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SMEs and patents: Is it worth it? A longitudinal analysis of the patent-performance relationship

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ABSTRACT

In response to scepticism about the benefits of patenting in small firms, this paper provides new evidence on the relationship between financial performance in SMEs and patents, distinguishing between applications and granted patents. Empirical analyses show that firms with a patent application still pending five years after the filing date report higher sales than comparable firms who have not filed. Yet, we also find that the monopoly rights attached to granted patents do not result in higher sales than simply filing for a patent. This analysis leads us to infer that the activities performed during the patent application process improve firm knowledge stocks and absorptive capacity, in turn promoting performance above and beyond the status quo. SME managers should find in this study solid empirical evidence supporting well-informed decision-making over patenting.

1. Introduction

In today's knowledge economy, innovation is crucial to a firm's path towards success and profitability (Maresch et al., 2016; Power & Reid, 2021; Schumpeter, 1934; Teece, 1986; Teece, 2006). Managers deal with many decisions concerning innovation activities, among which a paramount role is played by selecting the right instrument to protect intellectual property (IP) (Jee & Sohn, 2021).

This study explores the impact of patents on the financial performance of small-to-medium-sized enterprises (SMEs). SMEs constitute the backbone of most national economies, significantly contributing to employment and output growth (Haltiwanger et al., 2013). In addition, small firms are often powerhouses of innovation, especially in mid- and low-tech sectors. So, in line with studies on small business and innovation management, it makes sense to use patenting activity to indicate future growth opportunities and firm quality (Czarnitzki & Toole, 2011; Mina et al., 2021). However, when looking at the relationship between patents and financial performance, the empirical evidence provides various contrasting results. Some studies find a positive relationship (Agostini et al., 2015; Andries & Faems, 2013; Chang et al., 2012; Maresch et al., 2016), others report no association (Griliches et al., 1991), and others still find a negative relationship (Artz et al., 2010; Power & Reid, 2021). Moreover, the literature suggests that the strategic opportunities and value associated with patents are different for SMEs than for large firms (Arundel, 2001). Greater financial constraints (Carpenter & Petersen, 2002), peculiar governance structures, and the complexity of the patenting system play a relevant role in determining SMEs attitudes towards patenting (Blind et al., 2006; Holgersson, 2013) supporting the hypothesis that for many SMEs the

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motivations behind patenting are not necessarily associated with purposes of intellectual property protection (Hall et al., 2013; Holgersson, 2013). Instead, they are often focused on attracting customers and/or external investors (Blind et al., 2006).

SMEs typically have a lower propensity to patent (Arundel & Kabla, 1998; Brouwer & Kleinknecht, 1999; Mansfield, 1986), but when they do patent, they are more likely to put their patents to productive use (Hughes & Mina, 2010). These stereotypical facts suggest that the managers of SMEs will typically follow a different approach to patenting than large firms and that their attitudes towards it will often be sceptical (Holgersson, 2013).

Empirical studies on SMEs, however, do not provide coherent evidence either. Such examinations rely on a variety of different proxies for patenting, ranging from patent counts to patent applications (Agostini et al., 2015; Andries & Faems, 2013; Demirel & Mazzucato, 2012; Helmers & Rogers, 2011; Maresch et al., 2016; Power & Reid, 2021; Sohn et al., 2010). These contrasting findings raise doubts over the effectiveness of the patenting system in the context of small firms. They also hint that additional evidence might be helpful for SME managers in charge of steering their firm's IP management strategies or to policymakers who must design effective innovation policies for all businesses, not just large companies (Athreye et al., 2020).

We extend this literature by drilling down into the patenting process, intending to disentangle the different effects on performance induced by this process. We take the patenting process as starting once an SME has completed the development of their innovation and the firm's managers decide whether to apply for a patent. After examination by the patent office, the application can either be granted or remain pending. In some cases, the patent can be withdrawn by the applicant or it can be flagged as abandoned. Our research questions concern the two occurrences that can happen in the process mentioned.

First, we wonder whether applying for a patent increases firm performance. This question is explored by comparing the financial performance of similar firms that both did apply for patents (but did not obtain them) and did not apply for patents – hereafter, we often use the terms "Non-granted" and "Non-filers" to distinguish these two groups. A difference in performance would indicate that the mere effort of applying for a patent provides a significant increase in the firm's knowledge stocks and absorptive capacity. Such evidence is relevant for managers because applying for a patent is a lengthy and costly process, and new evidence on this issue could shed light on the potential benefits attached to the patenting process that is independent of the success of the patent application itself.

Second, we question whether the monopoly power of a granted patent confers some additional performance over and above a pending or withdrawn patent. This issue is rarely analysed in the literature (Farre-Mensa et al., 2019; Maresch et al., 2016). Both cases represent an existing innovation from the perspective of the firms, and although we might expect to observe a significantly better performance in granted patents, we argue that this is not always the case. In fact, our analysis reveals that even controlling for withdrawn patents, SMEs with granted patents do not systematically outperform comparable SMEs with patents still pending after a long time or withdrawn – hereafter referred to as "Granted" and "Non-granted".

Thus, in this study, we explore the relationships between patenting and performance for three different groups of SMEs:

- *Granted*: Firms that had their patent application successfully granted.
- *Non-granted*: firms that applied for a patent, but this was either rejected or had not been finalised five to ten years after the filing date, i.e., firms with a patent still pending after more than five years from filing or withdrawn by the filing company.
- *Non-filers*: firms that have not applied for a patent (identified as specified in the methodology section).

Further, because analysing these relationships is subject to a series of endogeneity concerns, we adopted a research design built to disentangle the effects of patents on performance from the effects of innovation. Part of this involves using quasi-experimental techniques in the selection on Non-filers group, but it also involves exploiting the fact that some firms in the sample have had their patents granted, i.e., the "Granted" group, while others have withdrawn or still hold pending patents, i.e., the "Non-granted" group with their not (yet) granted patents. The result is a picture of the changes in performance associated with patents through a longitudinal analysis of a sample of about 3500 Italian SMEs up to five years after patent filing.

