Innovation and business performance in Italy, 1913-1936

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Abstract. This paper provides systematic quantitative evidence on the innovative activities of Italian firms in the early twentieth century, as well as on their relation to business performance. It retrieves information on patents, trademarks, and international exhibition participation for a large sample of Italian joint-stock manufacturing firms in 1913 and 1936, and relates these innovation measures to short-term profitability and long-term survival.

In either period, around 40% of firms took either patents or trademarks, though typically with low frequency and intensity. The share further rises to 50% if exhibiting is added (in 1913). Conditional on other firm-level covariates, own patents and trademarks were not significantly related to profitability; however, competing firms' activities were, pointing to the possession of effective absorptive capabilities. Furthermore, most crucially, patenting and trademarking firms were significantly likelier to survive in the long run. Results are specular for exhibiting.

Keywords: innovation, patents, trademarks, international exhibitions, profitability, firm survival, Italy's historical development

JEL classification codes: N64, N74, N84, O33

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1. Introduction

How relevant was innovation in Italy's historical economic growth? This question lies at the heart of the debate among different interpretations of the country's long-run economic performance. At first glance, the country's GDP per capita trajectory may look like a great success story. A poor and backward country in the aftermath of its unification (1861), Italy experienced considerable growth and structural change over the twentieth century, to the extent that, in the decades following the Second World War (WWII), it converged to the GDP level of the most advanced economies. Writing at the end of this long expansion phase, Zamagni (1993) described Italy's trajectory as a journey "from the periphery to the core".

By the end of the century, however, Italy had entered a new phase, characterised by prolonged stagnation, which has now lasted for a quarter century. The fact that the process of convergence started and ended within the twentieth century, suggested Toniolo (2013) a different interpretation of Italy's long-term economic history, as a story of "convergence with two tails". Di Martino and Vasta (2015) go further and claim that this should rather be seen as a story of persistently suboptimal growth with two peaks of successful growth, namely the Giolittian era in the early twentieth century (before the First World War, WWI) and the post-WWII economic miracle.[2] The latter view stresses that this long-run suboptimal performance stems from Italy's failure to develop sound and persistent own technological capabilities and therefore to join in a stable way the leading countries at the technological frontier. What is more, Italy's weak innovation system can be seen as lying at the roots of the country's current economic decline (Felice, Nuvolari, and Vasta 2019; Felice and Pagano 2019).

The literature largely agrees on the fact that Italy has been persistently characterised by a weak innovative performance throughout its history and that innovation did not play an important role in the country's economic achievements, with its competitiveness mainly relying on low relative real wages instead (Barbiellini Amidei, Cantwell, and Spadavecchia 2013; Nuvolari and Vasta 2015a). Italy's industry was deeply rooted in traditional sectors (Giannetti and Vasta 2010), where innovation relies on formal research activities very little if at all, while it was weak in sectors characterised by high technological opportunity. Yet many different interpretations and qualifications of this weak innovative performance were proposed. Importantly, some scholars pointed out that the country still developed effective capabilities for the adoption and imitation of foreign technology, which fostered the country's own innovative activity and productivity growth (Giannetti 1998; Barbiellini Amidei, Cantwell, and Spadavecchia 2013).

Empirical historical assessments of Italy's innovativeness and of its role in the country's economic growth have been conducted at the country level (e.g. the above-mentioned Barbiellini Amidei, Cantwell, and Spadavecchia 2013; and Nuvolari and Vasta 2015a), at the provincial one (Nuvolari and Vasta 2017), and based on the analysis of entrepreneurs' biographies (Toninelli and Vasta 2014; Nuvolari, Toninelli, and Vasta 2018). At the firm level, systematic evidence on the occurrence of innovative activities, and on the effects of the latter, is missing. This paper fills this gap by looking at the innovativeness of Italy's largest manufacturing firms in two periods, namely the late Giolittian era (1906-1913) and the second part of the fascist era (1929-1936). These represent two crucial and formative moments for the Italian economy, namely the end of the first phase of sustained economic growth, and the reorganisation of Italy's industrial sector under the auspices of the state after the Great Depression, notably through the public holding company, *Istituto per la Ricostruzione Industriale* (IRI), founded in 1933 as a temporary agency to bail out troubled financial and

[2] The two decades preceding the First World War are usually named *età giolittiana*, after Giovanni Giolitti, the most influential statesman of the time, serving five times as Prime Minister between 1892 and 1921, as well as Minister of the Interior and Minister of the Treasury.

industrial companies (and eventually become a long-lasting gigantic conglomerate, employing as many as half a million workers at the peak of its expansion, in the 1980s). The paper quantifies the occurrence among Italian manufacturing firms of three different measures of innovative activity, namely patents, trademarks (TMs), and international exhibition participation, and estimates their relation with business performance in the short and long run, as proxied by profitability and survival, respectively.

It finds that innovative activities were quite widespread among large Italian firms, as around 40% of the firms in the sample were involved in patenting or trademarking in both 1913 and 1936. The share of innovative firms can be raised to around 50% if exhibiting is added to the picture (in 1913). However, these activities were typically characterised by low frequency and intensity. In terms of their relation to firm performance, the evidence suggests that, after controlling for firm- and sector-level confounders, own patenting and trademarking were not significantly related to short-term profitability, irrespective of their frequency; while exhibiting was, which is in line with a view of exhibitions as important means of promotion for firms in that period. However, a firm's profitability seems to be on average positively associated with competing firms' innovative activities, which may be interpreted as a sign that Italian firms possessed adequate absorptive capabilities. Heterogeneity analyses show that these results are driven by less innovative locations and sectors. Furthermore, most crucially, patenting and trademarking (but not exhibiting) are significantly more likely to survive in the long run.

The paper proceeds as follows. Section 2 reviews relevant literature. Section 3 introduces the data employed and the main variables in the analysis. Section 4 elaborates on the behaviour in the period under study of the key variables, namely those associated to firm performance and innovation. Section 5 provides econometric evidence on the nexus between firm innovative activities and short- and long-term performance. Section 6 discusses the findings.

2. Relevant literature

This paper relates and contributes to three strands of literature: first and foremost, to the literature on the role of innovation in Italy's historical development; second, to the general economic literature on the relation between innovation and firm performance; finally, to the economic (historical) literature on the measurement of innovative activity. These three strands of literature are reviewed in turn in the following subsections.

2.1 Italy's innovativeness in a historical perspective

As mentioned in the introduction, economic historians substantially agree on the fact that Italy has been persistently characterised by a weak innovative performance; however, different interpretations of this fact were proposed. An "optimistic" argument maintains that this was a rational response to the country's factor endowment (scarce resources, abundant unskilled labour) and to the consequent relative prices, making labour-saving, resource-intensive technologies non-advantageous (Federico 1996; Cohen and Federico 2001). To the other extreme of the spectrum, the above-mentioned recent interpretation by Di Martino, Vasta, and coauthors is pessimistic throughout (Vasta 1999a; 1999b; Nuvolari and Vasta 2015a) and highlights that Italy's failure to become a stable member of the technological frontier resulted in it following a suboptimal growth path (Di Martino and Vasta 2015). In the middle lie different shades of moderate pessimism. Giannetti (1998) argues that, while Italy persistently failed to develop strong own innovation capabilities, it nonetheless developed effective capabilities for the adoption and imitation of foreign technology, *à la* Abramovitz (1986). Consistently with this, Barbiellini Amidei, Cantwell, and Spadavecchia (2013) point out a significant contribution of foreign technology to both innovative activity and productivity growth.

Quantitative analyses on Italy's historical innovativeness and its role in the country's economic growth have been conducted at the aggregate level (e.g. the above-mentioned Barbiellini Amidei, Cantwell, and Spadavecchia 2013; and Nuvolari and Vasta 2015a) and at the provincial one (Nuvolari and Vasta 2017). The latter study, after documenting the highly unequal distribution of patenting activity across Italian regions in the pre-WWI era, identifies a significant relation between patenting and labour productivity growth at the provincial level (controlling for other determinants of growth). Further insights on the relevance of innovative activities among Italian entrepreneurs have come from biographical analyses. Toninelli and Vasta (2014) identify a cluster of "Schumpeterian" (educated, innovative, risk-taking) entrepreneurs, representing about one fifth of a sample of 386 Italian entrepreneurs. However, they maintain that this "seems not to have had as great a role as an intense pace of growth would have required" (Toninelli and Vasta, 2014, p.181). Nuvolari, Toninelli, and Vasta (2018) show that innovation intensity was an important driver of success for Italian twentieth-century entrepreneurs in terms of firm growth, although not in terms of celebrity, which is rather explained by political connections. To the best of my knowledge, no study has yet provided systematic quantitative evidence on the occurrence of innovative activities among a large sample of Italian firms, and on their effects on business performance – which is what the present paper aims to do.

2.2 The nexus between innovation and firm performance

As mentioned in the introduction, this paper relates three measures of innovation to short- and long-term firm performance. This distinction is important, as the seminal work by Geroski and Machin (1993) pointed out that innovation affects firm performance through different channels. An established view in economic theory, which can be traced back to the thought of Schumpeter (1934) and was formalised in the models by Aghion and Howitt (1992) and Klepper (1996), argues that the introduction of a new product or process entails a short-term competitive advantage, lasting until the time competitors can imitate the novel product or process. This channel, which Geroski and Machin (1993) term the "product view" of the innovation-performance nexus, can be seen as lying at the basis of firms' decision to innovate. Besides this, Geroski and Machin (1993, p. 36) argue that innovation enhances firm performance via another, subtler channel: specifically, "the process of innovation transforms the firm itself, building up its internal capabilities in a variety of ways that create generic differences between innovating and non-innovating firms". This "process view" of the innovation-profitability nexus unfolds over a long time horizon, as its effects "do not necessarily manifest themselves only after an innovation occurs".

On an empirical ground, the same work and a related paper by the same authors (Geroski, Machin, and Van Reenen 1993), studying a panel of 721 British manufacturing firms in the years 1972-1983, observe that both channels are at work, but the process view appears to be more relevant than the product view. Indeed, the effect on profitability of individual innovations is positive but small. Long-term, permanent effects, associated with the development of firms' capabilities, are much more important, and innovating firms appear to be less sensitive to cyclical shocks than non-innovating ones. These results have been substantially confirmed, for various countries and periods, by subsequent studies,[3] notably Leiponen (2000; on Finland, 1985-1993); Diederen, van Meijl, and Wolters (2002; on the Dutch agricultural sector, 1995-

[3] In fact, the existence of a positive short-term relation between innovation and profits was also pointed out by earlier studies by Smyth, Samuels and Tzoannos (1972), for the United Kindgom, and by Minisian (1962) and Scherer (1965), for the United States.

1998); Cefis and Ciccarelli (2005; on the United Kingdom, 1988-1992); Love, Roper, and Du (2009; on Ireland, 1991-2002); and Cozza, Malerba, Mancusi, Perani, and Vezzulli (2012; on Italy, 2000-2003).

All these studies refer to recent decades. To my knowledge, the only work that studies the nexus between innovation and firm performance in a historical perspective is that by Mowery (1983). Analysing several samples of American firms over 1921-1946, that is the period in which, in the Unites States, the inventive process started shifting its main location to manufacturing firms' research facilities, he found that (both large and small) research-performing firms grew faster than their competitors, and that research increased the likelihood of firms' survival among the ranks of the largest manufacturing firms, over the above-mentioned period. The present paper analyses the nexus between innovation and short- and long-run performance for large joint-stock firms in a similar historical context, namely pre-WWI years and the 1930s; however, unlike Mowery's study, it does not deal with a technological leader, but with a peripheral laggard economy, as Italy was in the observed period.

2.3 How to measure innovation

In spite of the importance of innovation for the growth of businesses and economies, quantifying innovative activities is a hard task for researchers. Patents are a standard gauge in studies dealing with innovation (Griliches 1990; Nagaoka, Motohashi, and Goto 2010), and are especially important in historical analyses, as they are available since long ago for many countries (Streb 2023). However, they suffer from well-known shortcomings: a patent strictly speaking represents an invention, rather than an innovation, that is the commercial application of an invention; furthermore, not all inventions are patented, with the use of patents varying widely across sectors, as well as across firms within them.

Trademarks, a different type of intellectual property right (IPR), can help capturing innovative activities that are missed by patent data (Mendonça, Santos Pereira, and Mira Goudinho 2004; Schautschick and Greenhalgh 2016; Sáiz and Castro 2018; Castaldi 2019). In particular, they are "useful to measure product innovations in the late stages of their development" as well as "innovation in small firms that often rely on developing new products from existing technology" (Schautschick and Greenhalgh 2016, pp. 365-366). Similar points are made by Barbiellini Amidei, Cantwell, and Spadavecchia (2013), who also point out that trademarks are underused in economic history.

Finally, the possibility of using data from historical international exhibitions as a measure of innovation was originally suggested by Moser (2005; 2011; 2012), who argued that items on display at London's 1851 Crystal Palace exhibition (and a few other exhibitions) provided a broad sample of innovations, encompassing both patented and non-patented ones. The suitability of exhibition data as a proxy for innovation was subsequently qualified by Domini (2019), arguing that "data from international exhibitions after the Crystal Palace [are] characterized, as a proxy for innovation, by an opposite drawback to that commonly attributed to patent data: while the latter represent inventions, which might fail to reach the market, the former indicate commercialized products, which might have no innovative content" (Domini 2019, p. 20). Indeed, it is well known in economic history that exhibitions were an important means of publicity for firms, at a time when mass advertisement was not yet developed (Khan 2013, pp. 107-108; Khan 2015, p. 39; Schroeder-Gudehus and Rasmussen 1992, p. 6). At the same time, Domini (2019) highlights that this does not imply that exhibitions were irrelevant for innovation: in fact, they were particularly important means for the promotion and diffusion of innovative products.

