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UPWIND SAILORS. FINANCIAL PROFILE OF INNOVATIVE ITALIAN FIRMS DURING THE DOUBLE-DIP RECESSION

by Daniele Pianeselli*

Abstract

We examine the issue of patents of Italian non-financial firms over the period 2008–2012, during which the Italian economy was hit by two almost consecutive recessions. We classify firms according to their patenting activity, taking into consideration their financial characteristics. We find that innovation is concentrated in the manufacturing sector, where very few large firms maintain a persistent level of inventive capacity. Firms increased their average patenting slightly during the crisis compared to the period 2003–2007. Since Italian innovating firms are large and mature, a higher cash flow and a lower indebtedness allow them to fund patent-generating activity using internal resources. Moreover, innovating firms grow faster than non-innovating ones, even during recessions.

JEL Classification: G010, G300, O300.
Keywords: innovation, crisis, financial profile, Italian firms.

Contents

* Bank of Italy, Directorate General for Economics, Statistics and Research. Economic Outlook and Monetary Policy Directorate.

1 Introduction*

The gap in innovation is considered a key factor behind the poor performance of the Ital-ian economy with respect to that of the other European countries (Bugamelli et al., 2012). According to the "2017 Global Innovation Index" report,[1] Italy ranks only 29th among the world's most-innovative economies, followed in Europe by Portugal and Greece. This feature is not recent but dates back to the previous decades. In 2002 the number of successful Italian applications to the European Patent Office was 74 per million inhabitants against an average of 158 for the other European firms (Scellato, 2007).

In this paper, we analyze the innovative performance, measured by the number of patents issued, for a sample of 162,959 Italian firms during the period 2008–12, in which the Italian economy was hit by the Global Financial and Sovereign Debt crises. These crises caused a strong double-dip recession, which severely hit the Italian industrial system. The aim of this study is to establish a link between the financial structure of innovative and non-innovative firms and their ability to develop patents. We overcome the classical dichotomy between innovators and non-innovators by dividing firms into categories of non-innovators, occasional, medium and great innovators. Consequently, we use between-group differences measured on a large set of financial ratios in order to define each specific financial profile.

Our results can be summarized as follows. First, we examine the patenting activity of Italian firms and the relative contribution of each sector to innovation, focusing on manufacturing, which alone accounts for the great majority of patents. Second, we compare the degree of persistence of patenting activity during the crisis period (2008–12) with respect to the previous period (2003–07). This analysis highlights the intensification of innova-tion activity during the crisis due to the increase in the extensive margin (from the status of non-innovator to occasional and medium innovator), but also in the intensive margin (from occasional to medium innovators status). Third, by using a ratio analysis and a regression analysis, we document that innovating firms are characterized by larger cash flow, profitability, rate of output growth and a specific capital structure. In this paper, we do not attempt to provide any causal interpretation, rather we present a comprehensive description of the phenomenon by reporting specific patterns and suggesting interesting areas for further research.

The remainder of the paper is organized as follows. Section 2 reviews the existing literature on the financial structure of innovative firms, while Section 3 describes the data and the methodology and provides summary statistics on the sample. Section 4 presents empirical evidence aimed at examining the financial profile of innovators. Section

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[1] This annual report of countries' innovative capabilities is jointly published by Cornell University, INSEAD, and the World Intellectual Property Organization. The latest edition is available at https://www.globalinnovationindex.org/home.

5 concludes.

2 Financial structure and innovation

The problem of selecting the right type of capital to finance investments whose yields are uncertain has been long debated both in the theoretical and empirical literature. The main contribution dates back to the famous paper by Modigliani and Miller (1958), which deals with the notion of the cost of capital and its implications in explaining firms' investment behavior. Theories of capital structure and financial behavior departed from Modigliani and Miller's (1958) conclusion that the source of funding is irrelevant, highlighting the effects of the presence of capital market imperfections.

With particular regard to investments in R&D, the existence of asymmetric information and moral hazard may explain why companies may favor specific sources of financing (Hall and Lerner, 2009). Asymmetric information stems from the different degree of information on project risk and quality between firms and investors (Akerlof, 1970). Moral hazard problems may arise from the possible diverging interests between shareholders and managers. Managers may be reluctant to undertake risky long-term projects or may indulge in activities unrelated to the company's interests. The choice of a different capital structure can affect managers' discipline and incentives and could also be considered a means of easing agency problems. The main implication of imperfect capital markets is that financial factors and constraints influence firms' investment decisions.

Following this line of research, many authors have focused on specific problems that may affect firms' investment behavior. Myers and Majluf (1984) postulate the existence of an ordered hierarchy in financial sources in terms of costs. The Myers-Majluf pecking order theory of capital structure suggests that when informational asymmetries and agency problems are high, firms prioritize their financing sources by first relying on internal funds, then choosing debt and lastly, issuing new equity. This ordering derives from the high dilution cost of issuing new equity when information is asymmetric between managers and investors.

A complementary approach is that followed by Aghion and Bolton (1992) which, focusing on control rights, reshuffles the rank order of financing sources. In fact, when a substantial part of a firm's capital constitutes intangible assets, the possibility of using debt is bounded by the lack of collateral. Consequently, the lower the tangibility of assets is, the more control rights outside investors demand in return. Traditional firms with enough collateral follow the original pecking order by choosing first debt and then equity. On the other hand, risky innovative firms with low collateral will be required to grant more control rights to investors, hence favoring equity over debt. A rich stream of empirical literature has developed from this theoretical base to analyze the financing of innovative activities. A substantial part of this research deals with the identification of financing constraints and the existence of a funding gap for innovation (Fazzari et al., 1988; Scellato, 2007; Mohnen et al., 2008; Hall and Lerner, 2009; Hottenrott and Peters, 2012; Hall et al., 2015; Kerr and Nanda, 2015). Here, we are more interested in highlighting the differences in the financial characteristics of innovators and non-innovators, describing their financial choices. Hall (1992) explores the degree of correlation among leverage, cash flow and R&D expenditures in a large panel of US manufacturing firms from 1973 to 1987. Hall underlines two main facts: the positive relation of R&D investment and cash flow and the strong negative correlation between R&D and leverage. The dominant role of internal resources is also pointed out by Himmelberg and Petersen (1994). By using different econometric specifications in a panel of 179 high-tech US firms, Himmelberg and Petersen find a large and statistically significant relationship between R&D and internal finance proxied by cash flow. Ughetto (2008) finds that Italian manufacturing firms favor cash flow over debt in financing R&D expenditures, but company size may affect this choice. While external financing is very hard for small innovative firms, larger companies are found to have relatively easier access. Baldwin et al. (2003) find similar results using survey data for 3,000 small Canadian firms. Moreover, Aghion et al. (2004) analyze the use of debt financing and R&D investments directly from balance sheet data for large and medium-sized UK publicly traded firms. They find a non-linear relationship between innovation expenditure and the debt to total assets ratio: the use of debt is sizable when R&D is low but, when R&D intensity grows, the debt to assets ratio falls significantly. On the contrary, they discover a linear relationship with new equity issuance. Casson et al. (2008) confirm the Aghion et al. (2004) results. Both papers empirically confirm the validity of the control rights approach where the rank in the pecking order changes with innovation intensity. Causal evidence is also shown by Atanassov (2005) and Magri (2014). By analyzing a large panel of US companies from 1974–2000, Atanassov finds that firms that use equity and bonds have a larger number of patents and patent citations than those that rely on bank loans. Magri uses survey data on 10,720 Italian manufacturing firms and documents that recourse to equity increases the probability of investing in R&D by 30–40%. However, this effect is significant only for small, young and highly leveraged firms. This finding is closely related to the literature which investigates the effect of ownership on innovation. A recent study by Acharya and Xu (2016) analyzes the effect of being publicly-traded on a firm's patenting behavior, finding a differential effect of listing. They find that publicly traded firms in industries more dependent on external financing generate more patents of higher quality and novelty than private firms. On the other hand, publicly-held firms do not show any significant improvement when they belong to industries where the use of external capital is residual.