This study makes several contributions to the literature on patents and SMEs performance.

First, we explore the different channels within the patent application process that might lead to an increase in financial performance, suggesting that the patent application efforts on their own may be valuable to the firms and result in increased financial performance.

Second, past literature shows contrasting findings on the effect of patent applications on financial performance. We contribute to this literature gap with a longitudinal analysis of a large sample of SMEs in a cross-industry setting, considering causality issues. Our results show higher sales growth for firms that have filed for patents versus those that have not.

Third, we provide empirical evidence that there is no significant difference in financial performance between SMEs with granted patents versus pending or withdrawn patents. This finding suggests that monopoly rights are less lucrative than previously thought and justifies the scepticism of SMEs managers regarding the monetary benefits of patented innovations.

The structure of this paper is as follows. Section 2 presents an overview of the previous studies on the patent-performance relationship and discusses the currently open issues. Section 3 describes the methodology, while Section 4 introduces our dataset, descriptive statistics, and econometric estimates. Section 5 articulates the discussions, conclusions, limitations, and future research directions.

2. Patents and economic performance

When an SME develops an innovation, a decision must be made as to whether to apply for a patent. When the firm requests approval from the patent office, the patent might be granted, revisions might be requested, or the patent might be refused. In the case of the first

outcome, the firm obtains the "legal title granting its holder the right to prevent third parties from commercially exploiting an invention without authorisation", as defined by the European Patent Office. Similarly, the patent can be granted when the applicant successfully provides revisions. At last, if the patent is refused, but the applicant files an appeal or goes to trial, a patent can remain pending for several years until a final decision is taken (European Patent Office, 2016).

Owning a patent is often viewed as an effective way to appropriate the returns of intellectual property assets (Czarnitzki & Toole, 2011). Although the market monopoly might seem the most important reason for a patent application, we argue that there is more to it than meets the eye. In this section, we first discuss the relevant literature on patenting and SMEs performance and then develop our hypotheses.

2.1. Existing evidence on the patent performance relationship for SMEs

We came across only a few studies that consider firm size or are explicitly focused on small firms. Among the studies finding a positive effect, Helmers and Rogers (2011) analyse a sample of British startups and, after controlling for selection and identification issues, find that those who apply for patents have a higher asset growth than those who do not. Similarly, Andries and Faems (2013) explore the differences in performance between small and large firms, examining 358 Belgian firms that participated in a CIS survey. Their study shows that SMEs that apply for patents can expect a positive effect on turnover. However, their conclusions are drawn from limited longitudinal data. Barontini and Taglialatela (2021) analysed a sample of Italian firms that patented in 2005, suggesting that firms that filed for a patent were more resilient when the great financial crisis struck in 2008. Also, Farre-Mensa et al. (2019), analysing a sample of US startups, show that patentees benefit for five years from additional employment and firm growth and are more successful in subsequent innovation. On this line, Maresch et al. (2016) analyse the role of patents on the performance of a sample of Austrian firms, showing that the number of patents does have a positive impact on firm performance and also that this impact is negatively related to patent age. As underlined by the authors, an interesting contribution would be to analyse firms whose patent applications were not finalised versus firms that have not attempted to patent.

However, insignificant evidence is found by Demirel and Mazzucato (2012), that, investigating the sales growth of a sample of US pharmaceutical firms, note that the number of patents a firm holds has little to no effect on firm growth. Sohn et al. (2010) reach a similar conclusion when studying Korean firms and the effects of patent stocks on firm performance. Agostini et al. (2015) use patent counts to study their effect on performance in an analysis of Italian SMEs operating in the mechanical sector, finding that higher patent counts are not significantly correlated to superior performance. At last, Power and Reid (2021) study a longitudinal sample of US startups, realising that a higher patent count reduces the likelihood that the startup is a high performer.

In summary, it's clear that, although this relationship has been subject to a number of studies, the literature presents many conflicting results, probably determined by the use of different measures and methodologies. Further, a dimension that has been often neglected is the separation of the effect of the patents from those of the underlying innovations. We aim to extend this literature by attempting such analysis comparing the performance of three groups: firms that have applied for a patent, but for which the patent application is still pending; similar firms that have not applied for a patent in the period of analysis; firms that have applied for a patent that was granted. In order to achieve that, it is essential to properly select the Non-filers group. Therefore, before developing hypotheses, we briefly discuss the literature on determinants of patenting decisions, which will constitute the basis for our selection process.

2.2. Determinants of the patenting decision

The decision to patent an invention is subject to several forces inside the firm (Agostini et al., 2022; Emodi et al., 2017), whose identification is a prerequisite to delving into a debate about the patent-performance relationship. This is because there are significant overlaps between the determinants of innovation and the decision to patent, and it is not easy to disentangle the effect of IP protection from the economic characteristics of innovation (De Rassenfosse, 2010).

Literature suggests that patenting behaviour is extremely sensitive to industry characteristics (Arora et al., 2008; Link & Scott, 2018) and that firm size and age are relevant for patenting activities (Andries & Faems, 2013; Messeni Petruzzelli et al., 2018). In addition, capital intensity, which indicates a firm's technological level and knowledge stocks, is relevant in determining the propensity to innovate and to patent, especially when the sector is taken into account (Almus & Czarnitzki, 2003). Managers that decide to patent must also consider the associated costs, especially in the case of smaller firms. Therefore, the availability of cash-flow and a firm's debt level are important determinants of both the decision to innovate and the decision to patent. Recent studies also suggest that the ownership structure – in our case, the ownership concentration – plays a role in firm performance and innovation effort (Fitza & Tihanyi, 2017; Succurro & Costanzo, 2019).