This paper makes use of all the three different measures mentioned above, since it aims at a broad definition of innovation, fitting a technological laggard country characterised by weak and often informal innovation practices, especially in the period under study. Furthermore, by showing results for different innovation measures, it will provide helpful insights for economic (historical) researchers to understand similarities and differences in the ability of these measures to capture the innovative phenomenon.

3. Data

This section introduces the data sources and explains how the variables used for the analysis are constructed.

3.1 Sources

The sample employed in this analysis is constituted by firms included in IMITA.db (*IMprese ITAliane Data Base*), a database providing extensive information about Italy's largest joint-stock companies, notably their balance sheets and some general characteristics such as foundation year, location, and sector.[4] It consists of the digitisation of *Notizie statistiche*, a series of volumes published at (roughly) 3-year intervals, first by *Credito Italiano* from 1906 to 1925, then by the *Associazione fra le società italiane per azioni* (*Assonime*) from 1928 to the 1970s. The criteria for a firm to be included in this source are that it is either listed in one of the Italian stock markets,[5] or it exceeds a given share-capital threshold, initially equal to 1M lire, then raised to 10M in 1953, 25M in 1956, 50M in 1961, and 100M in 1964.[6] While firms meeting these criteria represent a minority of the total population of Italian joint-stock companies (40% in 1913 and 22% in 1936), they account for around 90% of the latter's aggregate capital (Vasta 2006a, p. 270).

The sample employed in this work will be limited, on the side of time, to the benchmark years 1913 and 1936; and on the side of sectors, to manufacturing industries, corresponding to divisions 15 to 36 (section D) of the ISIC Rev. 3 classification.[7] The number of firms within these limits is 624 in 1913, and 1764 in 1936. For each of these, general firm information and balance-sheet variables are retrieved from IMITA.db.

As for innovation, as stated in the introduction, information is retrieved about three measures. Patent data is manually retrieved from the *Bollettino della Proprietà Intellettuale*, containing the lists of patents granted in Italy in each year. Trademark data is matched from the digital data made available by the Italian Central State Archive (ACS), based on applications to the *Ufficio Italiano Brevetti e Marchi*. Finally, information on firms' exhibiting activity is retrieved from a database compiled by Domini (2019), listing the manufactured products displayed at the Turin 1911 International Exhibition. That event had a particular relevance for Italy, as it took place at the end of its first important phase of economic growth and development, and was seen as a unique opportunity to show the progress of the country to the

[4] IMITA.db is a relational database, structured into three parts: the first contains information about firms, such as name, location, foundation year, and 4-digit industry code (in terms of ATECO 1991, an Italian industrial classification, corresponding to the United Nation's ISIC Rev. 3), in several benchmark years (from 1911 to 1983); the second reproduces each firm's yearly balance sheets; the third lists the names, positions, and professions, of each firm's board members. The database is accessible at http://imitadb.unisi.it.

[5] It should be noticed that listed firms represent a minority: as shown by Giannetti and Vasta (2012, Fig. 8.3), the number of companies listed at the *Borsa* of Milan was never larger than 180, until the late 1980s.

[6] As Vasta (2006a, fn. 1) notices, until 1937 a few companies that were members of *Assonime* were included in the source, even though they did not reach the set threshold. He also points out that in 1914 the threshold was exceptionally equal to 0.5M lire. As this does not lead to a spike in the number of balance sheets available in that year, this study uses a threshold of 1M lire for 1914 as well.

[7] Actually, section D of the ISIC Rev. 3 includes one more division, namely *Recycling* (37); but no firm in IMITA.db belongs this division, in the years covered by this study.

world, in the occasion of the fiftieth anniversary of its unification. Comparable data is not available in the case of the benchmark year 1936, a general reason being the decline undergone by international exhibitions after WWI, in terms of both frequency and relevance; and a particular one being that no international exhibition took place in Italy during the inter-war period. Hence, exhibition data is only used for benchmark year 1913.

A final piece of information that is added, for benchmark year 1936 only, is whether a firm was (partly or totally) controlled by the state via IRI.[8] Given the purpose of the institute, control by the latter may affect both a firm's performance and its propensity to innovate. Yet the number of manufacturing firms in IMITA.db's benchmark year 1936 in which part of the share capital was owned by IRI is very small: only 50, corresponding to 2% of the sample. What is more, the share owned by IRI is larger than 50% for only 26 firms.

3.2 Performance variables

Consistently with the above-mentioned theoretical framework by Geroski and Machin (1993), this work evaluates business performance along two dimensions: namely, short-term profitability, which reflects the product view of the innovation-performance nexus, and survival, which instead may reflect the process view. The former will be measured by the Return On Equity (*roe*), and, as a robustness check, by the Return On Assets (*roa*).[9] Both are based on balance-sheet information from IMITA.db, and are defined as follows:

(1) $$roe = \frac{profit}{share\ capital + provisions + profit}$$

(2) $$roa = \frac{profit}{total\ assets}$$

where *share capital* (Italian: *capitale sociale*) is a firm's portion of equity coming from the issue of shares, *provisions* (Italian: *riserve*) include retained earnings, and together with *profit* (which can be negative, i.e. a loss) they form a firm's total equity. After an adjustment of extreme values, *roe* takes values between –1 and +1, with positive (negative) values denoting profits (losses).[10] *roa* also takes values within that range, except for a handful observations with values lower than –1 because of relatively large losses. The largest outliers are recoded as missing.[11] In practice, in the following analysis, three-year averages of *roe* and *roa*, centred around a benchmark year, will be employed, in order to limit the influence of occasional swings in profitability. Two-year averages over a benchmark year and the previous year will be employed as robustness checks.[12]

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[8] This information was provided by M. Vasta.

[9] The Return on Investment (ROI), another commonly employed measure, cannot be computed from IMITA.db data because of a number of issues, including the impossibility of distinguishing the capital actually used in the operative management (Vasta 2006b, pp. 156-157).

[10] As noticed by Vasta (2006b, fn. 3), *roe* displays an anomalous behaviour, as a function of *profit*: in case of losses (i.e. negative profits), exceeding in absolute value the sum of share capital and provisions (call it S for simplicity of treatment), the denominator of the *roe* formula becomes negative, hence the fraction becomes positive. Furthermore, for losses ranging between −S and −S/2, *roe* is ranges between −∞ and −1. For values of *profit* higher than −S/2 (including positive values), *roe* ranges between −1 and +1. This anomalous behaviour can be avoided by recoding *roe* as equal to −1 for all values of losses exceeding in absolute value S/2, so that it always ranges between −1 and +1, with positive (negative) values unambiguously denoting profits (losses).

[11] There are 21 observations with *roa*<–1, of which 12 with –1.5≤*roa*<–1, four with –3≤*roa*<–1.5, and five with values ranging between –7.5 and –50. The latter five observations all refer to the same firm (Benzina Nazionale S.A.B.E.N.A.) and were recoded as missing due to their exceptionally large values.

[12] Notice that two- and three-year average variables can be computed for a relatively small number of observations, as they require the availability of multiple years of balance-sheet data, the presence of which depends on the criteria mentioned in the previous subsection.

A firm's survival time is evaluated, based on the availability of balance sheets referring to it in the source.[13] When balance sheets become unavailable, the firm exits the database. In fact, there can be two types of exit: a *general* firm exit occurs whenever a balance sheet referring to a certain firm is not available in a certain year t, after being available in t–1. A problem with this definition is that a firm may temporarily fall below the share capital threshold for inclusion in the source in a certain year, hence exit; but meet again the threshold at a later point, hence re-enter the database. To account for the fact that general exits include temporary ones, a second definition is introduced: a *permanent* exit occurs in the year after the one in which the latest balance sheet referring to a certain firm is available. To make an example: a firm with balance sheets available in years 1913,1914, 1916, and 1917, is coded as generally exiting in both 1915 and 1918, but as permanently exiting only in 1918. Variable *surv_temp* (*surv_perm*) denotes the number of years between a benchmark year and the first temporary (the permanent) exit.

Another challenge to the identification of firm exit comes from censoring: the last year of balance-sheet data is 1971 (or 1972, for a small share of firms); furthermore, balance sheets are unavailable for the years 1940-1945.[14] This is taken into account in the two definitions of exit: a firm is not coded as generally or permanently exiting if its last available balance sheet coincides with the end of the data; and it is not coded as generally exiting when it misses a balance sheet in the WWII years. This implies that firms which permanently exit in the years 1940 to 1945 are coded as exiting in 1940, with few exceptions.

Given the difficulties associated with the identification of firm exit, a simpler alternative way to assess survival is also considered as a robustness check: dummy variable *survival_bench* denotes whether a firm in a given benchmark year can be found in IMITA.db in a later benchmark year, namely 1936 for firms in benchmark year 1913, and 1960 for firms in benchmark year 1936. This allows circumventing the issue of censoring; however, on the negative side, it should be noticed that, even with this measure, a firm's failure to survive may capture a temporary fall of its share capital below the threshold for inclusion in the source.

A final problem, which is common to all these ways to assess firm survival, is that the capital threshold, on which the inclusion or exclusion of most firms from the data is based, changes over time in nominal and/or real terms. This is addressed by using, for every year, a different nominal threshold, which is equal to 1M lire at constant 1913 prices.[15] A "real-threshold" general exit is therefore identified if the value of share capital is lower than this constant-prices threshold, even if a balance sheet is available. A real-threshold permanent exit occurs in the year after the last balance sheet in which share capital meets the constant-prices threshold. Dummy *survival_bench_real* equals one if a firm from benchmark year 1913 (1936) meets the constant-prices threshold in 1936 (1960). At the same time, when using these variables, the constant-prices threshold is also employed to determine which firms are part of the sample itself. In this way, the samples from the two benchmark years become better comparable, as differences in terms of the real value of the capital threshold, and/or of the number of firms included in the source despite not meeting the threshold, are eliminated.

3.3 Innovation variables and controls

Shifting attention to the measures of innovation, the main variables are a series of dummies, denoting whether a firm is a patentee, trademarker, or exhibitor: *patd07* (*patd03*)

[13] It is worth mentioning that each firm in IMITA.db possesses a unique identifier, which accounts for name changes.

[14] In fact, 177 balance sheets (for all firms, including non-manufacturing ones) are available in 1940, corresponding to 5.6% of those available in 1939. Likewise, 477 balance sheets are available in 1972, corresponding to less than 5.7% of those available in 1971. A handful are available in 1941-1945 (7 in total, referring to 3 different firms).

[15] Constant-prices thresholds are based on the deflator from Baffigi (2013).

equals one if a firm takes out patents over an eight-year (four-year) time span, including a benchmark year and the seven (three) years preceding it (e.g. 1906-1913, or 1910-1913); *tmd07* (*tmd03*) is defined in an equivalent way, based on trademark data; while *patd* and *tmd* are dummies denoting patenting and trademarking in a single year, respectively. Finally, *exhd* equals one if a firm participated in the Turin 1911 International Exhibition. The latter dummy is coded as missing if a firm did not yet exist in the year of that exhibition, based on information on a firm's foundation year from IMITA.db.

In addition to these innovator-status variables, dummies expressing the frequency with which a firm takes out patents (patyr*n*) or trademarks (tmyr*n*) will also be considered; and so will variables denoting the number of other patentees, trademarkers, or exhibitors in the same sector as a certain firm (*indpatd07*, *indtmd07*, and *indexhd*, respectively).

Finally, the following control variables are computed based on balance-sheet information from IMITA.db: a firm's capital intensity (*capint*), indebtedness (or leverage ratio; *indebt*),[16] and relative size (or market share; *rsize*);[17] and the concentration index (C4; *conc*) and *scale* of a firm's sector. Table 1 provides definitions of all variables employed in the analysis, which in addition to those already mention also includes a firm's *age*, based on company information from IMITA.db, and *iripart*, a dummy denoting whether IRI owns shares in a firm.[18] Tables 2 to 4 display summary statistics and correlation coefficients between the main firm-level variables, which will be discussed in the following section.

Table 1. Definitions of variables.