Also the strategic choice of holding cash or other liquid assets to provide a certain degree of operational flexibility, the so-called financial slack, may significantly differentiate between innovative and non-innovative companies. Evidence is not univocal. On the one hand, this financial slack may be necessary in promoting experimentation, long-term vision and innovation. Therefore, it should be considered a critical strategy of highly innovative firms as it provides insulation against cash flow volatility, allowing to maintain R&D investment even during recessionary periods (O'Brien, 2003). On the other hand, other authors point to the negative effects of an excessive buffer of resources, which may increase inefficiency and the diversion of funds to dubious projects (Jensen, 1986). For example, Nohria and Gulati (1996) find that slack has a U-shaped effect on innovation, showing that too much or too little slack may damage innovation.

3 Dataset and summary statistics

This paper explores the financial profile of Italian firms to document how innovative firms differentiate with respect to non-innovative ones. In particular, the analysis combines evidence on firms' innovative outcomes between 2008–12 with their pre-determined financial structure. With this aim, it is crucial to choose a reliable indicator of innovation that can differentiate between firms. Previous studies on innovative firms usually based the classification on sectoral affiliation and industry-specific systems of innovation (Pavitt, 1984; Malerba and Orsenigo, 1997; Bogliacino and Pianta, 2013). In another stream of literature, where classification is firm-specific, authors propose proxies that relate to the inputs (R&D activity) or outputs (patented inventions) of innovative process (Acs and Audretsch, 2005).

While the information available on R&D investments from balance sheets is scant, the use of an output measure such as patents allows us to analyze the full set of firms in the sample by defining the profile of innovators according to the persistence of their patenting activity. Consequently, this paper categorizes Italian firms into four innovation classes[2] based on their degree of patenting during 2008–12, investigating the common financial characteristics of each class. First, we document the general trend of innovation by sector and year. Then, we focus on the manufacturing sector, which alone accounts for the great majority of Italian patents. We group manufacturing firms according to the number of patents issued in a specific time span, namely:[3]

[2] We follow Cefis (2003), which uses this taxonomy for 577 British firms. Cefis investigates the nature of patenting behavior, finding high persistence among innovators and the presence of a threshold effect at the first patent. After the first patent, the probability of acquiring a further patent increases. Thus, innovation and its persistence are not random but derive from a systematic heterogeneity across firms.

[3] Our taxonomy modifies the original analysys by Cefis (2003) by considering only "granted" patents and discarding subsequent applications to other patent offices for the same invention to avoid double-counting. Lastly, we consider averages and not yearly counting to smooth out the possible truncation effect, evident in 2011–12.

i) **non-innovators**, firms that never had a patent granted between 2008–12;

ii) **occasional innovators**, firms with less than one patent per year;

iii) **medium innovators**, firms with one to five patents per year;

iv) **great innovators**, firms with more than five patents per year.

3.1 Dataset

We use data on private and public firms collected by Orbis Bureau van Dijk - see Ribeiro et al. (2010) for a thorough description of the database. We use yearly data from the profit and loss (P&L) and asset and liability (A&L) accounts of Italian non-financial companies incorporated before 2006 and whose total assets or operating revenues amounted to over 2 million euros in at least one of the years between 2006–12. The choice of these thresholds stems from the criteria adopted by the European Commission (EC) in its definitions of small and medium-sized enterprises.[4] We matched this data with company ownership and intellectual property information also collected by Orbis.

Our sample accounts for more than 70% of overall Italian patenting, while the remaining part includes mainly sole proprietorships. Finally, we do not consider international branches of Italian corporations but we include Italian branches of multinational corporations. Yearly P&L and A&L data are used to construct micro-level financial ratios and indicators for each year. All variables, with the exclusions of age and firm characteristic, have first been winsorized at the 1st and 99th percentile and aggregated in the pre-crisis (2006–07) and crisis (2008–12) period. Detailed descriptions of these metrics together with descriptive statistics are provided in Appendix A. Overall, the sample consists of 162,959 non-financial firms, which have been granted with 83,654 priority patents.

3.2 Summary statistics

The patenting performance of Italian firms by sector and year is presented in Table 1. The table documents the positive trend of patents granted to Italian assignees. Yearly patents steadily grew from 2,686 in 2006 to 3,504 in 2010. This trend reversed in 2011 and in 2012 when they amounted to 1,936 and 1,216, respectively. This change is likely connected to truncation.[5] In Section 4.3 we perform the analysis controlling for truncation bias as in Dass et al. (2017).

[4] Size criteria for micro, small and medium-sized enterprises are defined in the EU recommendation 2003/361 available at `http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32003H0361` and further described in the Appendix A.

[5] The problem arises as the period analyzed comes closer to the end of the dataset (Hall et al., 2001). In fact, it is possible that the missing patents are those that had not yet been granted at the time of data retrieval. As discussed in the previous paragraph, the possible effect of truncation bias has been eased by averaging over the whole period the number of patents issued.

Sample by sector and year										
Sector	**Before 2006**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**Total Patents**	**Total Companies**
Accommodation & Food	141	2	0	4	2	4	2	1	156	4,410
	0.22%	0.07%	0.00%	0.13%	0.06%	0.11%	0.10%	0.08%	0.19%	2.71%
Agriculture, Forestry, Fishing & Mining	1,483	66	71	100	90	62	31	12	1,915	3,994
	2.27%	2.46%	2.66%	3.34%	2.64%	1.77%	1.60%	0.99%	2.29%	2.45%
Construction & Real Estate	3,457	38	56	72	98	83	29	8	3,841	51,915
	5.30%	1.41%	2.10%	2.41%	2.88%	2.37%	1.50%	0.66%	4.59%	31.86%
Energy, Gas & Water Supply	232	6	6	7	15	9	3	3	281	2,680
	0.36%	0.22%	0.22%	0.23%	0.44%	0.26%	0.15%	0.25%	0.34%	1.64%
Information, Communication & R&D	2,125	124	161	136	130	87	45	31	2,839	4,237
	3.26%	4.62%	6.03%	4.54%	3.82%	2.48%	2.32%	2.55%	3.39%	2.60%
Manufacturing	49,701	2,263	2,208	2,418	2,800	2,963	1,688	1,019	65,060	41,601
	76.18%	84.25%	82.70%	80.79%	82.21%	84.56%	87.19%	83.80%	77.77%	25.53%
Other Sectors	381	32	15	13	15	17	9	3	485	6,223
	0.58%	1.19%	0.56%	0.43%	0.44%	0.49%	0.46%	0.25%	0.58%	3.82%
Other Services	1,478	47	65	92	85	105	47	53	1,972	8,945
	2.27%	1.75%	2.43%	3.07%	2.50%	3.00%	2.43%	4.36%	2.36%	5.49%
Retail Trade	569	6	12	17	16	28	15	7	670	7,771
	0.87%	0.22%	0.45%	0.57%	0.47%	0.80%	0.77%	0.58%	0.80%	4.77%
Transportation & Storage	914	33	14	42	39	20	17	32	1,111	5,908
	1.40%	1.23%	0.52%	1.40%	1.15%	0.57%	0.88%	2.63%	1.33%	3.63%
Wholesale Trade	4,762	69	62	92	116	126	50	47	5,324	25,275
	7.30%	2.57%	2.32%	3.07%	3.41%	3.60%	2.58%	3.87%	6.36%	15.51%
Total	**65,243**	**2,686**	**2,670**	**2,993**	**3,406**	**3,504**	**1,936**	**1,216**	**83,654**	**162,959**
	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 1: Patenting behavior by sector and year

Construction is the most relevant sector by number of firms (with a share of 32% out of 162,959 firms) followed by manufacturing (over 25%) and wholesale trade (16%). The other eight sectors have a lower share (less than 5% each). However, patents are concentrated in manufacturing with over 80% of the total number and this share is stable over time.[6] The shares of patenting of the other sectors, including high-tech (information, communication and R&D), are relatively small.