Building on these previous findings, we aim to control a firm's likelihood of patenting by selecting a control sample composed of firms that could be potential patentees. In the ideal quasi-experimental methodological setting, we would have two inventions that are exactly the same, with only one of the two being patented. However, this being impossible, we must assume that the observable determinants presented above can identify pairs of firms with a similar likelihood to apply for a patent. It is necessary to carefully select the control sample to disentangle the effect of patents from those of the underlying innovations. We know this list is not exhaustive since other unobservable determinants can affect the propensity to patent and innovate. For instance, some authors report that R&D expenses play a key role (Arundel & Kabla, 1998; De Rassenfosse, 2010). However, data for small firm on R&D expenditure are often unavailable or unreliable, making these non-feasible choices for this type of analysis.

Overall, we argue that leveraging the observable determinants of the patent propensity, together with the empirical strategy

outlined below, can help disentangle the patent's effect from that of the underlying innovation.

2.3. Hypothesis development

As previously highlighted, a gap in the literature still exists about the impact on financial performance related to granted and pending or withdrawn patents. We aim to take this literature stream further by implementing an experimental research design that, with the help of patent application outcomes, can provide additional evidence of the effects of patents on SMEs in the medium term. In addition, previous studies often focus on either patent applications (whether granted or not) or granted patents. We investigate if any difference in performance should be expected between Non-granted, Non-filers, and Granted, to provide a comprehensive view of the relationship between the patenting process's several steps and SMEs' financial performance.

Consider two firms that have developed an innovation; one has attempted to patent their innovation and the patent has been withdrawn or is awaiting revisions, the other has made no attempt to protect their IP. Should we expect to observe a difference in performance between these two firms, as shown in Fig. 1? We argue that this is the case and that the patenting process has unique characteristics that contribute to the firm growth.

Our discussion begins with some conjectures on the potential differences in performance between these two types of firms – "non-filers" and "non-granted firms" (i.e., firms that applied for a patent, but this was either rejected, withdrawn by the filing company or still pending after more than five years from filing). As illustrated in Fig. 1, The starting point of the discussion is to acknowledge that the differences in the performance of these two groups do not depend on the legal ability to exercise monopoly market power. Instead, we argue that the activities performed during the process of applying for a patent can result in a set of benefits that will have a long-lasting effect on the firms. In a knowledge-based view of the firm, filing for a patent is associated with activities that increase the firm's accumulated knowledge stocks; lead to improved practices; optimise products and processes; and yield other collateral benefits that could be a trigger for superior performance (DeCarolis & Deeds, 1999).

While some of these improvements might be found in firms that have invented but not applied for a patent, we argue that several characteristics are unique to the patenting process.

First, the effort to position the invention in the state-of-the-art of the technology is likely a moment of professional growth for inventors because they must compare their products to existing knowledge and elaborate on the novelty introduced, acquiring and applying new knowledge (Valentim et al., 2016). Analysing prior art and identifying claims is a complex effort that will compel the inventor to investigate existing patented solutions, and could result in increased inventor competencies and skills (Chitale et al., 2020). It could also provide business intelligence that can be used to make improvements to other existing products or services the firm provides.

Second, for an SME the process of deciding whether to apply for a patent usually includes external consultants, such as patent attorneys and technology experts. This might lead to an increase in the firm knowledge search and spanning capabilities, which are traditionally more limited in smaller firms (Athreye et al., 2020; Mina et al., 2014).

At last, applying for a patent is time-consuming and requires considerable effort but could result in improved knowledge and competencies for the employees involved. In turn, these new skills confer the ingredients for further improvements in the firm's technologies, absorptive capacity, and overall performance (Cohen & Levinthal, 1990; DeCarolis & Deeds, 1999; Kostopoulos et al., 2011; Murovec & Prodan, 2009; Valentim et al., 2016).

On the downside, we can expect these positive effects to be, at least partially, offset by the drawbacks that come with the decision to file for a patent. There are in fact high upfront costs associated with external consultancies and managerial effort determined by the process of preparing and applying for patents, and previous studies have shown that these cost barriers are among the most relevant issues preventing SMEs from patenting (Athreye et al., 2020).

However, as a net effect, we expect that an increase in a firm's knowledge stocks and absorptive capacity from patent-specific

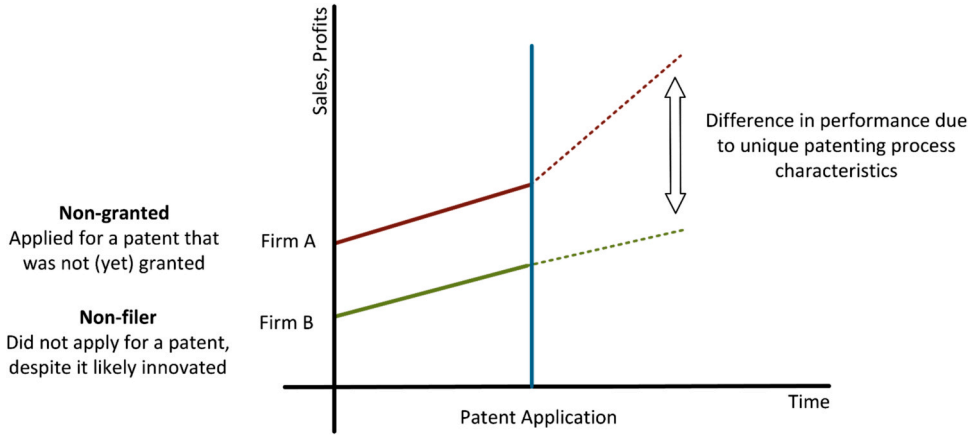

Fig. 1. Non-filers versus Non-granted, difference in performance.

procedures will outweigh the costs attached to applying for a patent. Therefore, we argue that filers will demonstrate better performance than similar non-filing firms. Thus, the following hypothesis is tested:

H.1. : *Firms that have filed for a patent that has been either withdrawn or is still pending have a better financial performance than comparable firms that have not filed for a patent.*

Our next point of discussion is the difference in performance between those who have been granted their patents versus those whose applications were either rejected or had not been granted by the time the embargo period expired – "Granted" vs "Non-granted" samples– as shown in Fig. 2. This perspective, rarely analysed in literature, allow us to disentangle the effect of patent protection from the effect of the invention and related R&D efforts. We argue that the patent status can be leveraged to provide an innovative perspective that might be useful to gain further insight into this relationship.