Label	Full name	Definition
age	Age	Years since foundation of firm
capint	Capital intensity	Physical assets of firm / Total assets of firm
conc	Concentration of sector	Total assets of top 4 firms in a firm's division / Total assets of division
exhd	Exhibitor	Dummy =1 if firm exhibits at the Turin 1911 International Exhibition
indebt	Indebtedness	Total debts of firm / Total assets of firm
indexh	Exhibitors in sector	Number of other exhibitors in a firm's division
indpatd(07)(03)	Patentees in sector	Number of other patentees in a firm's division in T ([T-7; T]) ([T-3; T])
indtmd(07)(03)	Trademarkers in sector	Number of other trademarkers in a firm's division in T ([T-7; T]) ([T-3; T])
iripart	IRI participation	Dummy =1 if IRI owns shares in the firm
patd(07)(03)(47)	Patentee	Dummy =1 if firm is granted at least one patent in T ([T-7; T]) ([T-3; T]) ([T-7; T-4])
patyr*n*	Years with patents	Dummy =1 if firm is granted patents in *n* years over [T-7; T]
roa	Return on assets	Profit / Total assets
roa2(3)	2-(3-)year average *roa*	Average of *roa* over [T-1; T] ([T-1; T+1])
roe	Return on equity	Profit / Total equity (see Equation 1)
roe2(3)	2-(3-)year average *roe*	Average of *roe* over [T-1; T] ([T-1; T+1])
rsize	Relative size	Total assets of firm / Total assets of a firm's division
scale	Scale of sector	Total assets of a firm's division (in '000 lire) / Number of firms in division
surv_temp(_perm)	Survival until temporary (permanent) exit	Number of years between T and the first temporary (the permanent) exit; *_real* denotes use of constant-prices threshold
surv_bench	Survival until later benchmark year	Dummy =1 if firm survives from 1913 (1936) to 1936 (1960); *_real* denotes use of constant-prices threshold
tmd(07)(03)(47)	Trademarker	Dummy =1 if firm is granted at least one trademark in T ([T-7; T]) ([T-3; T]) ([T-7; T-4])
tmyr*n*	Years with trademarks	Dummy =1 if firm is granted trademarks in *n* years over [T-7; T]

Note: T denotes a benchmark year (1913 or 1936).

[16] Four outlier values of this variable are recoded as missing.

[17] IMITA.db does not contain information about firms' revenues from sales and number of employees, two other measures of firm size that are widely employed in contemporary studies.

[18] Dummy *iripart* equals one for any positive amount of shares owned by IRI. For the 50 such firms in year 1936, the share owned by IRI ranges from a minimum of 11% to a maximum of 100%, with a mean (median) value of 52% (55%). An alternative dummy, equaling one only for shares owned by IRI of at least 50%, was discarded, given the small number of firms in question.

Table 2. Summary statistics, selected variables.

	1913					1936				
	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
age	624	9.60	8.24	0.00	58.00	1757	15.15	11.59	0.00	87.00
capint	615	0.44	0.21	0.00	1.00	1705	0.43	0.25	0.00	1.00
conc	624	0.37	0.19	0.16	1.00	1764	0.39	0.17	0.15	1.00
exhd	593	0.30	0.46	0.00	1.00					
indebt	614	0.39	0.22	0.00	1.74	1685	0.38	0.26	0.00	2.86
indexh	593	15.45	6.22	0.00	24.00					
indpatd07	624	13.35	6.23	0.00	22.00	1764	34.57	18.26	0.00	58.00
indtmd07	624	18.42	14.36	0.00	39.00	1764	52.33	40.60	0.00	108.00
iripart						1764	0.03	0.17	0.00	1.00
patd07	624	0.25	0.43	0.00	1.00	1764	0.26	0.44	0.00	1.00
roe3	527	0.04	0.10	-0.96	0.50	1426	0.04	0.08	-1.00	0.31
rsize	617	0.03	0.08	0.00	1.00	1706	0.01	0.04	0.00	0.73
scale	624	5.85	3.08	1.33	14.37	1764	22.15	18.38	5.72	111.66
surv_perm	616	28.20	22.79	1.00	60.00	1706	20.87	14.42	1.00	37.00
tmd07	624	0.23	0.42	0.00	1.00	1764	0.26	0.44	0.00	1.00

Note: only variables used in the main analyses are displayed; for survival_perm*, see Table 5; for* patyrn *and* tmyrn*, see Table 8; for variables use in the robustness checks, see Table A2 in the appendix.*

Table 3. Pearson correlation coefficients between selected firm-level variables, year 1913.

	patd07	tmd07	exhd	roe3	surv_perm	age	capint	indebt	rsize
patd07	1								
tmd07	0.1211*	1							
exhd	0.3487*	0.0959*	1						
roe3	0.0852*	(-)0.0013	0.1617*	1					
surv_perm	0.0884*	*0.0617*	0.0691*	0.1044*	1				
age	*0.0495*	*0.0469*	0.1066*	0.1661*	0.1559*	1			
capint	-0.0767*	-0.1193*	-0.1184*	-0.1496*	-0.1344*	-0.1854*	1		
indebt	0.0473	0.0164	0.0660	-0.3994*	-0.1008(*)	*(-)0.0084*	-0.1318*	1	
rsize	0.1795*	*0.0529*	0.1828*	*0.0083*	0.0825*	*0.0285*	-0.1081*	0.0841*	1

*Notes: (1) * denotes $p < 0.1$; (2) italics denotes a significant non-parametric Spearman rank correlation coefficient; (3) brackets around a star denote a non-significant Spearman correlation; (4) brackets around a minus denote a positive Spearman rank correlation coefficient.*

Table 4. Pearson correlation coefficients between selected firm-level variables, year 1936.

	patd07	tmd07	roe3	surv_perm	age	capint	indebt	iri_part	rsize
patd07	1								
tmd07	0.2015*	1							
roe3	0.0888*	0.0704*	1						
surv_perm	0.1624*	0.1471*	0.2277*	1					
age	0.0848*	0.0938*	0.1281*	0.1875*	1				
capint	-0.1188*	-0.1560*	-0.1653*	-0.1400*	-0.0530(*)	1			
indebt	0.0657*	0.0042	-0.2453*	-0.0726*	-0.1433*	-0.1798*	1		
iri_part	0.0695*	0.0209	-0.0778*	0.0505*	0.0976*	-0.0069	0.0841*	1	
rsize	0.2100*	0.1024*	0.0546*	0.1395*	0.0944*	-0.0950*	*0.0327*	0.1233*	1

*Notes: (1) * denotes $p < 0.1$; (2) italics denotes a significant non-parametric Spearman rank correlation coefficient; (3) brackets around a star denote a non-significant Spearman correlation; (4) brackets around a minus denote a positive Spearman rank correlation coefficient.*

4. Innovation and firm performance in early-twentieth century Italy: an overview

This section will describe the behaviour, in the cross-section(s) and over time, of the key variables in this analysis, i.e. those related to firm performance and innovation, over the period in question. Before proceeding, however, a brief sketch of the general macroeconomic context is in order.[19] The first four decades of the twentieth century were a period of development for the Italian economy, which grew at significantly higher rates than in the previous century, and underwent considerable structural change (Toniolo 2013). Over the years 1900-1913, real per capita GDP growth averaged 1.7% per year, *vis-à-vis* 0.6% in 1861-1900. WWI brought about recession, but in the 1920s a strong recovery occurred, which came to a halt with the 1929 crisis. Growth was then negative, on average, until 1936. This depression was overcome in the late 1930s, with a strong role of the state, which reorganised the industrial sector under its auspices. Over the period, the manufacturing sector grew faster than the whole economy.

4.1 Firm performance

An extensive account of long-term firm profitability patterns, based on data from IMITA.db, was made by Vasta (2006b). In line with the macroeconomic trends sketched above, the aggregate profitability of the manufacturing sector was around 5% during the Giolittian era, with higher values closer to the turn of the century and lower in the immediate pre-WWI years. After the war and post-war rollercoaster, it first regained stable healthy rates in the mid-1920s, then started a downward trend, which was aggravated by the 1929 crisis. As a result, in 1930 the aggregate manufacturing *roe* fell into negative territory, and then stagnated around zero until the mid-1930s, when the reorganisation of Italian industry by the state brought it back to 5% and more.

Most importantly, Vasta (2006b) identifies a relation of *roe* with some firm- and sector-level characteristics. At a sectoral level, a profitability gap in favour of light traditional sectors characterised, in general, the observed period. However, in the mid-1930s, the state's industrial reorganisation and rearming plans fostered the profitability of heavy sectors, so that the gap closed. In terms of Pavitt's (1984) classification of sectors by their technological innovation characteristics, in the period in question profitability was higher in traditional sectors (e.g. textiles), where firms tend to source technology externally from suppliers, and lower in sectors where firms rely more on their own innovative activities, with the exception of cutting-edge *science-based* sectors (e.g. chemicals and electrical machinery), which show good profitability.

Vasta (2006b) also shows that, over the period studied here (and beyond), the profitability of the firms in the IMITA.db database was positively related to their size (as measured by assets) and age, and negatively related to their level of indebtedness (i.e. financial leverage; in other words, profitability is positively related to the degree of financial independence of the firm). These insights are confirmed by Tables 3 and 4, which also show a significant negative correlation with a firm's capital intensity.

Vasta (2006b), however, does not provide information on firm survival, which is this study's measure of long-term firm performance. Table 5 shows the shares of firms in each benchmark year by survival time range, defined as the number of years between the benchmark and the year in which a permanent exit is identified. This shows quite a consistent pattern across the two benchmark years: between 35% and 40% of firms permanently exit within the first ten years (notice that, in both cases, a world war is included in this period); a similar share exits after more than 30 years (or never), and around one fourth lies in between. To make sense of these remarkably high survival rates, it should be noticed that the sample refers to large firms.

Table 5. Share (%) of firms in each benchmark year that permanently exit after a certain numbers of years.

surv_perm	1913	1936
Up to 10 years	37.3	35.0
11-20 years	10.9	12.3
21-30 years	13.5	13.1
More than 30 years / Never	38.3	39.6

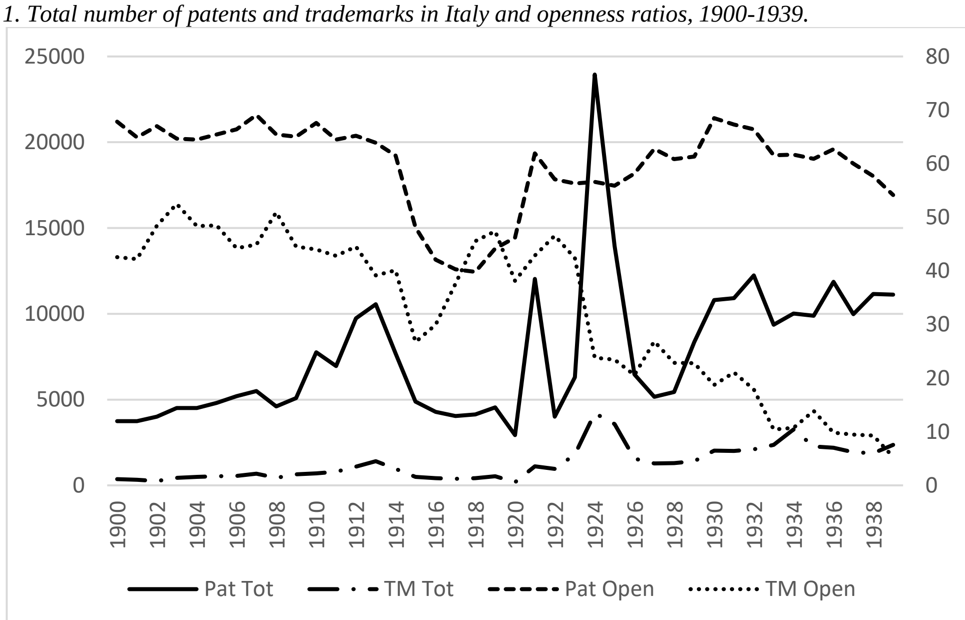
[19] Statements and figures in this paragraph are based on data from Baffigi (2013).

Finally, Tables 3 and 4 show a significant positive correlation between long-term (*surv_perm*) and short-term firm performance (*roe3*) and, consistently with this, the same signs (and significance) for the correlations of *surv_perm* with the above-mentioned firm-level characteristics (*age*, *rsize*, *indebt*, and *capint*), as observed for *roe3*. A difference can only be observed for *iripart*, which is significantly positively correlated to *surv_perm*, while significantly negatively correlated to *roe3*. This is not surprising, in light of IRI's function to bail out troubled firms and sectors.

4.2 Innovation

Figure 1 shows the dynamics of the number of patents and trademarks in Italy in the four decades under observation, as well as those of the respective openness ratios, i.e. the shares of patents or trademarks taken by foreigners. Overall, the number of patents and trademarks increased substantially over the period. During the Giolittian era, the total number of patents granted in Italy increased at a substantially faster pace than in the past, doubling from around 2400 in the mid-1890s, to around 5000 in the mid-1900s, then more than doubling again in a few years and peaking at 10560 in 1913. It should be noticed that the share of patents granted to foreigners remained stable over those years, at about two-thirds, showing that the expansion of the patent system was fed by increases in domestic and foreign contributions at similar rates. After a fall during the war and a phase of positive though irregular growth in the 1920s, during which the pre-war openness ratio was also recovered, in the 1930s the number of patents plateaued around a level slightly higher than the Giolittian-era peak, while the openness ratio declined. Hence, an increasing patenting activity by Italians went hand in hand with a decline in foreign participation in the Italian patent system, which can be related to the international closure during the Great Depression and the autarchic policies of the fascist regime. To sum up, both periods studied by this work saw an increase in Italian residents' patenting activity.

Figure 1. Total number of patents and trademarks in Italy and openness ratios, 1900-1939.



Sources: World Intellectual Property Organization (WIPO) for patent grants; ACS for trademark applications. Note: openness is defined as the share of patents (trademarks) accounted for by foreign residents.