The literature shows that financial characteristics cluster within industries, systematically differentiating financial ratios across sectors (Gupta, 1969; Hall et al., 2000). Hence, differences between innovative groups can mix up with sector-related factors when there is a strong prevalence of a single sector among innovators. For this reason, henceforth, we focus only on the financial profile of the subsample of 41,601 Italian manufacturing firms. Table 2 reports the number of manufacturing firms, patents granted, size and ownership structure by innovation group. Based on their patenting performance in 2008–12, each firm belongs either to non-innovators, occasional innovators, medium innovators, or great innovators. As expected, the majority of firms are considered non-innovators. Almost 94% of manufacturing firms have never been granted at least a patent. Conversely, occasional innovators, who received less than one patent per year, represent the largest group among innovators (2,196 firms, equal to 5.28% of the sample). Persistent innovative activity is very limited and clustered among relatively few companies. There are 367 medium innovators (per-year patents between one and five, 0.9% of the sample), while only 49 (0.1% of the sample) great innovators (per-year patents above five). Although the size of each group is different, each of the latter three groups accounts for about a third of total inventive activity. The 49 great innovators produced 3,911 patents between 2008 and 2012 (36% of the total amount of patented inventions). This outcome is not in line with those of other countries. Cefis (2003) finds that in the UK great innovators in the manufacturing sector represent 2.37% of the firms, but account for 77.85% of patents.[7] Firm size also explains the inventive activity. The presence of innovative firms among micro and small firms is negligible, and infrequent for medium-sized firms. Among large manufacturing firms, over 70% have never applied for at least one patent; half of the innovators occasionally engage in patenting, while the other half persistently pursue this strategy. This suggests that innovation persistence is traceable almost exclusively to large organizations, characterized by a set of capabilities, skills and structures rarely available in smaller entities.

Table 2 also illustrates the ownership structure of innovative groups. Public companies

[6]Evidence, not shown here, illustrates how concentration particularly increases at high level of innovation. Among great innovators (firms which steadily produce at least six patents each year) manufacturing companies amount to 49 out the 51 total number of firms in this class.

[7]These differences may suggest a less degree of persistence of innovative activities in Italian firms with respect to the British ones, but they may also reflect different size composition of the smaller British sample.

Manufacturing firms characteristics						
		Non-innovators	Occasional innovators	Medium innovators	Great innovators	Total
No. of firms		38,989	2,196	367	49	41,601
		93.72%	5.28%	0.88%	0.12%	100%
No. of original patents		0	3,522	3,455	3,911	10,888
		0.00%	32.35%	31.73%	35.92%	100%
Size						
	Micro	9,611	213	7	0	9,831
		97.76%	2.17%	0.07%	0.00%	100%
	Small	21,454	866	46	1	22,367
		95.92%	3.87%	0.21%	0.00%	100%
	Medium	6,636	824	145	6	7,611
		87.19%	10.83%	1.91%	0.08%	100%
	Large	1,288	293	169	42	1,792
		71.88%	16.35%	9.43%	2.34%	1000%
Publicly traded						
	Private company	38,943	2,178	354	39	41,514
		93.81%	5.25%	0.85%	0.09%	100%
	Public company	46	18	13	10	87
		52.87%	20.69%	14.94%	11.49%	100%
Corporate Group						
	Independent company	16,346	542	34	0	16,922
		96.60%	3.20%	0.20%	0.00%	100%
	Business group	22,643	1,654	333	49	24,679
		91.75%	6.70%	1.35%	0.20%	100%
	of which:					
	Domestic holding	20,765	1,428	244	32	22,469
		92.42%	6.36%	1.09%	0.14%	100%
	International holding	1,878	226	89	17	2,210
		84.98%	10.23%	4.03%	0.77%	100%

NOTE: Innovative classes are defined by the average number of priority patents granted between 2008–12. The construction of size and owner--ship structure is defined as in the Appendix A

Table 2: Manufacturing sample characteristics by innovative group

have a higher propensity to innovate in each group. Half of public companies have taken out a patent at least once during 2008–12 and the majority of those are persistent innovators. Lastly, firms belonging to international holding companies are more innovative than those that are part of domestic groups and single independent companies. Overall, statistics document that the majority of firms do not innovate at all, some engage in occasional innovation, while a few large firms maintain a persistent level of high inventive capacity.

We focus here only on a five-year time span of patent innovation, while Italian manufactures exhibit a long-term patenting pattern, as witnessed by the large number of patents issued before 2008 (Table 1). However, the likelihood of losing momentum, halting the persistent innovative effort, may have increased during the harsh recession of 2008–12 (OECD, 2012; Paunov, 2012).

Table 3 shows the transition probabilities in firm-level average patenting between 2003–07 and 2008–12. Transition probabilities document that persistence in the same state of innovative output is very high among non-innovators as 96% of firms have not switched to other classes. However, signs of persistence are evident also among medium and great innovators (48% and 59%, respectively). Moreover, data also show that the number of

Transition probabilities					
2003–07 → 2008–12	**Non-innovators**	**Occasional innovators**	**Medium innovators**	**Great innovators**	**Total**
Non-innovators	96.20%	3.65%	0.15%	0.01%	100%
	(38,176)	(1,448)	(59)	(2)	(39,685)
Occasional innovators	49.77%	41.39%	8.70%	0.13%	100%
	(772)	(642)	(135)	(2)	(1,551)
Medium innovators	13.06%	33.76%	48.41%	4.78%	100%
	(41)	(106)	(152)	(15)	(314)
Great innovators	0,00%	0.00%	41.18%	58.82%	100%
	(0)	(0)	(21)	(30)	(51)
Total	93.72%	5.28%	0.88%	0.12%	100%
	(38,989)	(2,196)	(367)	(49)	(41,601)

NOTE: Innovative classes are defined by the average number of priority patents granted between 2003–07 and 2008–12.

Table 3: Transition probabilities among four innovative groups (2003–07 and 2008–12)

innovators in the last period is larger than that of the previous period. Improvements stem from migration to occasional and medium innovators. Finally, innovative persistence is evident at a very high level of patenting.

Table 4 shows the transition probabilities of manufacturing, breaking down this industry by technological intensity.[8] Moving from high to low technology the rate of persistence of non-innovators increases while persistence at high level of patenting decreases. As expected, the share of innovators drops when technological intensity lowers. The sub-sectors with medium-high technology (manufactures of chemicals, machinery, motor vehicles and electrical equipment) are those with the highest number of persistent innovators.

The intensification of innovation activity during the crisis seems counterintuitive. However Archibugi et al. (2013), using the Community Innovation Survey to analyze the effect of the 2008 crisis on UK firms, conclude that the cumulative nature of innovation tended to be higher during the crisis than in tranquil periods. They found that previous innovators intensified their innovative efforts during the crisis. The descriptive evidence presented above suggests a similar pattern. It is likely that the effects of the crisis on firms' innovation were harsher on relatively younger and smaller enterprises than those in our sample. In fact, it is important to note that the innovators described by our sample are not small startup companies, but rather established firms with capacities to pursue innovation even in times of crisis. The financial characteristics of these innovators are indeed the main goal of this study and the content of the next section.

[8]The aggregation is based on NACE Rev. 2 at 2-digit level as defined by Eurostat in the Statistics on high-tech industry and knowledge-intensive services available at `https://ec.europa.eu/eurostat`.

Transition probabilities by technological intensity								
2003–07 → 2008–12	Non-innovators	Occasional innovators	Medium innovators	Great innovators	Non-innovators	Occasional innovators	Medium innovators	Great innovators
	High-technology				Medium-high technology			
Non-innovators	93.87%	6.00%	0.13%	0.00%	93.30%	6.39%	0.30%	0.02%
Occasional innovators	51.09%	36.50%	12.41%	0.00%	45.06%	45.06%	9.74%	0.14%
Medium innovators	18.75%	31.25%	50.00%	0.00%	12.57%	33.14%	48.00%	6.29%
Great innovators	0.00%	0.00%	27.27%	72.73%	0.00%	0.00%	35.71%	64.29%
Total	88.33%	8.93%	2.26%	0.48%	88.35%	9.50%	1.85%	0.31%
	(1,484)	(150)	(38)	(8)	(9,183)	(987)	(192)	(32)
	Medium-low technology				Low technology			
Non-innovators	96.36%	3.49%	0.15%	0.00%	98.15%	1.80%	0.05%	0.00%
Occasional innovators	52.30%	40.04%	7.44%	0.22%	58.40%	35.71%	5.88%	0.00%
Medium innovators	16.13%	37.10%	45.16%	1.61%	6.67%	33.33%	53.33%	6.67%
Great innovators	0.00%	0.00%	85.71%	14.29%	0.00%	0.00%	40.00%	60.00%
Total	94.59%	4.78%	0.61%	0.02%	97.21%	2.43%	0.32%	0.04%
	(13,766)	(695)	(89)	(3)	(14,556)	(364)	(48)	(6)