If patent protection can effectively allow a return on innovation, conventional wisdom suggests that we should observe better performance in granted firms. Observing a positive difference in performance between firms that were granted a patent and firms whose patent applications were still pending it could be argued that the differential in performance would be that granted patents allowed owners to recoup innovation returns.

Previous studies hint that reaping those returns can be very problematic for SMEs, due to a lack of resources with which to monitor and enforce patent rights (Holgersson, 2013; Holgersson & Granstrand, 2021; Jee & Sohn, 2021). For instance, according to evidence provided by Holgersson (2013), the lack of sheer resources with which to monitor their competitor's use of the patented technologies is a deterrent. Even worse, many SMEs lack the means with which to enforce their monopoly rights when they find a violator. Jee and Sohn (2021) offer evidence that IP protection only provides a limited contribution to an SME's ability to appropriate returns, especially when the legal system is weak and does not allow the controversy to be resolved quickly. Additional recent evidence provided by Holgersson and Granstrand (2021) suggests that patents are perceived by SMEs as being relatively weak instruments compared to other IP management strategies for boosting sales and sales margins. According to these studies, entrepreneurs often express concerns regarding their ability to effectively capture innovation returns, resulting in patenting being disregarded as a means of protecting IP. Therefore, these papers shed doubts on the effectiveness of patents to provide positive impacts for an SME's bottom line, although they do not test that notion directly.

We contribute to this literature stream, arguing that SMEs with patent protection are not able to consistently outperform similar firms with patents that have been published but have not (yet) been granted. If this hypothesis is confirmed, the monopoly right attached to a patent is therefore not a significant determinant of the performance difference. We argue that this effect is not significant because, as is often highlighted by SMEs managers, those firms are unable to effectively recoup their returns on innovation anyway. Accordingly, we test the following hypotheses:

H2. : *Firms that have been granted a patent do not show a better financial performance than firms with a patent that has been either withdrawn or is still pending.*

3. Methodology and data

3.1. Methodology

Testing the hypotheses put forward in the previous section is subject to a series of issues that have non-trivial solutions (Ernst, 2001; Kannebley et al., 2010). To establish a link between patents and firm performance, we would ideally have two groups of firms having

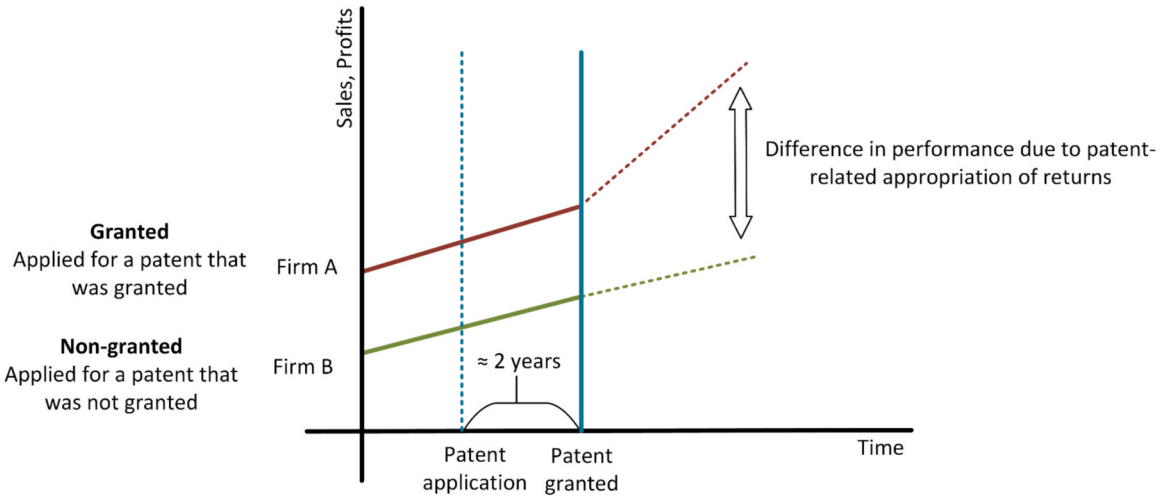

Fig. 2. Granted vs non-granted, difference in performance.

the same inventions soon to be market launched. One group – our treatment group – would patent, and the other – our control group – would not. Even more ideally, this decision would be made randomly.

As outlined by Helmers and Rogers (2011), we must use observational data and deal with simultaneity and heterogeneity issues when trying to isolate the difference in performance associated with patents. Simultaneity can be summarised in a simple question: How do we know that the decision to patent is not dependent on better performance (and vice-versa)? We have tried to reduce this bias with proper sample construction.

To avoid capturing effects on performance that are attributable to patents that we cannot control for (i.e., patents registered shortly before the patent that we analysed), we select only firms that did not register any patent for at least three years before the patent included in our analysis. Indeed, studies providing longitudinal results suggest that the larger effect of a patent on performance are most relevant during the first three to the first five years after filing (Cefis and Ciccarelli, 2005; Farre-Mensa et al., 2019; Maresch et al., 2016). Although this approach could exclude firms that produce a large number of patents, it provides more robust results. This research design also allows us to test for a clear temporal sequence between innovation and performance, an empirical issue common in previous studies on innovation and performance (Bowen et al., 2010).