Trademarks display very similar dynamics to those of patents, although on a much lower level throughout the period. The openness ratio is lower for trademarks than for patents throughout the period. Furthermore, it halves in the early 1920s and then keeps decreasing throughout the *ventennio fascista*. This decline is both starting earlier and more sizeable than that in the openness of the patenting system. This, however, means that the relative stability in the total number of trademarks in the 1930s conceals an increasing number of applications by Italians.[20]

Remarkably, firms, which are the object of the present study, represented a minority among Italian patentees. In 1911, only 10% of the latter were firms, compared to 24% of foreigners taking patents in Italy (Domini 2019, Table 3). Still in 1936, 13% of Italian patentees were firms, against 36% of foreigners.[21] On the one hand, these figures may be seen as a symptom of a generally scarce attention, devoted by Italian firms to innovation, *vis-à-vis* their foreign competitors. On the other hand, it should be noticed that a patent granted to an individual might still be exploited commercially by a firm.[22] This study acknowledges this and matches to the firms in the sample also patents granted to individuals, whenever a connection can be established, notably when a patent is on the name of a company's head.

Tables 6 and 7 provide information on the (co-)occurrence of the three innovation measures among the firms in this work's sample. One fourth of firms can be labelled as patentees in either of the two benchmark years (which, as explained above, means that they patented over the periods 1906-1913 or 1929-1936). A similar share took out at least one trademark, with the share being somewhat larger for benchmark year 1936 than for 1913 – which is in line with the increase in the number of trademarks as per Figure 1. Finally, 30% of firms in benchmark year 1913 took part in the Turin 1911 International Exhibition. It should be noticed that the sample employed in this work provides a good coverage of the universe of patentees, trademarkers, and exhibitors in the years observed, up to 90% in the case of corporate Italian patentees.[23]

There is some overlap between these three measures of innovative activity: the share of patenting firms also taking trademarks was 32% in 1913 and 42% in 1936. This is similar to the share of trademarking firms also involved in patenting. Overall, around 40% of firms in either benchmark year took out one IPR or the other; while 8% of firms in benchmark year 1913, and 11% of those in 1936, took out both. If exhibiting activity is added to the picture, 53% of firms in benchmark year 1913 can be classified as innovative.[24]

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[20] Barbiellini Amidei, Cantwell, and Spadavecchia (2013, Figures 14.1–14.3 and 14.5) show that similar trends characterised IPRs granted abroad to Italians. Italian residents' shares in patents granted in the major foreign countries steadily increased (if war years are excluded) until the mid-1920s, when they reached a peak; then they declined for some years and, in some cases, recovered during the 1930s. Italian residents' share of trademarks granted in France to all non-French residents displays peaks in the early 1910s, the early 1920s, and the mid-1930s.

[21] The calculation for 1936 is based on data provided by A. Nuvolari and M. Vasta. In terms of number of patents, firms accounted for 24% of all patents granted in Italy in 1911, but only for 14% of patents granted to Italian residents (Nuvolari and Vasta 2015b, Table 1). In 1936, these shares are 46% and 22%, respectively.

[22] Domini (2019) shows that, among Italian firms exhibiting at the Turin 1911 International Exhibition which can be matched to a patentee, 60% are matched to an individual patentee; likewise, among 1911 individual patentees that can be matched to an exhibitor, around half are matched to a firm exhibitor.

[23] See Table A1 in the appendix. IMITA.db firms with patents in 1911 (1936) represent 27% (29%) of all corporate Italian patentees in those two years. This share rises to as much as 90%, if IMITA.db firms with patents throughout the period 1906-1913 (1929-1936) are considered. Coverage seems even higher for trademark data, since IMITA.db firms with trademarks represent 7% (11%) of all Italian trademarkers in 1913 (1936) – a multiple of the corresponding share of patentees. However, the lack of systematic information on the type of trademarker prevents more detailed comparisons. Finally, exhibitors in IMITA.db represent 13% of all firms in the database by Domini (2019).

[24] Tables A3 to A5 in the appendix show the same information as Tables 6 to 8, using shorter four-year time windows (between T and T-3) for counting patents and trademarks. This does not influence much the figures shown in the text: in either benchmark, one fifth of firms take out patents, a similar share takes out trademarks, one third takes out one IPR or the other, and half take out IPRs or exhibit. Again, most firms take out IPRs with low intensity and frequency.

Table 6. Share (%) of firms with patents and/or trademarks in all firms in benchmark years 1913 (N=624) and 1936 (N=1764).

	1913			1936		
	tmd07=0	tmd07=1	Total	tmd07=0	tmd07=1	Total
patd07=0	60.42	14.74	75.16	58.62	15.59	74.21
patd07=1	16.99	7.85	24.84	15.08	10.71	25.79
Total	77.40	22.60	100.00	73.70	26.30	100.00

Table 7. Share (%) of firms exhibiting in the Turin 1911 International Exhibition in all firms in benchmark year 1913 that were founded in 1911 or earlier (N=593).

	patd07=0	patd07=1	tmd07=0	tmd07=1	Total
exhd=0	59.19	10.79	55.99	14	69.98
exhd=1	15.35	14.67	21.25	8.77	30.02
Total	74.54	25.46	77.23	22.77	100.00

Table 8. Share (%) of firms taking out certain numbers of patents/trademarks, and taking out patents/trademarks for certain numbers of years, in all firms taking out patents/trademarks in benchmark years 1913 and 1936.

	1913		1936	
	Patents (N=155)	TMs (N=141)	Patents (N=455)	TMs (N=464)
Units of patents/TMs				
1	41.94	49.65	41.76	36.21
2	21.29	19.15	20.22	15.95
3	10.97	14.18	9.23	8.62
≥4	25.81	17.02	28.79	39.22
Years with patents/TMs				
1	51.61	63.83	50.11	49.57
2	20.00	19.86	22.42	20.26
3	11.61	9.93	8.79	12.28
≥4	16.77	6.38	18.68	17.89

While Tables 6 and 7 jointly show that many of the firms in the sample carried out innovative activities, Table 8 shows that most firms taking out patents or trademarks did so in a non-persistent and low-intensity way. More than 40% of patenting firms took out only one patent over the eight-year time windows including each benchmark and the seven preceding years; and around three-fourths took out no more than three. Furthermore, half of them took out (one or more) patents only in one year. The situation is similar for trademarks.

Table 9 shows the shares of innovators, as defined by our three measures, in different sectors. While the shares of patenting firms are unevenly distributed, with very high shares (even above 50%) in the heavy industrial sectors of metal production, machinery, and transport equipment, and low shares in traditional sectors (e.g. around 10% in *Food and beverages*), those of trademarking firms are more similar across sectors. In some cases, a sector is characterised by a high share of firms involved in one IPR, but a low share of firms involved in the other: notably, 34% of firms in *Other transport* (i.e. railways, navigation, and aerospace) took out patents in benchmark year 1913 (45% in 1936), but only 3% (8%) of them took out trademarks. Exhibiting activity, like patenting, shows a rather uneven relevance across sectors; however, the sectors with the highest share of exhibitors are not always the same as those with the highest shares of patentees: for instance, *Paper* shows a below-average share of patentees, but a slightly above-average share of exhibitors. Still, the overall picture is one of weak innovative activity in traditional sectors, such as textiles, and particularly strong innovative activity, irrespective of the measure employed, in the sectors related to metal production and machinery (27 to 35; referred to as "metal-mechanical" sectors henceforth). This is not surprising, since these are sectors labelled by Pavitt (1984) as *production-intensive*, characterised by either economies of scale or specialised suppliers, in which the main source of technology for firms is in-house innovation.

Table 9. Share (%) of innovative firms in different sectors in years 1913 and 1936.

		1913				1936		
		N	patd07	tmd07	exhd	N	patd07	tmd07
15	Food and beverages	106	10.38	26.42	20.00	284	8.45	31.34
16	Tobacco	0	-	-	-	4	25.00	0.00
17	Textiles	143	13.99	27.27	13.77	350	16.57	30.86
18	Apparel	8	12.50	25.00	42.86	38	31.58	34.21
19	Leather, bags and footwear	10	30.00	30.00	55.56	39	23.08	38.46
20	Wood	8	12.50	0.00	0.00	26	15.38	7.69
21	Paper	25	12.00	12.00	32.00	58	29.31	25.86
22	Publishing and printing	14	0.00	0.00	21.43	70	8.57	7.14
23	Coke and petroleum	1	0.00	0.00	0.00	40	20.00	25.00
24	Chemicals	74	29.73	29.73	34.78	233	24.46	31.33
25	Rubber and plastic	2	0.00	50.00	0.00	10	70.00	50.00
26	Non-metallic minerals	69	17.39	13.04	21.31	162	19.75	14.20
27	Basic metals	42	38.10	11.90	46.34	92	29.35	18.48
28	Fabricated metals	21	47.62	33.33	52.38	79	50.63	26.58
29	Machinery and equipment	21	57.14	19.05	66.67	65	60.00	23.08
30	Office machinery	0	-	-	-	5	60.00	40.00
31	Electrical machinery	15	73.33	40.00	64.29	53	67.92	30.19
32	Communication equipment	1	100.00	0.00	100.00	11	54.55	27.27
33	Instruments	5	100.00	20.00	100.00	26	57.69	30.77
34	Motor vehicles	17	64.71	35.29	64.71	20	55.00	35.00
35	Other transport	29	34.48	3.45	35.71	65	44.62	7.69
36	Furniture and n.e.c.	13	46.15	30.77	23.08	34	41.18	35.29

Table 10 provides insights on the shares of innovative firms in different regions of the country. Unsurprisingly, the highest shares of innovative firms are in the North-West (including the regions of Liguria, Lombardy, and Piedmont, home to the "industrial triangle cities of Genova, Milan, and Turin, respectively). Lower shares, close to the national averages, can be observed in the regions of the North-East and Centre; while the South lags far behind. It is also worth noticing that barely 5% of all manufacturing firms in the sample (in either benchmark year) are based in the South – another symptom of the low industrial development of that part of the country – while more than 70% are in the North-West.

Table 10. Share (%) of innovative firms in different locations in years 1913 and 1936.

	1913				1936		
	N	patd07	tmd07	exhd	N	patd07	tmd07
Macro-regions							
North-West	458	26.42	25.98	33.26	1,241	28.53	29.65
North-East and Centre	131	23.66	13.74	22.95	422	22.04	20.14
South and Islands	35	8.57	11.43	10.34	101	7.92	10.89
Cities							
Florence	23	17.39	8.70	27.27	49	38.78	40.82
Genoa	58	22.41	12.07	39.66	126	21.43	20.63
Milan	178	30.34	35.39	34.73	623	32.91	32.91
Naples	14	14.29	0.00	16.67	36	11.11	19.44
Rome	36	36.11	13.89	36.36	121	18.18	14.88
Turin	74	32.43	24.32	43.24	135	32.59	34.81
Total of 6 cities	383	28.72	24.80	36.34	1,090	29.45	29.63

The picture is uneven also within the North-West, however, as the lower panel of the table reveals. Milan has a clear leading role, with a relative majority of firms based there and higher innovation rates, by any measure, than both the national and the North-Western average. The only other city for which similar claims can be made is Turin. Interestingly, the national capital, Rome, shows higher-than-average patenting and exhibiting rates in 1913, but lower-than-average ones in 1936. The relevance of Milan for industrial and innovative activity will justify, in the next section, a separate econometric analysis for firms located in this city. The same goes for the particularly innovative metal-mechanical sectors.[25]

Tables 3 and 4 also reveal a positive correlation of all innovation measures with *rsize* and *age*, a less clear-cut positive one with *indebt*, and a negative one with *capint*; while *iripart* shows a significant (though quite loose) positive correlation with patenting, and an insignificant one with trademarking. Finally, and most importantly, *patd07* and *tmd07* are significantly positively related to *surv_perm* and *roe3*.

To sum up, this study's sample reveals a large percentage of innovators among Italian joint-stock firms, although most of them take out IPRs with low frequency and intensity. The distribution of innovators by sector and location is highly uneven. Innovative firms are on average larger and older: this supports a "Schumpeter mark II" view, whereby innovators are typically firms with market power;[26] and helps explaining the relatively high innovativeness of firms controlled by IRI. Most importantly, innovative firms are characterised by superior firm performance, both in terms of short-term profitability and of long-term survival.

5. The innovation-performance nexus: econometric evidence

The last section ended by showing significant positive unconditional correlations between innovation and firm performance. However, these may be driven by several firm- and sector-level characteristics that were shown above to relate to both innovation and firm performance. In this section, regression analyses will be employed to test the innovation-performance nexus, conditional on potential confounding variables. Two separate analyses will be carried out, the first on the short-term relation of innovation with profitability, and the second on the relation with long-term survival.