Table 4: Transition probabilities by technological intensity among four innovative groups (2003–07 and 2008–12)

4 Empirical results

This section analyzes the most relevant financial ratios related to the profitability, capital structure and operating performance of firms. We aim to characterize the most important financial features that differentiate non-innovators from occasional innovators and, in turn, the latter from persistent innovators, both medium and great innovators. We also investigate if financial flexibility (also known as financial slack) can be interpreted as a distinctive feature of innovative firms. The literature documents that firms with excess financial resources, such as debt capacity and liquid reserves, may be more resilient to unexpected adverse shocks. For example, a firm with large financial reserves may be more capable of continuing to fund R&D projects even during a recession. We highlight the differences between groups as to their financial characteristics using a ratio analysis. A regression analysis will document the robustness of the evidence in a multivariate setting. We mainly rely on predetermined financial ratios with respect to innovative output without explicitly addressing causality. However, as the relationship between financial structure and innovation activity may be multifaceted and persistent, the causal nexus generally may run both ways.

4.1 Ratio analysis

We define innovative groups taking into account the invention activity of the period 2008–12. Financial ratios are computed as averages of the years before (2006–07) and during the crisis (2008–12). For each ratio we compare the financial profile defined ex-ante with respect to the inventive performance defined ex-post, considering as well the change in financial ratios during the crisis. We use measures of central tendency and dispersion as general indicators, testing the systematic difference between groups with the Wilcoxon rank-sum test (also known as the Mann-Whitney test) (Wilcoxon, 1945; Mann and Whitney, 1947).[9]

Our comparison starts with the analysis of profitability ratios in order to measure the adequacy of firm's returns on investment. The main determinants of a firm's profitability and returns are represented by management's ability to efficiently use assets to generate sales and control costs. However, each ratio evaluates a specific aspect of the company's performance, providing different information depending on the step of income statement and the choice of the denominator. Table 5 includes five common profitability measures.

EBITDA on assets summarizes operating profitability. The between group variation is limited both in 2006-07 and 2008-12. The average EBIDTA profits represent between 10% and 12% of company assets before the crisis and 7% and 9% during the crisis. The Wilcoxon rank-sum test confirms the significance of the difference between innovators and non-innovators, but exclude within the category of innovators differences in profitability (occasional versus persistent innovators).

Return on assets and **return on equity** measure, respectively, company effectiveness in employing assets to generate profits and the ability to earn returns on its equity investment. Both indicators signal a significant increase in returns when we move from non-innovators and from occasional to persistent innovators. As expected, all groups register a drop in returns during the crisis, but returns of persistent innovators decrease to a less extent.

Cash flow on operating revenues measures the company's ability to turn sales into available cash. This is a fundamental metric since the more the company is efficient at increasing operating cash flow, the more it can invest in fixed capital, R&D, repay its debts or distribute dividends to shareholders. Table 5 clearly documents that differences between groups are statistically significant. Means and medians, before and during the crisis, rise with the degree of innovation. Great innovators are two times more efficient than non-innovators at attaining a constant higher flow of cash. Interestingly, the differences between groups and the magnitudes of this ratio remain almost unchanged even during the recession.

Lastly, (pre-tax) **profit margin** indicates the income that a firm is able to generate from its sales after adjusting for all expenses. Here expenses exclude taxes as they are not a function of operations. Also this metric confirms an increase in profits at higher levels of innovation. Differences between groups are statistically significant at conventional level

[9]The rank-sum test is a powerful non-parametric test with very limited assumptions. In particular, it is more appropriate when the sample size is small, there are outlying observations and the normality assumption for the corresponding parametric method (t-test) does not hold. Given the ordered nature of our groups, we will test each group with the one immediately preceding (e.g., occasional versus non-innovators or great innovators versus medium innovators).

Financial analysis

Profitability ratios	EBITDA return on assets (2006-07)				EBITDA return on assets (2008-12)			
	Mean	Stand. Dev.	Median	Wilcoxon test $((n)-(n_{-1}))$	Mean	Stand. Dev.	Median	Wilcoxon test $((n)-(n_{-1}))$
Non-innovators	10.37	7.81	9.02	-	7.41	6.68	6.63	-
Occasional innovators	11.51	7.63	10.28	***	8.67	6.35	7.77	***
Medium innovators	11.94	8.55	10.44		9.12	7.50	8.20	
Great innovators	12.27	10.22	10.82		9.35	8.57	8.82	

	Return on assets (ROA) - (2006-07)				Return on assets (ROA) - (2008-12)			
	Mean	Stand. Dev.	Median	Wilcoxon test $((n)-(n_{-1}))$	Mean	Stand. Dev.	Median	Wilcoxon test $((n)-(n_{-1}))$
Non-innovators	2.29	5.09	1.09	-	1.08	5.12	0.61	-
Occasional innovators	2.97	5.22	1.77	***	1.82	5.10	1.17	***
Medium innovators	3.66	6.02	2.46	***	2.22	6.46	1.98	***
Great innovators	5.12	6.60	4.43	**	3.08	6.84	3.04	

	Return on equity (ROE) - (2006-07)				Return on equity (ROE) - (2008-12)			
	Mean	Stand. Dev.	Median	Wilcoxon test $((n)-(n_{-1}))$	Mean	Stand. Dev.	Median	Wilcoxon test $((n-n_{-1}))$
Non-innovators	6.36	29.61	6.58	-	-1.23	29.27	2.76	-
Occasional innovators	8.07	27.28	8.15	***	1.62	25.75	4.24	***
Medium innovators	7.61	29.24	9.57		-0.69	36.00	5.51	
Great innovators	16.46	18.08	13.11	*	6.90	22.30	11.61	*

	Cash flow / Operating revenues (2006-07)				Cash flow / Operating revenues (2008-12)			
	Mean	Stand. Dev.	Median	Wilcoxon test $((n)-(n_{-1}))$	Mean	Stand. Dev.	Median	Wilcoxon test $((n)-(n_{-1}))$
Non-innovators	5.54	7.11	4.19	-	4.29	9.46	3.90	-
Occasional innovators	6.17	6.11	5.06	***	5.44	7.19	4.94	***
Medium innovators	7.92	7.69	6.74	***	6.73	9.97	6.37	***
Great innovators	9.61	8.85	8.48	**	6.85	9.86	8.19	

	Profit margin (pre-tax) - (2006-07)				Profit margin (pre-tax) - (2008-12)			
	Mean	Stand. Dev.	Median	Wilcoxon test $((n)-(n_{-1}))$	Mean	Stand. Dev.	Median	Wilcoxon test $((n)-(n_{-1}))$
Non-innovators	3.60	9.52	2.87	-	-0.58	17.21	1.60	-
Occasional innovators	4.78	8.32	3.70	***	2.27	12.04	2.38	***
Medium innovators	5.98	10.51	4.93	***	2.68	15.97	3.40	***
Great innovators	7.63	12.88	7.19	*	3.54	17.31	4.28	

NOTE: The table reports descriptive statistics and the Wilcoxon rank-sum non-parametric test. Symbols *, ** and *** denote significance levels of 10%, 5% and 1%, respectively.

Table 5: Wilcoxon rank-sum test on the profitability ratios

(with the exclusion of the difference between great and medium innovators in 2008-12).

Overall, profitability is unambiguously larger at higher levels of innovation activity. Groups differences are statistically significant in all comparisons between innovative versus non-innovative firms and in the majority of comparisons between occasional versus persistent innovators.

The analysis proceeds by introducing indicators of financial structure of Italian innovative and non-innovative firms. Capital structure ratios describe the way a firm finances its overall operations and growth by using different sources of funds, but also reveal the distribution of returns among investors, a firm's liquidity and what would happen in a liquidation scenario. Table 6 reports some relevant structure ratios.