Heterogeneity is due to the natural differences that exist among firms that could impact in different ways on the decision to patent. Each firm has peculiarities that uniquely influence the decision to patent, therefore directly comparing filers with non-filers could produce biased results. As Kannebley et al. (2010) underline, such a comparison arises out of concerns over endogeneity, because the decision to patent is correlated with both observable and unobservable characteristics in firms. part of this heterogeneity can be controlled for by using an appropriate control group and implementing measures for fixed effects in the econometric estimation. In particular, we selected a control sample using a multivariate distance matching technique that allowed us to condition the selection of the control sample on observable factors that are recognised as major determinants of innovation. In other words, we selected firms that were very similar to our treated (patenting) firms, i.e., firms that have the same probability to patent as the actual patentees. Additionally, we controlled for individual unobserved heterogeneity that is constant through time by including firm fixed effects in our regression models.

The database building process is a tenet of this research design and is illustrated via three main steps. First, we refined a dataset of patenting firms according to the specifications mentioned earlier. Then, we gathered the data for the potential controls. Last, we ran a matching algorithm to select the firms that would form the control group for the statistical analysis.

Fig. 3. Selection process of Granted and Non-granted.

3.2. Sample construction

All data for this study were collected from the Amadeus database during the Spring of 2016. This database represents the universe of limited companies and provides balance sheets, financial and ownership data. In addition, we gathered patent data from the Amadeus Intellectual Property database, which originates from the PATSTAT database established and maintained by the European Patent Office. The data were collected following a multistage process, as described below.

3.2.1. Treatment sample

Starting with all 22713 Italian firms that were linked with a patent in the Amadeus database, we identified all patents that were filed by Italian firms between 2005 and 2010, assembling a sample of 7364 firms. Our data period begins in 2005 due to the availability of information in Amadeus while we decided to limit our sample to 2010 in order to have at least five years of performance data for each firm to analyse after the application.

After deleting firms that filed for a patent within three years after the previous patent, as outlined earlier, we were left with 3865 firms. Selecting only SMEs from these firms reduced the sample to 2384 firms, as shown Fig. 3. SMEs were defined according to the European Commission criteria – that is, a staff headcount of up to 250 employees and either a turnover of less than €50 million or balance sheet total assets of less than €43 million.

As previously discussed, granted patents are distinguished from patent pending or withdrawn patent. In 2016, we selected firms with filing date between 2005 and 2010 have been classified as pending or withdrawn after at least 5 years had passed from the filing date.

3.2.2. Control sample

The next step was to assemble a set of firms that form the control group. Aiming to have as large a set as possible to run the matching algorithm on, we retrieved up to ten comparable firms for each patentee from Amadeus. By comparable, we mean the firms should all have similar NACE codes (Statistical Classification of Economic Activities), year of establishment (Age), and revenues. More specifically, the procedure calls for selecting up to ten firms within the same sector of the patentee in terms of two- or four-digit NACE codes and within a certain range of Age, and Revenues (see Fig. 4). The values are extracted using the year when the patent was filed as the