5.1 Short-term performance: profitability

The regression equation builds on conventional structure-performance foundations (cf. Geroski, Machin, and Van Reenen 1993), whereby profitability is modelled as a function of firm characteristics (market shares, costs, etc.) and of the market structure. The cross-section regression equation reads as follows:

$$roe3_{iT} = \alpha + \beta\ inno_{iT} + \gamma\ ind\mathrm{inno}_{iT} + \delta\ X_{iT-1} + \varepsilon_{iT} \quad (3)$$

where i indexes firms and T indexes benchmark years. *inno* is one of the three innovator-status dummies, *patd07*, *tmd07*, and *exhd*. *ind*inno is a sector-level variable denoting the number of

[25] Tables A6 to A11 in the appendix present similar information to that in Tables 6 to 8, for firms based in Milan and for firms belonging to metal-mechanical sectors. Milanese firms show not only higher innovation rates by any measure, as mentioned in the text, but also higher numbers of patents and trademarks per firm, as well as more years in which firms take out IPRs, on average. Metal-mechanical firms show stronger patenting activity, in terms of share of patenting firms, number of patents, and years with patents, as well as stronger exhibiting activity, but weaker trademarking activity. Also Table A12, listing the top five patenting and trademarking firms in each benchmark year, validates many of the points made in this section: the firms with the highest numbers of IPRs typically come from the industrial triangle cities, in particular Milan (where all the top trademarkers are based); metal-mechanical firms dominate patenting, whereas different sectors can be observed among top trademarkers; finally, high patenting and high trademarking do not typically co-occur (and both do not always co-occur with exhibiting).

[26] This statement is also backed by a strong positive correlation between a sector's concentration index and its share of patentees, especially if outlier sectors with a concentration of 100% are excluded. The same applies to the share of exhibitors, and to a lesser extent to that of trademarking firms (the correlation of which is only significant in 1936 and if outliers are removed).

other firms, in a firm's sector, which can be classified as innovators, based on each innovation variable (*patd07*, *tmd07*, or *exhd*). The vector of controls X_{T-1} includes the firm- and sector-level variables introduced in the previous sections, namely, *age*, *capint*, *indebt*, *rsize, conc* (plus the interaction *rsize*conc*), scale, and (for 1936 only) *iripart*.[27] Controls (except for *age*) are entered with a lag, in order to maintain temporal coherence, since *roe3* is constructed as a 3-year average of *roe* between T−1 and T+1 (cf. Section 2).

Table 11. Cross-section OLS regressions of roe3 on innovator-status dummies.

	inno = patd07		inno = tmd07		inno =exhd
	1913	1936	1913	1936	1913
inno	0.008	0.008*	-0.007	0.005	0.023***
	(0.008)	(0.004)	(0.012)	(0.004)	(0.007)
ind*inno*	0.060	0.057***	-0.051	0.018**	0.221**
	(0.092)	(0.016)	(0.040)	(0.009)	(0.090)
age	0.002***	0.000***	0.002***	0.000***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L.capint	-0.069***	-0.073***	-0.077***	-0.073***	-0.059***
	(0.017)	(0.010)	(0.018)	(0.011)	(0.016)
L.indebt	-0.192***	-0.093***	-0.192***	-0.093***	-0.182***
	(0.032)	(0.020)	(0.032)	(0.020)	(0.032)
L.rsize	0.413**	0.490***	0.399**	0.492***	0.398**
	(0.177)	(0.093)	(0.190)	(0.093)	(0.175)
L.conc	0.056*	0.052***	0.011	0.060***	0.085***
	(0.028)	(0.018)	(0.028)	(0.023)	(0.029)
L.rsize*L.conc	-0.529**	-0.567***	-0.494***	-0.590***	-0.508**
	(0.208)	(0.108)	(0.221)	(0.112)	(0.211)
L.scale	0.001	0.000***	0.002	0.000***	-0.001
	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)
L.iripart		-0.033***		-0.030***	
		(0.011)		(0.011)	
Constant	0.085***	0.045***	0.121***	0.052***	0.044**
	(0.021)	(0.011)	(0.024)	(0.015)	(0.020)
N	521	1409	521	1409	513
Adjusted R^2	0.221	0.143	0.221	0.134	0.226

*Notes: (1) Heteroscedasticity-robust standard errors are employed; (2) *, **, and *** denote p < 0.1, p < 0.05 and p < 0.01, respectively; (3) ind*inno *is expressed in hundreds; (4) L. denotes the lag operator.*

The fact that *patd07* (*tmd07*) covers patents granted (trademarks applied for) in T and T−1, i.e. two of the three years over which *roe3* is calculated, may raise concerns about reverse causality from *roe3* to *patd07* (*tmd07*). This, however, may be excluded on various grounds: first, even assuming that a firm may use its profits to fund expenditure in research and development (R&D), there would be a lag between this input and its output, i.e. a patent (trademark) application (Geroski and Machin 1993, fn. 3; Geroski, Machin, and Van Reenen 1993, fn. 3), as well as between a patent application and its grant. Furthermore, such a view might be argued not to fit the historical period in question, when modern in-house corporate R&D processes were only starting, nor a technological laggard country, such as Italy. As for *exhd*, reverse causality is excluded simply by timing, as the Turin exhibition took place in 1911, while *roe3* is calculated over 1912 to 1914. This nonetheless, potential reverse causality will be addressed in the robustness checks, by introducing a lag of the dependent variable on the right-hand side,[28] and by an instrumental variable (IV) approach.

[27] The set of controls builds on Geroski, Machin, and Van Reenen (1993), Cefis and Ciccarelli (2005), and Vasta (2006b). The inclusion and definition of some variables differs from these sources, owing to data limitations.

[28] The lagged dependent variable on the right-hand side reflects "cash flow influences on innovative activity which feed through to innovation and thence to profitability within a year or so" (Geroski, Machin, and Van Reenen 1993, fn. 3). This is not included in the main analysis because reverse causality from profits to

Another potential source of endogeneity are omitted variables, resulting in correlation between *inno* and the error term, ε. This is addressed in the main analysis by using the large set of controls introduced above; and in the robustness checks by running fixed-effects (FE) regressions, controlling for unobserved time-invariant confounders. Further robustness checks will include changes of dependent variable and sample, as explained below.

Table 11 shows the cross-section OLS estimation results, for different innovation variables and benchmark years (with *exhd* being only available for 1913). The main explanatory variable, *inno*, is only statistically significant at conventional levels in two cases, namely in 1936 when *inno=patd07*, and in 1913 when *inno=exhd*. Of these two, however, only the latter turns out to consistently pass the robustness checks, described below. The coefficient attached to *exhd* implies that exhibiting firms' *roe3* is on average 2.3 percentage points (p.p.) higher than that of non-exhibiting ones.[29] This is a large value, compared to the mean value of *roe3* in the sample (4%, according to Table 2).

Table 12. Cross-section OLS regressions of roe3 on innovation-years dummies.

	inno = pat		inno = tm	
	1913	1936	1913	1936
*inno*yr1	0.000	0.012***	-0.018	0.007
*inno*yr23	0.012	0.007	0.008	0.005
*inno*yr4m	0.032***	-0.002	0.037	0.000
ind*inno*d07	0.057	0.102***	-0.055	0.019**
N	521	1409	521	1409
Adjusted R^2	0.221	0.143	0.224	0.133

*Notes: (1) Heteroscedasticity-robust standard errors are employed; (2) *, **, and *** denote p < 0.1, p < 0.05 and p < 0.01, respectively; (3) ind*inno*d07 is expressed in hundreds; (4) the coefficients on controls (which are the same as in Table 11) and the constant are omitted.*

Table 13. Cross-section OLS regressions of roe3 on innovator-status dummies, interacted.

	1913			1936
	(1)	(2)	(3)	(1)
patd07	0.006	0.004		0.013***
tmd07	-0.014		-0.017	0.009
exhd07		0.026***	0.019**	
patd07*tmd07	0.014			-0.014*
patd07*exhd07		-0.007		
tmd07*exhd07			0.018	
indpatd07	0.129	-0.156		0.052**
indtmd07	-0.079*		-0.101**	0.004
indexhd		0.320**	0.306***	
N	521	513	513	1409
Adjusted R^2	0.222	0.224	0.231	0.143

*Notes: (1) Heteroscedasticity-robust standard errors are employed; (2) *, **, and *** denote p < 0.1, p < 0.05 and p < 0.01, respectively; (3) indpatd07, indtmd07, and indexhd are expressed in hundreds; (4) the coefficients on controls (which are the same as in Table 11) and the constant are omitted.*

innovation output can be excluded at short lags, as explained in the text; and because the inclusion of a lagged dependent variable violates exogeneity in fixed-effects estimation, performed in the robustness checks.

[29] Table A13 in the appendix investigates more deeply the timing of the effect of exhibiting, by means of three yearly regressions, for 1913 (the benchmark year), 1912, and 1911 (the Turin exhibition's year). Given the focus on precise time dynamics, the yearly *roe* is used, instead of *roe3*; consequently, control variables are not lagged. Interestingly, a (significant) increase in profitability takes place in 1912 and (not significant at conventional levels) in 1913, while no change occurs in 1911. These dynamics are consistent with the timing of the exhibition, which took place in the second half of 1911, and with the idea that exhibiting boosted firms' popularity and prestige, e.g. with the prizes awarded at the exhibition.

Table 14. Cross-section OLS regressions of roe3 on innovator-status dummies, geographical and sectoral analyses.

	inno = patd07		inno = tmd07		inno =exhd
	1913	1936	1913	1936	1913
Milan					
inno	0.028*	0.013**	-0.009	0.001	0.019
ind*inno*	-0.025	0.054***	-0.160*	0.016	0.266
N	157	502	157	502	155
Adjusted R^2	0.183	0.196	0.183	0.179	0.197
Metal-mechanical sectors					
inno	0.014	0.003	0.001	0.009	0.013
ind*inno*	0.096	0.008	0.017	0.115	0.055
N	124	351	124	351	124
Adjusted R^2	0.065	0.092	0.054	0.103	0.063

*Notes: (1) Heteroscedasticity-robust standard errors are employed; (2) *, **, and *** denote p < 0.1, p < 0.05 and p < 0.01, respectively; (3)* ind*inno is expressed in hundreds; (4) the coefficients on controls (which are the same as in Table 11) and the constant are omitted.*

Likewise, the coefficient on the number of competing exhibitors in the same sector (*indexhd*) is positive and significant: as the variable is expressed in hundreds, the estimated coefficient implies that 100 (10) exhibitors more in the same sector are associated with a 22.1 (2.2) p.p. higher *roe3*. The corresponding variable based on patent data, *indpatd07*, is not significant in 1913, but it is in 1936, implying that 10 additional patentees in the same sector are associated with a 0.5 p.p. higher *roe3*. Also *indtm07* is significant in 1936, but turns out to be sensitive to changes of dependent variable and sample.

Results on control variables are in line with expectations: significant negative coefficients are consistently estimated for (lagged) *capint*, *indebt*, and *iripart*, and positive ones for *rsize* and *conc* (though the latter does not always reach statistical significance), in line with the unconditional correlations discussed above. A negative interaction term *rsize*conc* moderates the effects of these two variables.[30]

The following three tables extend the analysis in several ways. While the regressions so far have compressed information on firm-level innovation into innovator-status dummies, Table 12 makes use of variables that reflect the frequency of a firm's patenting and trademarking activities, namely dummies that denote in how many years a firm takes patents or trademarks: 1 (inno*yr1*), 2 or 3 (inno*yr*23), or more than that (inno*yr*4m). The same (lagged) controls are employed as in Table 11; but they are omitted from the table, together with standard errors, for conciseness. Overall, the intensity of innovation does not seem to alter the general picture of insignificance as per Table 11, with the exception of patenting in 1913, for which it seems that the most frequent patentees have a *roe3* 3.2 p.p. higher than non-patentees. The significant positive coefficient attached to *patyr1* in 1936 turns out not to be robust to changes of dependent variable and sample.

Table 13 explores potential interaction effects between (pairs of) the three innovation measures. The non-interacted coefficients show a similar picture as per Table 11, in terms of sign and significance. The only interaction term that is significant at any conventional level is *patd07*tmd07* in 1936, which would imply a reduction in the profitability premium of patenting firms to zero, when they also take out trademarks. However, this result, besides being only mildly significant, is not robust to changes of dependent variable and sample.

Finally, Table 14 explores geographical and sectoral differences, by running regressions on subsamples of firms based in a particularly innovative location or sector, namely Milan (the most innovative city in the country by all measures) and metal-mechanical sectors. The

[30] Notice that, since both variables vary between 0 and 1, the marginal effect of *rsize* and *conc* remains positive, except in the case of very small sectors (see Table 9 for the number of firms in each sector), where the two variables may take values equal or close to 1.

regressions on the Milan subsample show significant coefficients in the first two columns, referring to patenting. However, they all turn out not to be robust to using the real-threshold sample, except for the coefficient on *patd07* in 1913, which is anyways only significant at the 10% level. Likewise, in the regressions on metal-mechanical sectors, all coefficients attached to *inno* and ind*inno* are not significant. Most striklingly, in both sets of regressions, the coefficient attached to *exhd* is not significant, while it was consistently significant in all regressions run on the full sample (Tables 11 to 13). On the one hand, this may be explained by the smaller samples on which these regressions are run. On the other, it may denote that the main results shown above are driven by less-innovative locations and sectors.

Robustness checks

As already mentioned in the text, a battery of robustness checks is run. First, the main regressions as per Equation 3 (Table 11) are re-run, employing a different dependent variable or sample. The profitability measures that are considered, as alternatives to *roe3*, are: the non-averaged *roe*, a two-year average over T-1 and T, called *roe2*; *roa* and its respective two- and three-year averages, *roa2* and *roa3*. Furthermore, smaller samples based on a constant-prices share capital threshold are used, as explained in Section 2, to enhance comparability between 1913 and 1936.