Cash ratio evaluates the firm's ability to repay short-term debts with the cash amount held by the company. Among liquidity indicators, this is the most conservative as it includes among current assets only cash or cash equivalents. The cash relative to the current liabilities is higher for more innovative firms. However, only less innovative firms seem to have had increased precautionary reserves during the crisis. The mean rises significantly while median remains stable, suggesting the presence of outliers.

The relevance of very liquid assets could also be measured by the **cash to total assets** ratio, which measures the share of a company's assets that are cash or that can be converted to cash immediately. The Wilcoxon rank-sum test reports a significant difference only between innovators and non-innovators. Additionally, the cash surplus of innovative firms is relatively smaller than the one measured with respect to the current liabilities.

Debt ratio is one of the two main indicators of financial leverage and can be interpreted as the proportion of a company's assets that are financed by debt. It also indicates the degree of financial risk of the firm. There is strong significant evidence that more innovative companies are less likely to finance their assets through debt than are less or non-innovative firms. This is true at each level of innovation and before and during the economic crisis.

Liquidity ratio, also known as the *acid test ratio*, is similar to the cash ratio but less stringent. It includes accounts receivable and short-term investments among liquid assets (but excludes inventory). However, here the test does not reject the null hypothesis, for almost all group differences.

Solvency ratio, which measures the extent of the residual claims of shareholders on assets, confirms the picture set out before. The use of debt is limited among innovative firms, which instead finance their assets with shareholders' funds. Before the crisis the ratio amounted to 25% for non-innovative firms and 40% for great innovators. During the crisis, this share slightly increased for non-innovative firms (to 31%) while remained unchanged for great innovators. Moreover, all group differences are significant at conventional levels (with the exclusion of great innovators versus medium innovators between 2008-12).

Lastly, we introduce two other relevant measures of financial structure: leverage and the ratio of current assets on current liabilities, also known as the *current ratio*. Those ratios are also commonly used by literature to approximate the concept of financial slack. The leverage ratio accounts for the debt capacity or potential slack, while the current ratio exhibits the degree of liquidity or available slack.[10]

Leverage ratio measures the proportion of capital that comes in the form of debt. The main difference here is between persistent innovators and occasional/non-innovators, both before and during the economic crisis. The average (median) leverage of great innovators is 20% (14%) for great innovators, while average/median leverage for occasional/non-

[10] See Daniel et al. (2004) for a meta-analysis on the topic.

Financial analysis								
Structure ratios	**Cash ratio (2006-07)**				**Cash ratio (2008-12)**			
	Mean	**Stand. Dev.**	**Median**	**Wilcoxon test $((n)-(n_{-1}))$**	**Mean**	**Stand. Dev.**	**Median**	**Wilcoxon test $((n)-(n_{-1}))$**
Non-innovators	0.19	0.33	0.06	-	0.25	0.46	0.07	-
Occasional innovators	0.19	0.30	0.08	***	0.24	0.41	0.08	***
Medium innovators	0.22	0.35	0.10	**	0.28	0.48	0.10	*
Great innovators	0.30	0.48	0.15		0.27	0.39	0.15	
	Cash / Total assets (2006-07)				**Cash / Total assets (2008-12)**			
	Mean	**Stand. Dev.**	**Median**	**Wilcoxon test $((n)-(n_{-1}))$**	**Mean**	**Stand. Dev.**	**Median**	**Wilcoxon test $((n)-(n_{-1}))$**
Non-innovators	0.08	0.10	0.03	-	0.08	0.10	0.03	-
Occasional innovators	0.08	0.10	0.04	***	0.08	0.10	0.04	***
Medium innovators	0.08	0.10	0.05		0.08	0.10	0.04	
Great innovators	0.09	0.11	0.07		0.09	0.10	0.06	
	Debt ratio (2006-07)				**Debt ratio (2008-12)**			
	Mean	**Stand. Dev.**	**Median**	**Wilcoxon test $((n)-(n_{-1}))$**	**Mean**	**Stand. Dev.**	**Median**	**Wilcoxon test $((n)-(n_{-1}))$**
Non-innovators	21.37	18.78	18.45	-	20.27	17.74	17.06	-
Occasional innovators	21.71	17.87	19.71	**	21.34	17.11	19.06	***
Medium innovators	19.02	16.13	17.15	**	19.09	16.20	16.42	**
Great innovators	10.18	11.75	5.80	***	11.98	13.09	6.29	***
	Liquidity (2006-07)				**Liquidity (2008-12)**			
	Mean	**Stand. Dev.**	**Median**	**Wilcoxon test $((n)-(n_{-1}))$**	**Mean**	**Stand. Dev.**	**Median**	**Wilcoxon test $((n)-(n_{-1}))$**
Non-innovators	1.14	0.80	0.93	-	1.28	1.09	0.97	-
Occasional innovators	1.09	0.62	0.92		1.19	0.82	0.95	
Medium innovators	1.16	0.75	0.96		1.27	0.96	1.00	*
Great innovators	1.37	1.05	1.06		1.18	0.64	1.03	
	Solvency ratio (Assets) - (2006-07)				**Solvency ratio (Assets) - (2007-2012)**			
	Mean	**Stand. Dev.**	**Median**	**Wilcoxon test $((n)-(n_{-1}))$**	**Mean**	**Stand. Dev.**	**Median**	**Wilcoxon test $((n)-(n_{-1}))$**
Non-innovators	25.49	19.54	20.70	-	30.99	21.53	27.04	-
Occasional innovators	27.97	18.21	24.05	***	33.62	19.75	30.81	***
Medium innovators	32.50	17.68	30.51	***	37.25	19.15	34.81	***
Great innovators	40.21	21.38	39.37	**	40.75	20.82	37.03	
Potential slack	**Leverage ratio(2006-07)**				**Leverage ratio (2008-12)**			
	Mean	**Stand. Dev.**	**Median**	**Wilcoxon test $((n)-(n_{-1}))$**	**Mean**	**Stand. Dev.**	**Median**	**Wilcoxon test $((n)-(n_{-1}))$**
Non-innovators	42.75	32.74	43.05	-	37.76	30.07	35.26	-
Occasional innovators	41.31	30.14	41.43		37.36	27.76	36.19	
Medium innovators	35.09	27.04	34.86	***	32.51	25.19	29.91	***
Great innovators	21.19	21.57	14.00	***	22.88	21.61	15.13	**
Available slack	**Current ratio (2006-07)**				**Current ratio (2008-12)**			
	Mean	**Stand. Dev.**	**Median**	**Wilcoxon test $((n)-(n_{-1}))$**	**Mean**	**Stand. Dev.**	**Median**	**Wilcoxon test $((n)-(n_{-1}))$**
Non-innovators	1.50	0.93	1.23	-	1.70	1.25	1.32	-
Occasional innovators	1.52	0.72	1.33	***	1.70	0.99	1.40	***
Medium innovators	1.62	0.89	1.37	*	1.78	1.11	1.47	
Great innovators	1.89	1.19	1.49	*	1.70	0.84	1.48	

NOTE: The table reports descriptive statistics and the Wilcoxon rank-sum non-parametric test. Symbols *, ** and *** denote significance level of 10%, 5% and 1%, respectively.

Table 6: Wilcoxon rank-sum test on the structure ratios

Financial analysis								
Other ratios	**Interest cover (2006-07)**				**Interest cover (2008-12)**			
	Mean	**Stand. Dev.**	**Median**	**Wilcoxon test** $((n)-(n_{-1}))$	**Mean**	**Stand. Dev.**	**Median**	**Wilcoxon test** $((n)-(n_{-1}))$
Non-innovators	27.04	58.35	3.10	-	23.33	69.90	2.38	-
Occasional innovators	30.81	69.81	4.13	***	31.13	83.07	3.35	***
Medium innovators	34.81	71.47	5.04		37.16	95.46	4.80	
Great innovators	37.03	67.68	4.73		31.65	70.93	5.43	
	Tangibility (2006-07)				**Tangibility (2008-12)**			
	Mean	**Stand. Dev.**	**Median**	**Wilcoxon test** $((n)-(n_{-1}))$	**Mean**	**Stand. Dev.**	**Median**	**Wilcoxon test** $((n)-(n_{-1}))$
Non-innovators	0.22	0.19	0.17	-	0.27	0.21	0.21	-
Occasional innovators	0.18	0.14	0.14	***	0.22	0.17	0.18	***
Medium innovators	0.17	0.12	0.14		0.20	0.15	0.17	
Great innovators	0.16	0.11	0.14		0.17	0.10	0.17	
	Turnover growth (2006-07)				**Turnover growth (2008-12)**			
	Mean	**Stand. Dev.**	**Median**	**Wilcoxon test** $((n)-(n_{-1}))$	**Mean**	**Stand. Dev.**	**Median**	**Wilcoxon test** $((n)-(n_{-1}))$
Non-innovators	14.35	34.28	8.84	-	2.53	15.26	1.18	-
Occasional innovators	14.91	29.38	10.57	***	3.84	11.86	2.12	***
Medium innovators	15.36	30.84	11.06		4.17	11.54	2.36	
Great innovators	20.77	43.62	7.94		7.08	11.83	4.42	*

NOTE: The table reports descriptive statistics and the Wilcoxon rank-sum non-parametric test. Symbols *, ** and *** denote significance level of 10%, 5% and 1%, respectively.