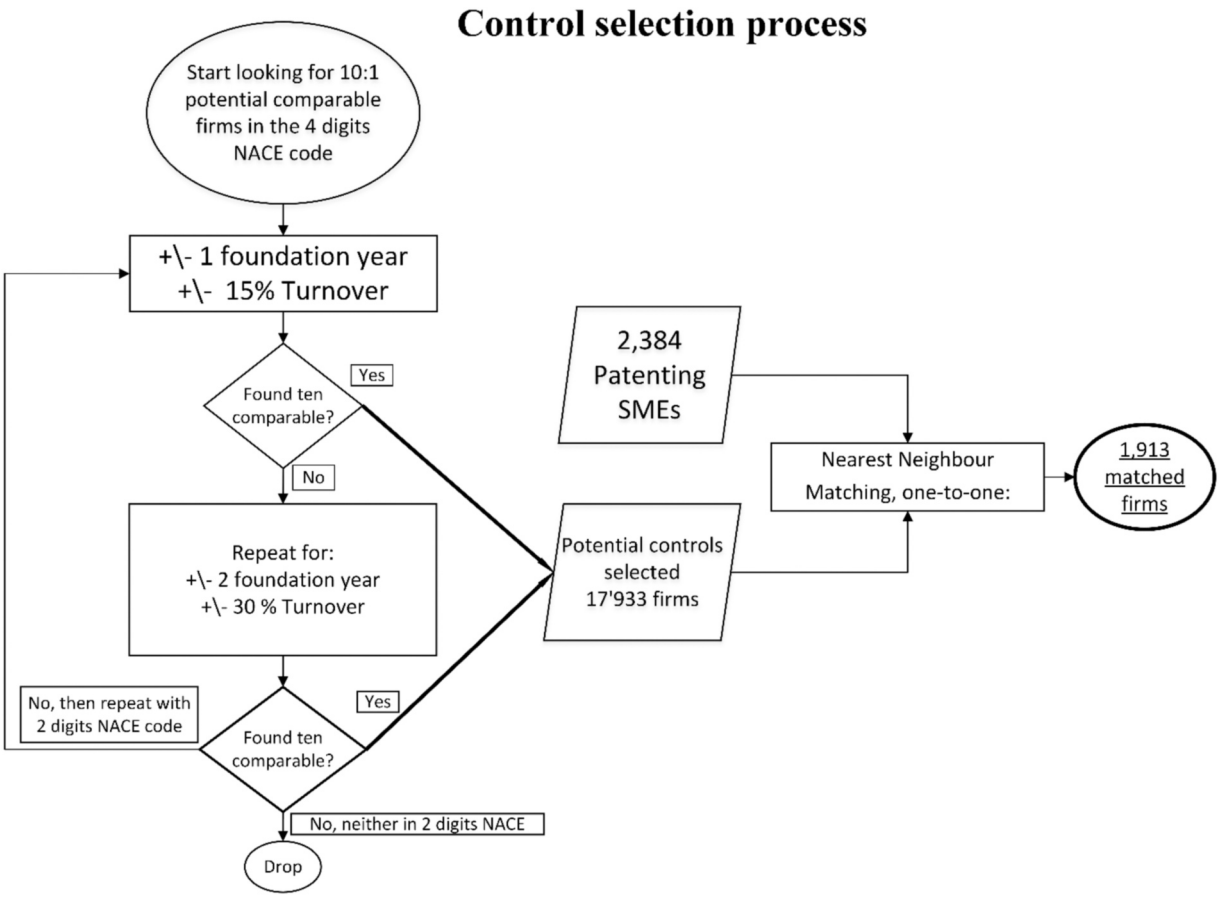

Fig. 4. Selection of control firms and matching process.

reference year, to guarantee an appropriate comparability. Firms that filed for one or more patents in previous years (2005–2010) were excluded from the potential control group. This initial sample included 17,933 potential control firms to which we applied nearest neighbour matching, as described in the next subsection.

3.3. Propensity score nearest neighbour matching

The propensity score matching (PSM) algorithm performs a one-to-one matching, selecting a control firm for each firm in the treatment group based on values that minimise the propensity score distance from this firm. The distance minimisation function includes an exact match on the sector and on the year in which the patentee filed for the patent and applies standard PSM on Size, Cash Flow, Capital intensity, Leverage, Age and Ownership Structure. A complete list of variables used in the analyses is provided in Table 1. In order to increase the matching quality, we impose a caliper distance of 0.2 of the standard deviations of the Logit of the propensity score, as in Islam et al. (2018).

We highlight that matching on the same sector and year is extremely important to ensure that firms are compared to similar firms and that they are subject to the same macroeconomic events, such as the financial crisis that started in 2008. As a practical example, if the patentee filed for a patent in 2010 and belonged to the NACE code 5, the matching algorithm would first restrict potential controls to firms belonging to the NACE code 5 and for which data in 2010 was available. It would then calculate the minimum distance on the base of the caliper and covariates provided.

As discussed in the theory section, the most relevant determinants of the likelihood to patent are included in the selection process. In addition to firm size, age and sector classification we considered:

Capital intensity, proxied as the ratio of tangible to total assets. The aim here is to account for the different technologies used by these firms (Almus & Czarnitzki, 2003), ensuring that each firm is matched with a control firm that is not only in the same sector but also has a very similar knowledge stocks.

Leverage and the ratio of cash flow to total assets. They help in controlling for the capital structure and financial conditions of each firm. Indeed, many costs are involved in filing a patent application and, therefore, it is important to select a control firm with similar financial capabilities to that of the patenting firm.

Ownership structure, proxied by a dummy indicating the ownership concentration level. The level of ownership concentration is relevant in influencing firms performance and innovation efforts (Fitza & Tihanyi, 2017; Succurro & Costanzo, 2019) and, therefore, we tried to select firms that had a similar level of ownership concentration just before the treatment firm decided to patent.

Fig. 5, which shows the standardised percentage of bias across the covariates in both the unmatched and the matched sample, reveal that the matching process is successful in selecting the set of comparable firms.

In line with Rosenbaum and Rubin (1985), we assess the matching quality by comparing significant differences between the matched and the unmatched samples. Table 2 reports t-tests and the ratio of the variances of the two samples. The results suggest that the significant differences observed in age and size within the unmatched sample become insignificant within the matched sample. Additional indicators of matching quality are the standardised mean and median bias and Rubin's b and r (Rubin, 2001). The threshold values Rubin (2001) recommended are that B is less than 25 and that R is between 0.5 and 2 for the samples to be considered sufficiently balanced, as presented in Table 3. Both conditions are satisfied in our sample; therefore, we deem the matching process satisfactory.

3.4. Econometric model

The nearest neighbour matching detailed above allowed us to select a control group based on observables. As pointed out earlier, it is reasonable to assume the presence of diffused heterogeneity between the matched firms because of unobservable characteristics. To deal with this issue, we exploited the longitudinal dimension of our data, relying on a fixed effect difference-in-differences estimator. This method relaxes the assumption that the outcome is only influenced by the observable covariates identified in the matching procedure. Indeed, fixed effects DiD allows for heterogeneity control at a firm level through the individual fixed effects included in the

Table 1
Variable list.

Variables	Description
Size	Log of total assets as a proxy the firm size.
Cash flow	Cash flow on total assets to account for the firm's availability of cash to invest.
Capital Intensity	The ratio of tangible asset to total assets as a control for the different technologies used in the process (Almus & Czarnitzki, 2003).
Leverage	Financial leverage, measured by total asset minus shareholder funds and minus trade payables, normalised on total assets.
Age	Log of firm age; the literature shows that older firms are more reluctant to innovate (Huergo & Jaumandreu, 2004).
Year	Year of the patent filing date.
Industry	A set of industry dummies, built on NACE classification (4 Digits).
Ownership structure	Ownership indicators to account for the different propensities of firms to patent (Birley & Westhead, 1990; Ortega-Argilés et al., 2005). These indicators are a categorical variable with four values that were taken from the Amadeus database, Bureau Van Dijk.
Number of patents	The number of patents that any firm in the sample has in portfolio in each year under analysis. Previous studies shown that this is a significant determinant of financial performance (Agostini et al., 2015).
Return on Assets	Net income on Total Assets.
Sales	Natural logarithm of turnover.