A second set of robustness checks addresses the potential endogeneity concerns mentioned above: by adding a lagged dependent variable to Equation 3, or using an IV approach, to account for potential reverse causality; and by running FE regressions, to control for time-invariant unobserved firm characteristics, such as managerial ability, which may affect both innovativeness and profitability. Results from these robustness tests are available in the appendix (Tables A14 to A16). Mismatches between the results from regressions using an alternative dependent variable or sample (Table A14) and the main regressions (Table 11) were already mentioned above in the text, when present. The rest of this subsection will therefore focus on the exercises tackling endogeneity.

Table A15 shows the exercises tackling reverse causality. The upper panel shows the results of a regression which adds to Equation 3 a lag of the dependent variable, namely its third lag *L3.roe3* (i.e. the average of *roe* between T−4 and T−2), which is chosen to avoid a direct relation with the dependent variable *roe3* (calculated over T−1 to T+1). As expected, the significant positive coefficient attached to the lagged dependent variable denotes a strong persistence of profits. Reassuringly, this does not alter the picture drawn so far: the only significant innovator-status variable is *exhd*, with an estimated coefficient only slightly lower than in Table 11; and significant coefficients are attached to sector-level variables *indpatd07* in 1936 and *indexhd* in 1913.

The middle and lower panels address reverse causality in a different way, namely by instrumenting the innovation variable with previous innovation. To do so, first, a different innovator-status dummy is created, *patd03* (*tmd03*), denoting whether a firm takes out patents (trademarks) over the four-year time window [T−3; T] (instead of [T−7; T] as in the main analysis). Then, this variable is instrumented by a "past innovator-status" dummy, *patd47* (*tmd47*), denoting whether a firm takes out patents (trademarks) over the previous four-year time window [T−7; T−4]. Notice that this approach cannot be employed for dummy *exhd*, as exhibition data only refers to a single point in time, i.e. the exhibition year 1911. While the OLS estimates of Equation 3, employing the innovation variables calculated over the shorter time window (middle panel of Table A15), show significant positive estimates for *patd03* in both 1913 and 1936, both coefficients lose significance when the variable is instrumented (bottom panel). Instead, *indpat03* remains positive and significant in 1936, much in line with Table 11.

Finally, we can exploit the longitudinal structure of IMITA.db and use FE estimation to control for time-invariant unobservables. Again, notice that this can be done for patenting and trademarking, but not for exhibiting, information on which is only available for a single year. The FE regression equation reads as follows:

$$(4) \qquad roe_{it} = \alpha_i + \sum_{j=0}^{3} \beta_j \text{inno}_{it-j} + \sum_{j=0}^{3} \gamma_j ind\text{inno}_{it-j} + \delta X_{it} + \theta_t + \varepsilon_{it}$$

where t indexes years in the [T−4; T] window (with T denoting a benchmark year); α_i is a firm fixed effect; and *inno* is either *patd* or *tmd*. Notice that *inno* and *ind*inno are now *yearly* dummies, entered with several lags. As a vector of time dummies, θ_t, controls for yearly macroeconomic fluctuations, the dependent variable is now *roe* (not its average, *roe3*). Consequently, the vector of controls, X_{it}, which includes the same variables as before, is not lagged.

Table A16 shows the long-run effects of *inno* and *ind*inno, according to pooled OLS and FE regressions. Long run effects can be calculated as the sums of the estimated coefficients on all lags of a certain variable, i.e. $\sum_{j=0}^{3} \hat{\beta}_j$ for *inno* and $\sum_{j=0}^{3} \hat{\gamma}_j$ for *ind*inno. In line with the cross-sectional evidence, the coefficients on own patenting and trademarking are never significant. In addition, also sector innovation variables are insignificant, with the exception of the FE coefficient *indpatd* for benchmark year 1936.[31]

Taking stock of all regressions so far, own patents and trademarks do not appear to boost firm profitability, irrespective of the frequency with which they are taken, or of their being used in combination or isolation. Instead, exhibiting is associated with significantly higher profitability. Furthermore, depending on the innovation measure and period, a higher number of competing innovating firms may result in higher profitability. These findings are robust to a large battery of checks, aiming at verifying the sensitivity of results to specific sample and variable choices, and at addressing endogeneity concerns. However, heterogeneity analyses show that they do not hold in the most innovative city (Milan) and in the most innovative sectors (metal-mechanical ones), which hints at them being driven by less innovative ones.

5.2 Long-term performance: survival

After investigating the relation between innovation and short-term firm performance, let's now turn to the nexus with long-term performance, as measured by firm survival. This is investigated by means of a Cox proportional-hazards model in which a firm's hazard rate h_i (which can be defined as the instantaneous failure rate) is regressed on the same set of variables as in Equation 3,[32] with the difference that independent variables are not lagged, as the reason for doing so is now irrelevant and that would reduce the number of observations. In formula:

$$(5) \qquad h_i(t|inno_{iT}, ind\text{inno}_{iT}, X_{iT}) = h_0(t)\exp(\beta_0 + \beta_1 inno_{iT} + \beta_3 ind\text{inno}_{iT} + \gamma X_{iT})$$

[31] When running regressions on the smaller samples based on the constant-prices capital threshold, the coefficient on *indpatd* in 1936 also turns insignificant, while that on *tmd* becomes significant at the 10% level. Cross-sectional regressions with *roe* as dependent variable, run on different years, reveal that a significant positive relation between *roe* and *indpatd* starts only in 1935, while it is not significant before. This helps reconciling the cross-sectional evidence, shown earlier in this section, with the results from the pooled OLS regression, run over the four years 1933-1936.

[32] In fact, the interaction between *conc* and *rsize* is removed, as coefficients are otherwise very unstable, most likely due to complete separation.

Table 15 shows the results of Cox regressions, where the failure event is a permanent exit. It should be noticed that coefficients are exponentiated, hence a coefficient larger (smaller) than one implies a positive (negative) relation between an independent variable and firm exit. The tables paint a picture that is practically specular to that resulting from the earlier short-term performance analysis: taking out either type of IPR is significantly negatively related to firm exit, hence positively related to survival, while exhibiting is unrelated to it. For example, the top-left coefficient in Table 16 denotes that the hazard rate is 22% lower (calculated as 0.781−1=−0.219) for patenting firms in 1913, compared to non-patenting firms. At the same time, the coefficient on the sector innovation variable (ind*inno*) is always insignificant. Finally, the estimated coefficients on controls are largely in line with expectations: older, larger, less capital-intensive, and less indebted firms show significantly better chances to survive. The only puzzle concerns *conc*, which has a positive relation with the hazard rate, when significant, whereas one would expect firms in concentrated industries, characterised by strong market power, to be better able to survive. *Scale* and *iri_part* are never significant: after controlling for them being typically larger and older, IRI-controlled firms thus turn not to have better chances to survive than other firms, in contrast with the significant unconditional correlation as per Table 3.

Table 15. Cox regressions, permanent exit hazard on innovator-status dummies.

	inno = patd07		inno = tmd07		inno =exhd
	1913	1936	1913	1936	1913
inno	0.781**	0.731***	0.874	0.783***	0.842
	(0.088)	(0.052)	(0.096)	(0.053)	(0.096)
ind*inno*	3.878	0.775	1.386	1.054	5.413
	(4.166)	(0.151)	(0.783)	(0.118)	(6.052)
age	0.983***	0.984***	0.983***	0.984***	0.986**
	(0.006)	(0.003)	(0.006)	(0.003)	(0.006)
capint	1.933***	1.578***	1.988***	1.578***	1.899***
	(0.438)	(0.199)	(0.462)	(0.198)	(0.460)
indebt	1.879***	1.353***	1.848***	1.332**	2.018***
	(0.366)	(0.150)	(0.359)	(0.150)	(0.404)
rsize	0.171**	0.003**	0.145**	0.003**	0.146***
	(0.121)	(0.007)	(0.113)	(0.007)	(0.108)
conc	2.978***	1.148	2.372*	1.212	3.214***
	(1.104)	(0.294)	(1.119)	(0.392)	(1.241)
scale	0.983	0.997	0.989	0.996*	0.982
	(0.019)	(0.002)	(0.017)	(0.002)	(0.018)
iripart		0.882		0.867	
		(0.172)		(0.168)	
N	611	1685	611	1685	586
Pseudo R^2	0.007	0.008	0.006	0.008	0.007

*Notes: (1) Heteroscedasticity-robust standard errors are employed; (2) *, **, and *** denote p < 0.1, p < 0.05 and p < 0.01, respectively; (3) ind*inno *is expressed in hundreds.*

Table 16. Cox regressions, permanent exit hazard on innovation-years dummies.

	inno = pat		inno = tm	
	1913	1936	1913	1936
*inno*yr1	0.774*	0.749***	0.875	0.853*
*inno*yr23	0.857	0.709***	0.855	0.778**
*inno*yr4m	0.675	0.707**	0.978	0.601***
ind*inno*d07	3.897	0.780	1.382	1.075
N	611	1685	611	1685
Pseudo R^2	0.007	0.008	0.006	0.008

*Notes: (1) Heteroscedasticity-robust standard errors are employed; (2) *, **, and *** denote p < 0.1, p < 0.05 and p < 0.01, respectively; (3) ind*innod07 *is expressed in hundreds; (4) the coefficients on controls (which are the same as in Table 15) are omitted.*

Next, the same extension analyses are presented as done above for short-term performance, namely: Table 16 shows estimates of Cox regressions with regressors denoting the frequency of innovation; Table 17 explores interaction effects; and Table 18 investigates geographical and sectoral specificities. In the interest of space, these analyses are shown only for permanent exit and without reporting standard errors, as in Subsection 4.1. Interestingly, Table 16 shows lower coefficients, hence better survival chances, for firms in the benchmark year 1936 with more years in which they take out IPRs; which is again in sharp contrast with results from the short-term analysis. A similarity, however, emerges from Table 17, finding no significant interaction effects. Finally, based on Table 18, results for Milan-based firms are substantially in line with those from the main regression (Table 15), except for the fact that also the coefficient attached to *exhd* is now significant. This is not the case in regressions on firms belonging to metal-mechanical sectors, where instead the positive relation between both IPRs and survival is confirmed for firms in the benchmark year 1936 only.

Table 17. Cox regressions, permanent exit hazard on innovator-status dummies, interacted.

	1913			1936
	(1)	(2)	(3)	(1)
patd07	0.765**	0.830		0.768***
tmd07	0.855		0.792*	0.824**
exhd07		0.896	0.805*	
patd07*tmd07	1.137			0.987
patd07*exhd07		0.975		
tmd07*exhd07			1.267	
indpatd07	4.728			0.704
indtmd07	0.974	0.828	0.852	1.125
indexhd		7.050	7.881*	
N	611	586	586	1685
Adjusted R^2	0.007	0.007	0.007	0.009

*Notes: (1) Heteroscedasticity-robust standard errors are employed; (2) *, **, and *** denote p < 0.1, p < 0.05 and p < 0.01, respectively; (3) indpatd07, indtmd07, and indexhd are expressed in hundreds; (4) the coefficients on controls (which are the same as in Table 15) are omitted.*

Table 18. Cox regressions, permanent exit hazard on innovator-status dummies, geographical and sectoral analyses.

	inno = patd07		inno = tmd07		inno =exhd
	1913	1936	1913	1936	1913
Milan					
inno	0.701*	0.759**	0.819	0.714***	0.625**
ind*inno*	0.570	0.555*	1.489	1.001	0.086
N	173	594	173	594	165
Adjusted R^2	0.013	0.008	0.011	0.008	0.017
Metal-mechanical sectors					
inno	0.764	0.775**	1.341	0.705**	0.712
ind*inno*	0.412	0.370	0.005	0.135	7.001
N	146	403	146	403	145
Adjusted R^2	0.011	0.011	0.012	0.011	0.013

*Notes: (1) Heteroscedasticity-robust standard errors are employed; (2) *, **, and *** denote p < 0.1, p < 0.05 and p < 0.01, respectively; (3)* indinno *is expressed in hundreds; (4) the coefficients on controls (which are the same as in Table 15) are omitted.*

Robustness checks

Also for the long-term performance analysis, a battery of robustness checks is performed, making use of different measures of firm survival. First, general exits are employed instead of permanent exits. Second, the alternative versions of both exit variables, based on a constant-prices share capital threshold, are employed. Notice that these robustness regressions are run on a smaller sample, as the constant-prices threshold is also used for determining inclusion in the sample, as explained in Section 2. Finally, dummy *surv_bench*, denoting survival between two benchmark years separated by 23-24 years, is considered; which requires a different regression method, namely a probit model. Again, results from the robustness checks are shown in the appendix (Tables A17 to A19).

The Cox regressions using general exits as failure events (Table A17) are practically congruent to those using permanent exists (Table 15) , in terms of sign, size, and significance of the estimated coefficients on the innovation variables; the only noticeable difference being a significant coefficient on *tmd07* in 1913 as well. Furthermore, the regression using the real-threshold exit measures (Table A18) are in line with the main Cox regressions (Tables 15 and A17) except for the coefficient on *exhd* (barely) gaining significance in the regressions using general exits, and that on *patd07* losing it in the 1913 regressions using permanent exits.