Table 7: Wilcoxon rank-sum test on the operational and other ratios

innovators accounts to more than 40%. There is evidence of deleveraging among non-innovators from 2006-07 to 2008-12, while average debt remained unchanged for persistent innovators. Innovators and in particular persistent ones seem to have a higher potential slack with respect to non-innovators and this slack remained available even during the crisis. However, it is likely that this evidence is driven by credit constraint faced by innovative firms more than the deliberate strategy to save potential slack. In fact, debt is an unsuitable mean of financing for innovative firms which lack of adequate collateral. A more appropriate mean of acquiring flexibility during recessionary periods is constituted by available slack. **Current ratio** is the least stringent indicator of liquidity as it incorporates all current total assets of a company (both liquid and illiquid) and relates them to the firm's current liabilities. The test strongly rejects the null hypothesis for innovators and non-innovators, but the same evidence between occasional and persistent innovators is weak and limited to the pre-crisis period. Overall, differences in available slack seem to be small in magnitude and limited in statistical significance.

Table 7 reports the last set of indicators that measure the operating efficiency of the companies, such as the margin of safety a company maintains during its operations, the tangibility of its assets and the rate of growth of turnover.

Interest coverage evaluates the ability of a company to pay the interest on its outstanding debt with its available earnings. The higher the safety margin is, the more a company can adapt to financial hardship. Means and median widely diverge, but they are both above the safety level for all groups (the rule of thumb indicates 1.5 as the minimum acceptable level to avoid that the burden of interest expenses triggers bankruptcy). Differences between groups are significant only between innovators and non-innovators, showing a higher ability to repay interest for the former companies.

Tangibility indicates the proportion of assets that have a physical form and can be used as collateral. As expected, innovative firms show a lower level of tangible assets, which in turn may be related to the lower level of indebtedness. The Wilcoxon test confirms the significance of this difference only between innovators and non-innovators, while tangibility for medium and great innovators does not seem to be statistically different from that for occasional innovators.

Last, **turnover growth** appears to be higher in innovators than non-innovators. Interestingly, all four groups experienced a substantial drop in the sales growth rate during the economic crisis. However, the extent of this reduction is attenuated in persistent innovators with respect to non-innovators.

4.2 Regression analysis

The previous analysis documents that innovative firms are more profitable, less indebted, grow faster and have a higher flow of cash, but a lower degree of asset tangibility. Moreover, group differences seem to widen with innovation intensity. All these characteristics appear to be stable over time. In this section we test whether the differences in terms of profitability, capital structure and debt management are robust to the inclusion of size, age and other relevant variables. Therefore, we estimate a multivariate model which estimates the marginal effect of the most relevant financial ratios on the number of patenting activity at firm level between 2008 and 2012. The dependent variable is a count which takes non-negative integer values, with a great amount of small numbers, including zero. We approximate this process by fitting a Poisson regression model.

Table 8 presents our estimates for the periods 2006–07 and 2006–12. Among the regressors we consider cash flow, profitability, financial leverage, liquidity, tangibility and growth, firm size, age, the number of past patents (2003–07) and sub-sectors fixed effects (columns 2–3 and 5–6). We first include the predetermined values of the financial ratios with respect to the ex-post innovative activity (columns 1–3). Then, we run the regression over a longer timespan (2006–12) in columns 4–6. In order to test the robustness of results to the choice among different metrics, we again run the original regressions (columns 1 and 3) using different proxies (columns 3 and 6). Profitability is proxied alternatively with profit margin and EBITDA return on assets. Leverage is proxied with leverage ratio or debt ratio. Finally, liquidity is represented by current ratio or liquidity ratio. Variance Inflation Factors (VIFs) have been examined to detect multicollinearity. All of the VIF scores are below 3 and the mean VIF score is 1.5.

The estimates for the period 2006–07 (column 1-3) show a large and highly significant effect of the cash flow to operating revenues ratio. A percentage point increase raises the expected number of patents by 5.3% (5.6%, in column 3, where different proxies and sub-sector fixed effects are considered). The effect is sizable given that the previous analysis highlighted a cash flow ratio difference of several percentage points between extreme groups. Profitability is not associated with a significant effect on patenting, both as profit margin and EBITDA profits.

Conversely, leverage is related to a lower level of patenting. Even accounting for the lower level of tangible assets in innovative firms, a percentage point rise in leverage (which means a relative increase in indebtedness) decreases the expected number of patents by 0.6%. When the effect of sub-sectors is included, this value ranges between 0.3% and 0.8%, depending on the choice of the ratio denominator. Interestingly, liquidity turns out to be negative and highly significant. The negative effect slightly increases when liquidity is accounted excluding relatively illiquid assets, such as inventories (column 3). However, the magnitude of the effect estimated here is low. The maximum average difference in liquidity ratios between groups is around 0.2, which in turn represents a maximum estimated reduction in patenting of 3–4%.

Anyway, the negative coefficient of liquid assets may be puzzling at first and at odds with the positive and significant effect of cash flow. However, the two ratios describe different aspects. While cash flow ratio accounts for the ability to acquire cash resources to finance operations and investment which might suggest a higher capability of employing internal resources, liquidity signals the company's decision of holding a certain amount of cash or liquid assets with respect to its current liabilities. Therefore, excessive resource cushion may also result in possible inefficiencies and unproductive use of cash. Sales growth rate and firm's age correlates positively with number of granted patents. The effects are both significant at conventional levels.

A much stronger role is played by past patenting performance and the dimensional variables. In fact, each patent acquired in the previous five years rises the number of expected (ex-post) patents by 1.1%. This result confirms the role of persistency among Italian innovators. Lastly, size coefficients suggest that larger firms are able to produce on average more patents than smaller ones and this effect is highly statistically significant for all the categories.[11] Columns 4–6 run again the same regressions to test the stability of coefficients over a longer time-span, which also includes the recessionary period. Sign, significance and magnitude remain virtually unchanged. The only exception is the growth rate coefficient, which significantly rises, signaling how successful innovation correlates more so with sales growth in the longer period, which includes the crisis.

[11] The very high coefficients of size are due to the choice of the base category. Overall, micro enterprises are responsible of very few patents, which in turn reflects on the very high relative effect of the other categories.