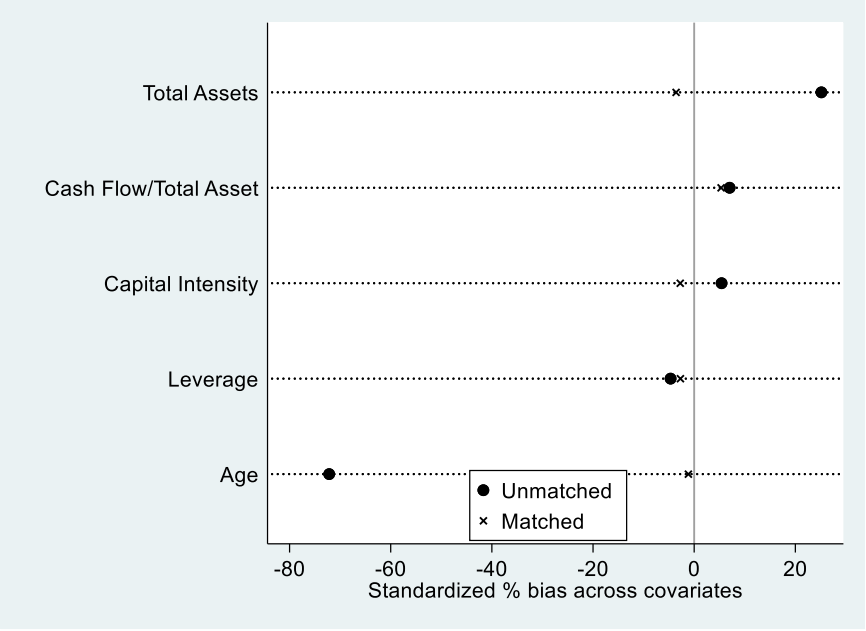

Fig. 5. Graphical representation of pre and post-matching standardised percentage bias for continuous covariates. Values closer to zero suggest that the matching process has been successful.

Table 2
Mean comparison of matched and unmatched sample with two-sample t-test values and standard variance ratio.

Variable	Unmatched/ Matched	Mean		t-test p-values
		Treated	Control	
Size	U	8.294	7.921	0.000 ***
	M	8.380	8.433	0.246
Cash Flow	U	0.060	0.053	0.003 ***
	M	0.058	0.052	0.060 *
Leverage	U	0.488	0.501	0.064 *
	M	0.482	0.490	0.306
Capital Intensity	U	0.185	0.175	0.017 **
	M	0.189	0.194	0.414
Age	U	2.679	3.184	0.000 ***
	M	2.939	2.947	0.634

Significance levels: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3
Standardised mean and median bias in unmatched and matched sample.

Sample	Mean Bias	Median Bias	B	R
Unmatched	22.9	7	95.4 *	3.14 *
Matched	3.1	2.8	7.8	0.77

Significance levels: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

regression. Consequently, we could control for time-invariant unobservable differences between individuals, comparing the conditional before-after treatment outcome of the participants with non-participants (Caliendo & Kopeinig, 2008). As confirmed by the theoretical and empirical studies, a joint DiD and matching approach helps to improve the quality of non-experimental research (Benavente et al., 2007; Blundell & Costa Dias, 2005; Blundell & Dias, 2009; Kannebley et al., 2010). Applying only difference-in-difference to a control group that diverges greatly in the pre-treatment period would not lead to a valid estimation (Bertrand, 2009).

Data of the matched patentees and the selected control sample are regressed via the following equation:

$$Y_{i,t} = \beta_0 + \beta_1 Pat_i + \beta_2 YEAR_i + \beta_3 Pat_i \times YEAR_i + CONTROLS_{i,t} + \alpha_i + \varepsilon_{i,t}$$

where $Y_{i,t}$ is our performance proxy variable, Pat_i indicates if the firm is in the treated group or not (and is time invariant), $CONTROLS_i$ are a set of control variables as specified below, α_i are individual effects of the firms and ε_{it} is the error term. Unlike a typical DiD estimator, our treatment dummy interaction with $YEAR_i$ is a set of time dummies, centred on the year of patent application and used to control for different years in the panel. The vector of coefficients β_3 are therefore the actual difference-in-difference estimators adapted for multiple periods, as suggested by Wooldridge (2022).

A relevant point to highlight is that past literature adopted different measures for firm performance, and this could partially explain why the empirical evidence is mixed. As highlighted by Rosenbusch et al. (2011), most studies investigating the impact of innovation on SMEs use several different performance measures, usually without an explicit justification. The most common measures are the stock market return (Geroski et al., 1993) return on asset (Helmers & Rogers, 2011), return on equity (Sohn et al., 2010), return on sales (Andries & Faems, 2013), sales growth (Agostini et al., 2015; Demirel & Mazzucato, 2012; Sohn et al., 2010), the change in growth rates in profits and growth (Maresch et al., 2016), and composite measures (Power & Reid, 2021).

Therefore, the most common performance measures are focused on profitability and growth, and in line with previous studies, we decided to focus on these measures. In addition, as Maresch et al. (2016) highlighted, if a firm is expanding in terms of turnover or profit amount, successful patents might accelerate this expansion rate. Therefore, we also provide robustness tests of patenting activity on these two additional growth rates.

In these regressions we control for Cash Flow, Age, Size, Leverage, the number of patents and we also include Industry and Year dummies. These variables have been shown to be significant determinants of performance (Ahinful et al., 2023; Galbreath & Galvin, 2008), and, although they were included in the matching process, we include them to take into account their longitudinal changes.

4. Results

We start analysing the differences between the pre-treatment and post-treatment for the two groups, estimating a DiD model with OLS regression. After the matching process, we assembled a panel dataset for all firms, starting from the reference year (the filing of the patent) and ending five years after the reference year.

