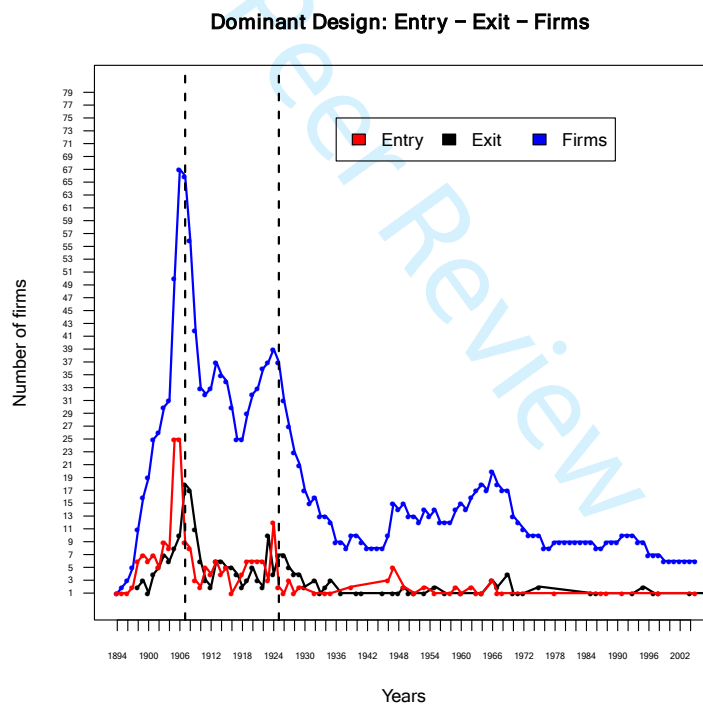


Figure 3: Kaplan-Meier survival curves (in log scale) by cohort (240 firms) and classification (200 firms). Differences in survival curves both cases are statistically significant (p-values 0.0018 and 0.028 respectively).

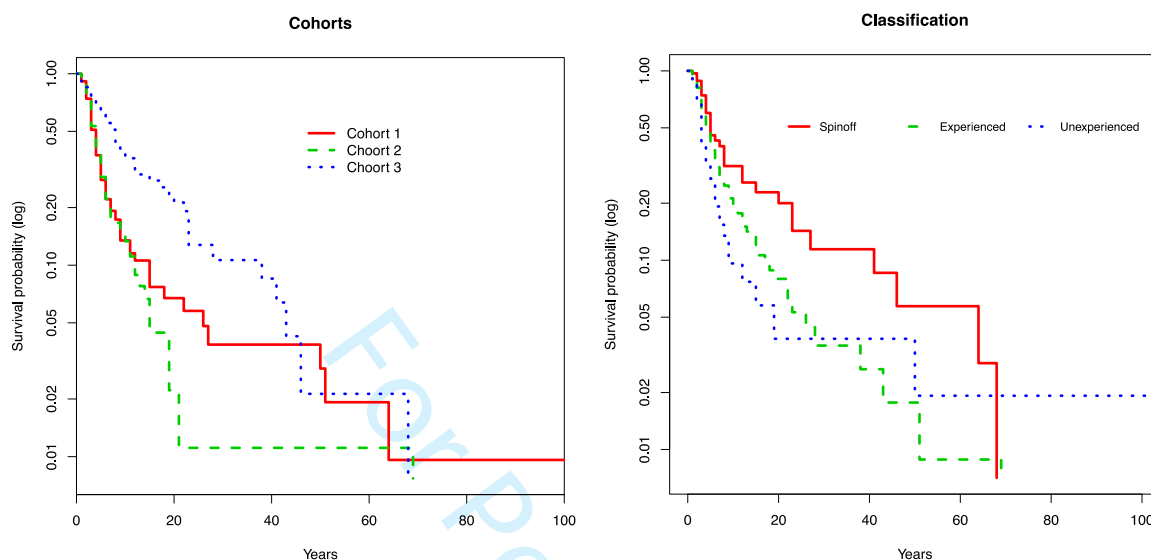


Figure 4: Education in Italy. Italy represents the average regional or province behavior given the population (selected provinces).