Dependent variable: Total number of granted patents 2008-12							
		2006-07			**2006-12**		
		(1)	(2)	(3)	(4)	(5)	(6)
Cash flow		.053***	.054***	.056***	.045***	.049***	.048***
		(.012)	(.013)	(.008)	(.009)	(.009)	(.011)
Profitability		-.003	-.008	-.013	-.005	-.010*	-.008
		(.010)	(.011)	(.009)	(.007)	(.006)	(.011)
Leverage		-.006***	-.003**	-.008***	-.007***	-.004**	-.008***
		(.002)	(.002)	(.003)	(.002)	(.002)	(.003)
Liquidity		-.210***	-.149**	-.230**	-.246***	-.216***	-.314***
		(.076)	(.074)	(.091)	(.070)	(.071)	(.085)
Tangibility		-2.855***	-1.959***	-1.817***	-2.731***	-1.993***	-1.865***
		(.408)	(.409)	(.356)	(.309)	(.324)	(.308)
Growth		.004**	.003**	.003**	.025***	.024***	.023***
		(.002)	(.002)	(.001)	(.003)	(.003)	(.003)
Age		.006*	.006*	.006*	.006**	.007**	.007**
		(.003)	(.003)	(.003)	(.003)	(.003)	(.003)
Past patenting		.011***	.011***	.011***	.011***	.011***	.012***
		(.000)	(.001)	(.001)	(.001)	(.001)	(.001)
Size							
	Small	.783***	.747***	.764***	1.131***	1.101***	1.079***
		(.113)	(.114)	(.116)	(.145)	(.146)	(.148)
	Medium	2.453***	2.334***	2.347***	2.800***	2.685***	2.659***
		(.136)	(.134)	(.135)	(.176)	(.175)	(.176)
	Large	4.129***	3.960***	3.959***	4.465***	4.300***	4.269***
		(.137)	(.136)	(.139)	(.163)	(.163)	(.166)
Constant		-2.798***	-3.053***	-2.909***	-2.998***	-3.193***	-3.088***
		(.229)	(.276)	(.277)	(.210)	(.266)	(.290)
Sub-sectors		NO	YES	YES	NO	YES	YES
Pseudo R^2		0.45	0.49	0.49	0.46	0.50	0.50
Wald χ^2		2,785.5	3,533.1	3,892.9	2,424.3	3,121.2	3,669.3
P-value		<.001	<.001	<.001	<.001	<.001	<.001
Observations		39,960	39,960	40,003	41,471	41,471	41,478

NOTE: This table reports the results of the Poisson regressions over the number of granted patents between 2008-12. Symbols *, ** and *** denote significance level of 10%, 5% and 1%, respectively. Standard errors are robust to heteroskedasticity.

Table 8: Poisson model - Effect of financial characteristics on patenting

Overall, the multivariate analysis substantially confirms the previous evidence, with the exception of profitability ratio. Firms that successfully patented during the crisis are on average relatively large, established and with previous history of innovation. Their indebtedness is relatively lower than non-innovators, as it is also their collateral. Lastly, they show a relatively faster growth and a higher ability to produce cash flow out of their sales. The interpretation of these final results together with the previous evidence will be discussed in detail in the concluding section.

4.3 Robustness checks

We run a set of tests to check the robustness of our results to truncation bias. Patent count truncation can be a substantive issue, especially for recent years. In our dataset the average application-grant time-lag (between 2006 and 2010) is 3.8 years, while our dataset is updated to the beginning of 2016 (the truncation point). Hence, the choice of analyzing patenting up to 2012 may raise some concerns, since we have seen a drop in patent count over the years 2011–2012. Following the literature, we directly correct the truncation bias by adjusting the currently-available information on patent count. As in Fang et al. (2014), we adjust the number of patents in the last two years, dividing the original number by the expected share of the patents granted at the end of the dataset (2016) for each vintage year. We base the correction on the empirical distribution of the 2006–2010 application-grant time-lag, differentiating for eight patent technological classes (IPC classification). Therefore, this method also takes into account the possible variation in application-grant time-lag across different technologies and years (fixed effect). Similarly, Dass et al. (2017) concludes that excluding the last 3–4 years of patent data and using class-year fixed effects can sufficiently correct the truncation bias.

Table 9 presents results for the truncation-adjusted patent counts. Columns 1–3 replicate the corresponding regressions using the corrected number of patents for 2011. The year 2012 (the one with the highest possible truncation) is excluded. The first set of regressions confirms the consistency of the previous results. Sign, significance and magnitude of all coefficients remain virtually unchanged. When the year 2012 is also included and corrected with the class-year fixed effects method (columns 4–6), we observe a slight softening of the effects relative to cash flow, liquidity and tangibility, while sign and significance remain stable. The other regressors are not sensitive to the truncation bias. Overall, the findings do not appear to be driven by the truncation in patent data as we excluded in advance the relatively recent data near the end of the dataset (years between 2012 and 2016).

Dependent variable: Total number of granted patents 2008–12						
	2006–07			2006–12		
	(1)	(2)	(3)	(4)	(5)	(6)
Cash flow	.054***	.055***	.056***	.034***	.037***	.034***
	(.013)	(.013)	(.009)	(.007)	(.007)	(.011)
Profitability	-.005	-.010	-.013	-.006	-.009*	-.002
	(.011)	(.011)	(.009)	(.006)	(.005)	(.012)
Leverage	-.006***	-.003*	-.007***	-.007***	-.005**	-.008***
	(.002)	(.002)	(.003)	(.002)	(.002)	(.003)
Liquidity	-.212***	-.145**	-.236**	-.213***	-.194***	-.277***
	(.077)	(.074)	(.093)	(.068)	(.068)	(.086)
Tangibility	-2.969***	-2.024***	-1.868***	-2.412***	-1.703***	-1.590***
	(.418)	(.410)	(.356)	(.288)	(.298)	(.296)
Growth	.004**	.003**	.003**	.026***	.025***	.025***
	(.002)	(.002)	(.001)	(.003)	(.003)	(.003)
Age	.005	.006*	.005	.006*	.007**	.007**
	(.003)	(.003)	(.003)	(.003)	(.003)	(.003)
Past patenting	.011***	.011***	.011***	.010***	.012***	.012***
	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)
Small	.775***	.737***	.751***	1.165***	1.129***	1.096***
	(.115)	(.116)	(.119)	(.165)	(.158)	(.161)
Medium	2.445***	2.320***	2.329***	2.887***	2.757***	2.724***
	(.138)	(.137)	(.138)	(.204)	(.192)	(.194)
Large	4.130***	3.947***	3.941***	4.628***	4.436***	4.409***
	(.141)	(.140)	(.142)	(.188)	(.176)	(.181)
Constant	-2.818***	-2.979***	-2.821***	-2.942***	-3.084***	-3.034***
	(.234)	(.279)	(.283)	(.197)	(.285)	(.316)
Sub-sectors	NO	YES	YES	NO	YES	YES
Pseudo R^2	0.45	0.49	0.49	0.48	0.53	0.53
Wald χ^2	2,599.2	3,443.5	3,844.9	2,416.5	3,282.6	3,800.4
P-value	<.001	<.001	<.001	<.001	<.001	<.001
Observations	39,960	39,960	40,003	41,359	41,359	41,378

NOTE: This table reports the results of the Poisson regressions over the number of granted patents between 2008–12. Symbols *, ** and *** denote significance level of 10%, 5% and 1%, respectively. Standard errors are robust to heteroskedasticity.

Table 9: Poisson model - Effect of financial characteristics on patenting - Corrected sample

5 Conclusion

We analyze the financial profile of Italian non-financial companies according to their innovative activity. Our results highlight a link between the number of patents issued in 2008–12 with companies' financial characteristics. We document that patents are concentrated in specific firms and sectors, negligible for micro and small companies and very small for medium-sized companies. Even among large manufacturing firms, over 70% have never applied for a patent. This performance improves when firms are publicly traded and, to a lesser extent, for firms owned by international holding groups. Italian innovation is mostly concentrated among manufacturing firms (with over 80% of patenting in 2006–12 and about 76% before the year 2006).

The largest share of Italian manufacturing firms is not innovative; some of them are occasional innovators, and only few large firms maintained a persistent level of high inventive capacity. Overall, medium and great innovators represent 0.9% and 0.1% of the sample, but account respectively for 32% and 36% of the issued patents. The 49 best innovators are all large companies with more than 250 employees. This is related to the nature of persistent innovation, which requires a set of capabilities, skills and structures that are hardly available within smaller organizations, as well as related to the typical specialization of production of Italian manufacturing firms. The average number of patents increased from 2003–07 to 2008–12, owing to firms moving to the status of occasional- and medium-innovators. However, only large firms have a persistent innovation pattern, since they are the only ones capable of pursuing research and innovation during the contractionary phase of the business cycle.

Results show that there is a significant difference both between innovators and non-innovators and, among innovators, between occasional and persistent ones. These group differences increase with innovation intensity, remain stable over time and are invariant after controlling for size, age and sub-sector. Innovators are relatively large, mature and established firms with large cash flows and low leverage, capable of financing patent-related activities with internal funds. They are also able to better weather the negative phase of the business cycle, owing to the limited growth reduction with respect to non-innovators. Finally, innovators avoid the accumulation of unproductive financial cushions, even during crisis.