Finally, the probit model with the dummy *surv_bench* as dependent variable reads as follows:

(6) $$\Pr(surv\_bench_{iT} = 1 \mid inno_{iT}, ind\text{inno}_{iT}, X_{iT}) = \Phi(\beta_0 + \beta_1 inno_{iT} + \beta_3 ind\text{inno}_{iT} + \gamma X_{iT}), T = 1913, 1936$$

Results from the probit (Table A18) are in line with those from the Cox regressions: patentees are significantly more likely to survive than non-patentees, by 11% in 1913 and by 12% in 1936. The same applies for firms taking trademarks, although the effect is only significant for 1936. Instead, exhibiting is not significantly related to survival. Furthermore, the number of other innovating firms in the same sector is generally insignificant, irrespective of the innovation variable employed.

Taking stock, results for long-term performance, as measured by survival, are specular to those observed for short-term profitability: a firm's survival is significantly positively associated with its own patenting and trademarking, especially when the latter have high frequency; but not with exhibiting. The number of innovators in the same sector is never significantly related to survival, irrespective of the innovation measure. No significant interaction effects are found. Robustness tests confirm these claims.

6. Conclusions

This paper contributes to the literature on the role of innovation in Italy's historical process of growth by presenting, for the first time, systematic evidence on the occurrence of innovative activities among Italian firms in the first half of the twentieth century, as well as on the relation of these activities with business performance in the short and in the long run. It measures innovative activities in a comprehensive way, using multiple gauges, namely patents, trademarks, and participation in the Turin 1911 International Exhibition. It focuses on two important and formative periods for the Italian economy, namely the (late years of the) Giolittian growth spurt, and the 1930s, during which Italy's industrial sector reorganised under the intervention of the state.

A multifaceted picture emerges. First, innovative activities turn out to be widespread among Italian firms, to an extent that may seem surprising for a technological laggard country such as Italy at that time. Around 40% of the firms in the sample were involved in patenting or trademarking in both 1913 and 1936. If exhibiting is added to the picture, the share of innovative firms rises to around 50%. While these shares are remarkable, they must be weighed against the fact that many of the firms classified as innovative took out IPRs with low frequency and intensity. Furthermore, it should be kept in mind that IMITA.db is a sample of large joint-stock firms, which are likelier to innovate. When these aspects are factored in, the evidence can more easily be reconciled with Toninelli and Vasta's (2014) estimate of the share of "Schumpeterian" entrepreneurs in Italy (21.5%).

The paper then assesses the relation between firm-level innovative activities and business performance, distinguishing between short-term performance, as measured by profitability, and long-term performance as measured by survival. After controlling for potential firm- and sector-level confounders, patenting and trademarking turn out not to be related to profitability (irrespective of their frequency), while exhibiting is. At the same time, a positive relation between a firm's profitability and competing firms' innovation activities emerges, depending on the innovation variable and period. Heterogeneity analyses show that these results do not hold in the most innovative city (Milan) and in the most innovative sectors (metal-mechanical ones). When looking at survival, specular results emerge: patenting and trademarking are associated to better chances to survive (and the strength of the association increases with their frequency); while the relation is not significant in the case of exhibiting. In this case, results do not look different for Milan and the metal-mechanical sectors.

Different points deserve discussion. First, own patenting and trademarking do not appear to be a driver of short-run competitiveness for Italian manufacturing firms in the two periods under study; however, firms seem able to turn innovations from their competitors into profits. This lends itself to a positive interpretation, as it may be a sign that Italian firms possessed adequate absorptive capabilities to use effectively externally-generated knowledge – a point already made by previous literature (e.g. Giannetti 1998); as well as to a negative one, as imitation might be a substitute for own innovative efforts. The fact that the relation between competing firms' innovation and own profitability does not emerge when looking at the most innovative city and sectors, hence is driven by less innovative ones, is in line with the idea that firms far from the technological frontier rely on the imitation of technologies developed by leading innovators.[33] Furthermore, to the extent that productivity and profitability are related (see e.g. Bottazzi, Secchi, and Tamagni, 2008, on present-day Italy), this paper's results may suggest that the positive effect of patenting on aggregate productivity observed by Nuvolari and Vasta (2017) stems from efficiency gains in lagging imitating firms, rather than in leading innovative ones.

On the other hand, own innovative activities did matter for firms' long-run performance, while the imitation of competing firms' innovation did not. This is in accordance with Geroski and Machin's (1993) argument that the main channel through which innovation benefits firm performance is by endowing them with superior capabilities that make them less sensitive to cyclical fluctuations, rather than by boosting profitability in the short term. From a historical point of view, these findings about the long-term performance-innovation nexus imply that innovation contributed to shaping the Italian capitalist landscape, with large innovative firms forming an industrial core that was relatively stable over time. In light of the mechanism sketched above, this core might have favoured the technological upgrading of competing imitating firms, and thus contributed to the good economic performance of the country in the twentieth century (also) through this indirect channel.

The resulting picture of a stable core of innovative firms, surrounded by laggard firms deriving competitiveness by absorbing externally generated knowledge, is quite well in tune

[33] This interpretation is also backed by an additional cross-section regression exercise, where Equation 3 is run on three subsamples defined by a firm's innovator status: the first (second) includes firms for which an innovator status variable (*patd07*, *tmd07*, or *exhd*) equals one (zero), while the third includes firms for which *all* innovator status variables equal zero at the same time (hence differs from the second in as much as some firms are involved in some innovation activity but not in others). Results from this exercise, shown in Table A20 in the appendix, show that the significant positive coefficients on *ind*inno displayed in the main regression output (Table 11) are driven by non-innovative firms in the case of trademarking in 1936 and exhibiting in 1913, though not in the case of patenting in 1936.

with Malerba's (1993) account of Italy's national innovation system in the late twentieth century. That author highlighted the dual nature of the system, which he described as articulated into "small firm networks", successful in adaptations and incremental innovations, and a rather frail core R&D system, including large firms. This paper's results show that the duality of Italy's national innovation system has deep historical roots.

A final point deserving attention is the difference in results between patenting and trademarking, on one side, and exhibiting, on the other: unlike the other measures, exhibiting is significantly related to profitability, but not to survival. This is consistent with a view of exhibiting as representing firms' commercialisation and advertisement of their (not necessarily innovative) products, rather than the introduction of new products. Furthermore, the puzzling finding that the return from exhibiting disappears in locations and sectors where a large share of firms are innovative can be rationalised by thinking that exhibitions' signalling effect is particularly important for firms that need to establish their reputation as innovative, in environments where most firms are not. This possible signalling effect is in tune with Domini's (2019) evidence that exhibitions were key events for individual inventors to establish their reputation and foster their careers – even though most of the items on display were not innovative. This makes it clear that, while exhibition data appear to capture different activities than patenting and trademarks, exhibitions still played an important role for innovators.

All in all, this paper draws a wide and complex picture. Innovative activities appear widespread among Italian (large) firms in the period under study. Firms appear to possess effective absorptive capabilities, enabling them to turn external innovations into profits. Finally, innovation is a significant determinant of firm survival; which might have led to the formation of a cluster of core innovative firms, able to exert positive spillover effects on the entire industry thanks to absorption by laggard firms. A decline of innovation in this innovative core might therefore hamper the ability of the entire system to upgrade technologically. Future research, covering the post-WWII era, should provide firm-level evidence on to what extent a rise and decline in the innovative activities of core innovative firms took place and could be a contributor to the country's productivity stagnation in the most recent decades. Particular attention should be devoted to firms controlled by IRI, which this study observed to be particularly innovative, though they represented only 2% of firms in the 1936 sample. As IRI expanded considerably in the following decades, it might have played an important role in the dynamics of Italy's innovative activity.

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Appendix

Table A1. IMITA.db's coverage of the universe of patentees, trademarkers, and exhibitors.

	T	[T-7; T]
Patentees in IMITA.db benchmark 1913	47	155
% in firms in IMITA.db benchmark 1913 (founded 1911)	7.93	26.14
% in total Italian patentees in 1911	2.77	9.13
% in firm Italian patentees in 1911	26.70	88.07
Patentees in IMITA.db benchmark 1936	146	455
% in firms in IMITA.db benchmark 1936	8.28	25.79
% in total Italian patentees in 1936	4.02	12.54
% in firm Italian patentees in 1936	29.44	91.73
Trademarkers in IMITA.db benchmark 1913	44	141
% in firms in IMITA.db benchmark 1913 (founded 1911)	7.42	23.78
% in total Italian trademarkers in 1913	7.11	22.78
Trademarkers in IMITA.db benchmark 1936	143	464
% in firms in IMITA.db 1936	8.11	26.30
% in total Italian trademarkers in 1936	10.72	34.78
Exhibitors in IMITA.db benchmark 1913	178	
% in firms in IMITA.db benchmark 1913 (founded 1911)	30.02	
% in total Italian exhibitors in 1911	7.84	
% in firm Italian exhibitors in 1911	13.27	

Sources: the denominators employed for computing the shares in Italian patentees are based on data provided by A. Nuvolari and M. Vasta; for the shares in trademarkers, on ACS data; for the shares in exhibitors, on data from Domini (2019).

Table A2. Summary statistics, variables used in robustness checks.

	1913					1936				
	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
roe	617	0.02	0.17	-1.00	0.44	1,704	0.02	0.13	-1.00	0.47
roe2	595	0.02	0.13	-1.00	0.45	1,636	0.02	0.10	-1.00	0.44
roa										
roa2	595	0.02	0.12	-2.13	0.42	1,637	0.02	0.06	-1.07	0.32
roa3										
rsize	617	0.03	0.08	0.00	1.00	1,706	0.01	0.04	0.00	0.73
surv_temp	616	15.90	10.34	1.00	28.00	1706	3.64	1.09	1.00	5.00
surv_temp_real	504	11.71	12.93	1.00	60.00	1125	14.38	13.61	1.00	37.00
surv_perm_real	504	30.26	24.31	1.00	60.00	1125	28.42	11.43	1.00	37.00
surv_bench	624	0.47	0.50	0.00	1.00	1,764	0.48	0.50	0.00	1.00
surv_bench_real	624	0.47	0.50	0.00	1.00	1,764	0.43	0.49	0.00	1.00

Table A3. Share (%) of firms with patents and/or trademarks (four-year time window) in all firms in benchmark years 1913 (N=624) and 1936 (N=1764).

	1913			1936		
	tmd03=0	tmd03=1	Total	tmd03=0	tmd03=1	Total
patd03=0	68.75	11.70	80.45	66.72	13.66	80.39
patd03=1	14.42	5.13	19.55	12.47	7.14	19.61
Total	83.17	16.83	100.00	79.20	20.80	100.00

Table A4. Share (%) of firms exhibiting in the Turin 1911 International Exhibition and with patents or trademarks (four-year time window) in all firms benchmark year 1913 that were founded in 1911 or earlier (N=593).

	patd03=0	patd03=1	tmd03=0	tmd03=1	Total
exhd=0	62.56	7.42	59.53	10.46	69.98
exhd=1	17.54	12.48	23.44	6.58	30.02
Total	80.10	19.90	82.97	17.03	100.00

Table A5. Share (%) of firms taking out certain numbers of patents/trademarks, and taking out patents/trademarks for certain numbers of years (four-year time window), in all firms taking out patents/trademarks in benchmark years 1913 and 1936.

	1913		1936	
	Patents (N=155)	TMs (N=141)	Patents (N=455)	TMs (N=464)
Units of patents/TMs				
1	44.26	58.1	48.55	39.78
2	19.67	19.05	19.94	17.17
3	13.11	11.43	8.09	8.72
≥4	22.96	11.42	23.42	34.33
Years with patents/TMs				
1	54.92	72.38	61.85	58.86
2	22.95	22.86	21.39	22.07
3	12.30	1.90	7.80	11.44
≥4	9.84	2.86	8.96	7.63

Table A6. Share (%) of firms with patents and/or trademarks in all firms in ISIC Rev. 3 divisions 27-35 in benchmark years 1913 (N=151) and 1936 (N=416).

	1913			1936		
	tmd07=0	tmd07=1	Total	tmd07=0	tmd07=1	Total
patd07=0	41.72	7.95	49.67	44.71	5.77	50.48
patd07=1	38.41	11.92	50.33	32.69	16.83	49.52
Total	80.13	19.87	100.00	77.40	22.60	100.00

Table A7. Share (%) of firms exhibiting in the Turin 1911 International Exhibition and with patents or trademarks in all firms in ISIC Rev. 3 divisions 27-35 in benchmark year 1913 that were founded in 1911 or earlier (N=148).

	No patents	Patents	No TMs	TMs	Total
No exhibit	33.78	12.16	37.84	8.11	45.95
Exhibit	15.54	38.51	41.89	12.16	54.05
Total	49.32	50.68	79.73	20.27	100.00

Table A8. Share (%) of firms taking out certain numbers of patents/trademarks, and taking out patents/trademarks for certain numbers of years, in all firms in ISIC Rev. 3 divisions 27-35 taking out patents/trademarks in benchmark years 1913 and 1936.

	1913		1936	
	Patents (N=76)	TMs (N=30)	Patents (N=206)	TMs (N=94)
Units of patents/TMs				
1	19.74	56.67	27.67	48.94
2	18.42	20.00	21.84	15.96
3	18.42	23.33	8.74	5.32
≥4	43.42	0.00	41.75	29.78
Years with patents/TMs				
1	26.32	73.33	33.98	59.57
2	25.00	23.33	24.27	22.34
3	21.05	3.33	12.62	6.38
≥4	27.63	0.00	29.13	11.71

Table A9. Share (%) of firms with patents and/or trademarks in all firms in Milan in benchmark years 1913 (N=178) and 1936 (N=623).