Overall, results support the hierarchical view of financing since, moving from non-innovators to great innovators, the use of cash flow to fund innovation increases, while leverage decreases. However, we do not address the direction of causality. With reference to Italy, we document that Italian innovators are good performers, endowed with a long-term vision, the skills and the means to pursue innovation and face adversities. However, Italian innovating firms are not numerous with respect to the size of the productive system. These firms are mainly concentrated in the manufacturing sector and are too few to reverse the performance of the Italian economy in the last two decades. To fill the gap between Italy and the other European countries, both the extensive and the intensive margins should be exploited: Italy needs both a significant increase in the patenting performance of persistent innovators and the entry of new innovators; the role played in patent innovation by smaller companies and new startups is left for future research.

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Appendix A Construction of variables

Time-invariant firm characteristics have been derived from Orbis Bureau van Dijk. This section reports a brief description of the construction of these variables. The main factors that determine the size classification, as defined by the European Commission Recommendation 2003/361, are staff headcount and either turnover or total assets. Table A1 reports the official ceilings. In the recommendation, the European Commission explains that the criterion of staff numbers is the most important, while a financial criterion is introduced to measure the real scale and performance of an enterprise. The choice of combining operating revenues (turnover) with total assets derives from the necessity to account for sector-based turnover differences that could bias the evaluation of the overall wealth of the businesses. Therefore, micro firms have less than 10 employees and either turnover or assets smaller than 2 million euros. Similarly, small (medium) firms are defined as those with less than 50 (250) workers and which meet at least one of the two financial criteria (10 million euros in assets or revenues for small firms and 43 million euros in assets and 50 million euros in turnover). All enterprises above these thresholds are considered to be large. Crucially, these factors change from year to year. Therefore, all the figures are evaluated at pre-crisis levels, by averaging those values in the years 2006–07.

Size	Staff headcount	Total assets	or	Operating revenues
Micro	< 10	$\leq 2m$		$\leq 2m$
Small	< 50	$\leq 10m$		$\leq 10m$
Medium	< 250	$\leq 43m$		$\leq 50m$
Large	≥ 250	$> 43m$		$> 50m$

Table A1: Size definition cut-offs

Sectors are based on the values of NACE rev.2, the statistical classification of economic activities in the European Community (Eurostat, 2008), reported by Orbis for each firm. Through these codes, sectors have been constructed by aggregating each NACE division (a two-digit value) into meaningful groups. Financial corporations (divisions 63-66) have been excluded from the analysis, while those companies without a sectoral code have been dropped from the sample. Table A2 reports the 11 aggregated sectors, with the corresponding sections and divisions of NACE rev.2 classification. Table 1 in Section 3 employs this classification to describe the sample and the relative weight of each sector.

Sector	Nace rev.2 section	Nace rev.2 division (d)
Agriculture, Forestry, Fishing and Mining	A+B	$d \leq 9$
Manufacturing	C	$d > 9 \cap d \leq 33$
Energy, Gas and Water supply	D+E	$d > 34 \cap d \leq 43$
Construction and Real estate	F+L	$d > 40 \cap d \leq 43 \cup d = 68$
Wholesale trade	G	$d > 44 \cap d \leq 46$
Retail trade	G	$d = 47$
Transportation and Storage	H	$d > 48 \cap d \leq 53$
Accommodation and Food	I	$d > 54 \cap d \leq 56$
Information, Communication and R&D	J+M	$d > 57 \cap d \leq 63 \cup d = 72$
Other Services	M+N	$d > 68 \cap d \leq 75 \cup d > 79 \cap d \leq 82$
Other Sectors	N+O+P+Q+S	$d > 76 \cap d \leq 79 \cup d > 83$

Table A2: Sector aggregation according to the Statistical classification of economic activities (NACE rev.2)

The variable “publicly traded” indicates if the ownership is dispersed among the general public and if it is freely traded in stock markets (public company) or if it is exclusively privately owned and traded (private company). It derives from the original variable “listeddelistedunlisted” in Orbis and is evaluated for the year 2006.

The values of the variable “corporate group” derives from the original variables “noofcompaniesincorporategroup” and “guocountryisocode” which respectively reports the number of companies in the business group and the nationality of the ultimate owner (in case of business group). The latter is assigned to “international holding” if the value is different from Italy. All these variables are evaluated for the year 2006.

Variable Name	Definition	Num. Obs.	Mean	St. Dev.	Min	Max	Median
Age	Constructed as the difference (in years) between the financial year of the data and the company's date of founding.	41,601	23.25	14.70	4.00	156.00	21.00
Cash flow / Operating revenues	Constructed as the percentage ratio of a company's internal cash flow to its operating revenues. This metric evaluates the ability to turn sales into cash.	41,509	4.76	7.81	-84.27	48.70	4.04
Cash Ratio	Constructed as the ratio of a company's total cash and cash equivalents to its current liabilities. This metric evaluates the ability to repay short-term debts.	41,587	0.23	0.40	0.00	3.08	0.08
Cash / Total assets	Constructed as the ratio of a company's total cash and cash equivalents to its total assets. This metric measures the share of a company's assets that are cash or can be converted into cash immediately.	41,588	0.08	0.09	0.00	0.54	0.04
Current ratio	Constructed as the ratio of a company's current assets to its current liabilities. This metric evaluates the ability to pay short-term obligations. It includes in current assets also stocks, valued at acquisition cost.	41,601	1.64	1.10	0.24	9.29	1.31
Debt ratio	Constructed as the percentage ratio of a company's total long-term and short-term debt to total assets. This metric measures the proportion of a company's assets that are financed by debt.	41,601	20.60	17.06	0.00	75.66	18.02
EBITDA return on assets	Constructed as the percentage ratio of a company's EBITDA profit generated to total assets. This metric evaluates the company's profitability, allowing a meaningful comparison between companies with different capital structure, debt structure and geographical locations.	41,510	8.34	6.40	-24.17	37.27	7.45
Interest coverage	Constructed as the ratio of a company's earnings before interest and taxes (EBIT) to the amount interests paid on its debts during the calendar year. This metric evaluates the company's ability to repay interest on its outstanding debt with available earnings.	41,191	23.87	64.17	-85.46	610.00	2.93
Leverage	Constructed as the percentage ratio of a company's total debt (loans and long-term debt) to the sum of total debt and shareholders' funds. This metric measures the proportion of capital which comes in the form of debt.	41,591	39.08	29.04	0.00	100.00	37.76
Liquidity ratio	Constructed as the ratio of a company's liquid current assets (cash, accounts receivable and short-term investments) to its current liabilities. This metric evaluates the ability to pay short-term obligations. Also known as the 'Acid test ratio', it ignores illiquid assets such as inventory.	41,601	1.24	0.95	0.13	7.82	0.97
Profit margin (pre-tax)	Constructed as the percentage ratio of a company's profits before taxes to its operating revenues. This metric evaluates profitability excluding taxes which are not a function of operations.	41,601	0.81	13.35	-138.68	39.20	1.97
Return on assets (ROA)	Constructed as the percentage ratio of a company's net income generated to total assets. This metric evaluates the company's profitability and efficiency in using its assets to generate earnings.	41,601	1.47	4.66	-26.69	22.78	0.81
Return on equity (ROE)	Constructed as the percentage ratio of a company's net income generated to shareholders' funds. This metric evaluates the company's profitability using the capital shareholders' have invested.	41,469	1.17	24.54	-329.73	80.91	3.84
Solvency ratio (Assets)	Constructed as the percentage ratio of a company's shareholders' funds to total assets. This metric measures the amount of assets on which shareholders have a residual claim in case of liquidation.	41,601	29.64	20.14	0.00	87.93	25.82
Tangibility	Constructed as the ratio of a company's tangible assets amount (including fixed and current assets) to the value of total assets. This metric measures the proportion of assets that have a physical form and can be used as collateral.	41,600	0.25	0.20	0.00	0.87	0.21
Turnover Growth	Constructed as the growth rate over time of operating revenues. This metric measures the rate of expansion (or contraction) of business.	41,562	4.63	14.63	-77.25	239.47	2.92

Table A3: Definition of time-variant variables