	1913			1936		
	tmd07=0	tmd07=1	Total	tmd07=0	tmd07=1	Total
patd07=0	46.63	23.03	69.66	49.6	17.5	67.09
patd07=1	17.98	12.36	30.34	17.5	15.41	32.91
Total	64.61	35.39	100.00	67.09	32.91	100.00

Table A10. Share (%) of firms exhibiting in the Turin 1911 International Exhibition and with patents or trademarks in all firms in Milan in benchmark year 1913 that were founded in 1911 or earlier (N=167).

	patd07=0	patd07=1	tmd07=0	tmd07=1	Total
exhd=0	55.09	10.18	44.31	20.96	65.27
exhd=1	14.37	20.36	19.76	14.97	34.73
Total	69.46	30.54	64.07	35.93	100.00

Table A11. Share (%) of firms taking out certain numbers of patents/trademarks, and taking out patents/trademarks for certain numbers of years, in all firms in Milan taking out patents/trademarks in benchmark years 1913 and 1936.

	1913		1936	
	Patents (N=54)	TMs (N=63)	Patents (N=205)	TMs (N=205)
Units of patents/TMs				
1	33.33	42.86	42.44	37.07
2	20.37	19.05	17.56	17.07
3	12.96	15.87	9.76	6.83
≥4	33.34	22.22	30.24	39.03
Years with patents/TMs				
1	42.59	58.73	50.24	50.24
2	24.07	20.63	23.41	18.54
3	16.67	9.52	6.34	15.61
≥4	16.67	11.12	20.01	15.61

Table A12. Top 5 companies by number of patents and trademarks in 1913 and 1936.

Name	Location	Division	Patents	TMs	Exhibits
Top patentees in 1913					
A.E.G. Thomson Houston	Milano	31	66	2	no
Società Italiana Gio. Ansaldo & C.	Roma	29	59	3	yes
United Shoe Machinery Company d'Italia	Milano	29	37	0	yes
Società Italiana Koerting	Genova	29	26	0	yes
Fiat Fabbrica Italiana Automobili Torino	Torino	34	25	0	yes
Top patentees in 1936					
C.G.E. Compagnia Generale di Elettricità	Milano	31	256	31	
Pirelli	Milano	25	208	61	
F.I.A.T.	Torino	34	195	7	
Compagnia Italiana Westinghouse Freni e Segnali	Torino	35	169	1	
Fabbrica Italiana Magneti Marelli	Milano	31	99	8	
Top trademarkers in 1913					
Manifattura di Tessuti Candidi	Milano	17	0	34	no
Cucirini Cantoni Coats	Milano	17	0	19	no
Fabbriche Riunite di Fiammiferi	Milano	36	1	14	yes
Florio & C. Società Anonima Vinicola Italiana	Milano	15	0	11	no
Manifattura Italiana Cinghie Massoni & Moroni	Milano	19	1	10	yes
Top trademarkers in 1936					
De Angeli Frua Società per l'Industria dei Tessuti Stampati	Milano	17	3	80	
Franck Industria Nazionale di Succedanei al Caffè	Milano	15	0	73	
Stabilimenti Italiani Gibbs	Milano	24	1	72	
Cucirini Cantoni Coats	Milano	17	1	65	
Pirelli	Milano	25	208	61	

Note: patents granted in the benchmark year and in the preceding seven years are considered.

Table A13. Cross-section OLS regressions of roe on exhibitor dummy, years 1911 to 1913.

	1913	1912	1911
exhd	0.019	0.028***	-0.010
indexhd	0.202	0.111	0.016
N	586	582	561
Adjusted R^2	0.226	0.131	0.113

*Notes: (1) Heteroscedasticity-robust standard errors are employed; (2) *, **, and *** denote $p < 0.1$, $p < 0.05$ and $p < 0.01$, respectively; (3) indexh is expressed in hundreds.*

Table A14. Cross-section OLS regressions: alternative sample and dependent variables.

	inno = patd07		inno = tmd07		inno =exhd
	1913	1936	1913	1936	1913
Real-threshold sample					
inno	0.010	0.005	-0.004	0.005	0.020***
ind*inno*	-0.061	0.038*	-0.048	0.007	0.167**
N	385	559	385	559	379
Adjusted R^2	0.240	0.106	0.239	0.101	0.236
Dep. var.: roe2					
inno	0.008	0.004	0.002	0.001	0.021*
ind*inno*	-0.074	0.056***	-0.066	0.016	0.171
N	589	1609	589	1609	580
Adjusted R^2	0.220	0.122	0.220	0.116	0.216
Dep. var.: roe					
inno	0.004	0.007	0.004	0.005	0.019
ind*inno*	0.054	0.062***	-0.034	0.019	0.202
N	612	1683	612	1683	586
Adjusted R^2	0.214	0.111	0.214	0.107	0.226
Dep. var.: roa3					
inno	0.006	0.003	0.005	0.004*	0.018***
ind*inno*	0.115	0.034***	0.038	0.011**	0.223***
N	521	1410	521	1410	513
Adjusted R^2	0.322	0.206	0.320	0.198	0.340
Dep. var.: roa2					
inno	0.008	-0.004	0.007	0.001	0.021**
ind*inno*	0.064	0.029***	0.048	0.008	0.195**
N	589	1611	589	1611	580
Adjusted R^2	0.284	0.147	0.284	0.143	0.296
Dep. var.: roa					
inno	0.007	-0.006	0.009	0.002	0.023**
ind*inno*	0.184	0.020**	0.075	0.003	0.281***
N	612	1685	612	1685	586
Adjusted R^2	0.218	0.112	0.217	0.110	0.230

*Notes: (1) Heteroscedasticity-robust standard errors are employed; (2) *, **, and *** denote $p < 0.1$, $p < 0.05$ and $p < 0.01$, respectively; (3) ind*inno *is expressed in hundreds; (4) the coefficients on controls (which are the same as in Table 11) and the constant are omitted.*

Table A15. Cross-section OLS regressions: tackling reverse causality.

	inno = patd		inno = tmd		inno =exhd
	1913	1936	1913	1936	1913
Lagged dep. var.					
L3.roe3	0.187***	0.260***	0.183***	0.257***	0.180***
*inno*07	0.007	0.004	-0.006	0.004	0.021***
ind*inno*07	0.101	0.063***	-0.030	0.019**	0.194*
N	456	1220	456	1220	456
Adjusted R^2	0.258	0.307	0.257	0.295	0.269
Window [T; T-3]					
*inno*03	0.014*	0.008*	0.001	0.002	
ind*inno*03	0.276**	0.069***	-0.053	0.023**	
N	521	1409	521	1409	
Adjusted R^2	0.229	0.143	0.220	0.133	
IV estimation					
*inno*03	-0.005	0.011	0.003	0.010	
ind*inno*03	0.300**	0.068**	-0.054	0.021*	
N	521	1409	521	1409	
Adjusted R^2	0.223	0.142	0.220	0.131	

*Notes: (1) Heteroscedasticity-robust standard errors are employed; (2) *, **, and *** denote p < 0.1, p < 0.05 and p < 0.01, respectively; (3)* indinno*07 and* indinno*03 are expressed in hundreds; (4) the coefficients on controls (which are the same as in Table 11) and the constant are omitted.*

Table A16. Panel regressions of roe on innovator-status dummies, long-run effects.

	inno = patd		inno = tmd	
	1913	1936	1913	1936
Pooled OLS				
inno	0.012	-0.008	0.030	0.007
ind*inno*	-0.003	0.000	0.000	0.000
N	2829	7778	2829	7778
N groups	616	1710	616	1710
Adjusted R^2	0.144	0.148	0.145	0.148
FE				
inno	0.012	-0.017	0.054	0.018
ind*inno*	0.008	0.003*	0.007	-0.000
N	2829	7778	2829	7778
N groups	616	1710	616	1710
Adjusted R^2	0.096	0.109	0.098	0.108

*Notes: (1) Standard errors are clustered at the firm level; (2) *, **, and *** denote p < 0.1, p < 0.05 and p < 0.01, respectively; (3)* indinno *is expressed in hundreds; (4) long-run effects are calculated as the sum of lags 0 to 3 for a given variable; (5) the coefficients on controls (which are the same as in Table 11) and the constant are omitted.*

Table A17. Cox regressions, general exit hazard on innovator-status dummies.

	inno = patd07		inno = tmd07		inno =exhd
	1913	1936	1913	1936	1913
inno	0.775**	0.596***	0.809*	0.707**	0.879
	(0.096)	(0.101)	(0.102)	(0.113)	(0.105)
ind*inno*	1.945	0.864	0.867	1.015	0.879
	(2.205)	(0.350)	(0.511)	(0.241)	(0.105)
age	0.982**	0.986**	0.981**	0.985**	0.983**
	(0.007)	(0.006)	(0.007)	(0.007)	(0.007)
capint	2.023***	2.056***	1.993***	2.089***	1.998***
	(0.489)	(0.532)	(0.491)	(0.537)	(0.510)
indebt	2.041***	1.746***	2.000***	1.780***	1.978**
	(0.542)	(0.366)	(0.532)	(0.367)	(0.541)
rsize	0.194*	0.000**	0.187*	0.000**	0.138*
	(0.181)	(0.000)	(0.180)	(0.000)	(0.143)
conc	2.597**	2.744*	1.751	2.376	2.190*
	(1.047)	(1.516)	(0.868)	(1.670)	(0.949)
scale	0.971	0.996	0.973	0.996	0.975
	(0.020)	(0.005)	(0.018)	(0.005)	(0.021)
iripart		1.255		1.202	
		(0.473)		(0.447)	
N	611	1685	611	1685	586
Pseudo R^2	0.008	0.016	0.008	0.015	0.007

*Notes: (1) Heteroscedasticity-robust standard errors are employed; (2) *, **, and *** denote p < 0.1, p < 0.05 and p < 0.01, respectively; (3) ind*inno *is expressed in hundreds.*

Table A18. Cox regressions using real-threshold exit variables and samples.

	inno = patd07		inno = tmd07		inno =exhd
	1913	1936	1913	1936	1913
Dep. var.: surv_temp_real					
inno	0.784**	0.705*	0.776**	0.753*	0.822*
ind*inno*	0.925	1.124	1.196	0.445**	1.248
N	436	613	436	613	421
Adjusted R^2	0.018	0.031	0.019	0.034	0.019
Dep. var.: surv_perm_real					
inno	0.834	0.767**	1.015	0.698***	0.929
ind*inno*	3.618	1.104	0.762	1.032	14.655*
N	436	613	436	613	421
Adjusted R^2	0.006	0.009	0.005	0.010	0.006

*Notes: (1) Heteroscedasticity-robust standard errors are employed; (2) *, **, and *** denote p < 0.1, p < 0.05 and p < 0.01, respectively; (3) ind*inno *is expressed in hundreds; (4) the coefficients on controls (which are the same as in Table 15) are omitted.*

Table A19. Probit regressions of surv_bench on innovator-status dummies, average marginal effects.

	inno = patd07		inno = tmd07		inno = exhd
	1913	1936	1913	1936	1913
Dep. var.: surv_bench					
inno	0.110**	0.124***	0.051	0.102***	0.060
ind*inno*	-0.170	0.106	-0.023	0.021	-0.575
N	612	1685	612	1685	586
Pseudo R^2	0.051	0.066	0.046	0.063	0.050
Dep. var.: surv_bench_real					
inno	0.104**	0.085**	0.011	0.139***	0.005
ind*inno*	-0.278	-0.036	0.211	0.036	-1.012*
N	436	613	436	613	421
Pseudo R^2	0.049	0.049	0.044	0.061	0.047

*Notes: (1) Heteroscedasticity-robust standard errors are employed; (2) *, **, and *** denote p < 0.1, p < 0.05 and p < 0.01, respectively; (3) ind*inno *is expressed in hundreds; (4) the coefficients on controls (which are the same as in Tables 16 and 17) are omitted.*

Table A20. Cross-section OLS regressions: split samples by innovator status.

	1913			1936		
	inno=1	*inno*=0	patd07=0 tmd07=0 exhd=0	*inno*=1	*inno*=0	patd07=0 tmd07=0 exhd=0
inno = patd07						
ind*inno*	-0.074	0.056	-0.027	0.062***	0.058***	0.067***
N	129	392	252	412	997	770
Adjusted R^2	0.144	0.241	0.272	0.139	0.15	0.136
inno = tmd07						
ind*inno*	-0.198	-0.032	-0.043	0.003	0.025**	0.028**
N	119	402	252	408	1001	770
Adjusted R^2	0.212	0.235	0.273	0.157	0.121	0.131
inno = exhd						
ind*inno*	0.258	0.201*	0.287**			
N	152	361	252			
Adjusted R^2	0.131	0.238	0.286			

Notes: (1) The specification is as per Equation 3, with the exception that inno *is missing, as it lacks variability in samples defined by it taking specific values; (2) Heteroscedasticity-robust standard errors are employed; (3) *, **, and *** denote p < 0.1, p < 0.05 and p < 0.01, respectively; (4) ind*inno *is expressed in hundreds; (4) the coefficients on controls (which are the same as in Tables 16 and 17) are omitted.*