The validity of the DiD methodology is based on the "parallel trends assumption", i.e., the evidence that the two samples behave in similar way before the "treatment". There is no explicit test to validate this assumption, so the literature suggests a graphical analysis instead (as in (Wing et al., 2018)). Therefore, we visually inspected the dependent variables, as reported in Fig. 6. From the graphs, is evident that return on equity and sales follow a similar pattern before year 0, confirming the validity of the estimation.

As already discussed, implementing fixed effects for the firms in DiD regressions helped us to control for both the differential effects

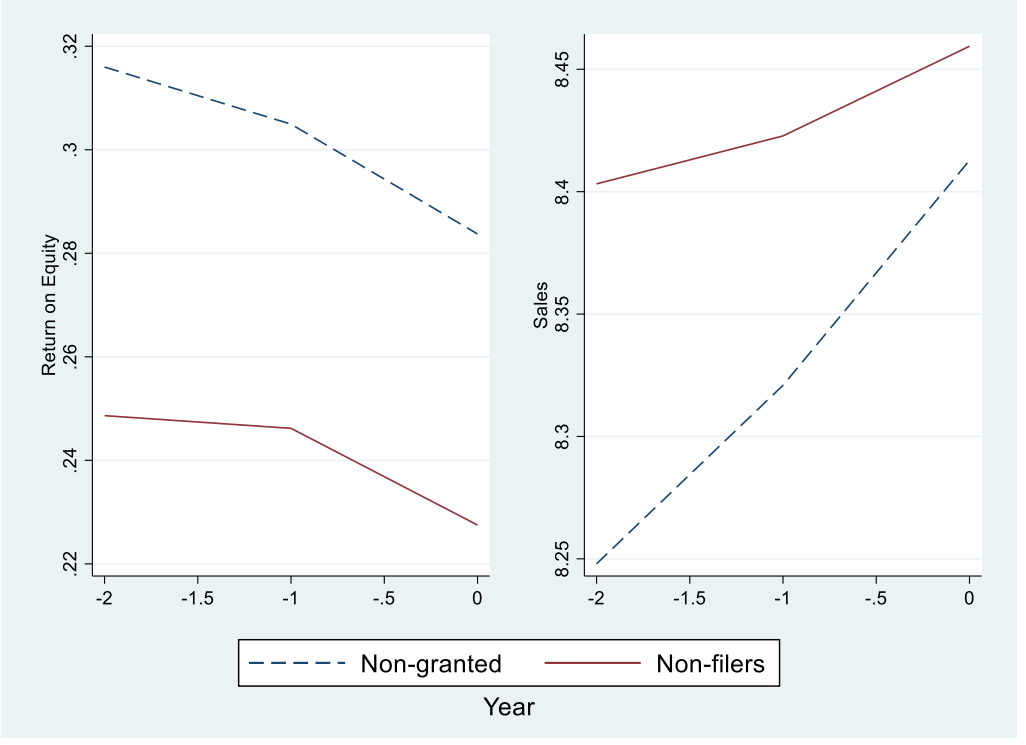

Fig. 6. Graphic analysis of the parallel trends assumption for the firms that filed for a patent that was not granted (patentees) versus firms that did not (non-patentees). The visual inspection suggests that the parallel trends assumption is satisfied.

between changes in outcome for the groups and also for individual firm heterogeneity.

The results of the first set of DiD models are given in Table 4, which shows the difference from the sample of Non-granted vs Non-filers. The regression results for Models (1) and (2) are pooled OLS regressions and do not include firm fixed effects. What we see here is that patentees do not show better performance in terms of sales and in profitability. Then we take into account of time invariant characteristics introducing individual fixed effects in Regressions (3) and (4), which include also robust standard errors clustered on individuals (Cameron & Trivedi, 2005). These results suggest that the "non-granted" sample outperforms the control group (non-filers) in terms of sales for a short period of time, starting from the second year after the innovative effort, which is as we expected. Specifically, the fixed effects estimates show that the increase in sales is between 3,4% and 4,1% vs. their non-filing counterparts in the first two to three years after the filing date. Turning to the coefficients for differences in return on equity, these are in the expected direction, but they are marginally significant in year 1 and 3 or not significant at all. Therefore, we do not find evidence that firms who attempted to file a patent are more profitable than the control sample. Overall, however, the results do suggest that firms that apply for a patent are still able to reap some benefits from the application process itself, even if the patent is not granted, and lead us to partially accept H1.

4.1. Do successful applicants have better performance than those with pending or withdrawn applications?

As previously discussed, some studies shed doubts on the effectiveness of patents in providing a significantly better performance than firms whose patent applications were rejected or have not yet been finalised. To determine whether this is in fact the case, we compared firms with a successful patent application i.e., patentees, to firms with patent applications not (yet) granted, i.e., filers. The original sample comprised 502 Granted and 1411 Non-granted. We guess that both groups of firms have benefitted from an existing invention, but that only the patentees can exercise the monopoly rights provided by the patent. Thus, this comparison tests whether it is something about the patenting process that leads to performance gains or whether it is the monopoly rights that affords greater revenues.

Our empirical analysis consists again of a DiD estimation, but with a major change to the reference year for observing differences in performance: we defined the treatment timing as the year in which the patent was granted, and not to the time of the application as we did previously. Hence, the performance indicators in this analysis evolve over a period of around three years instead of the five years of the previous analysis. We applied the matching procedure described above to the firms that had successfully filed for a patent and the corresponding Non-granted, identifying 487 matches. The tests performed on the matched sample (not reported) confirm that the matching successfully reduced the differences between the two groups, and the graphic analysis of the "parallel trends" assumption in Fig. 7 suggests estimation validity.

Table 4
Difference-in-differences regression on performance of Non-granted vs Non-filers.

	Return on Equity (1)	**Sales** (2)	**Return on Equity** (3)	**Sales** (4)
Year 0	Base Year - Patent was filed			
Pat#Year 1	0.008	-0.008	0.010 *	0.009
	(0.005)	(0.012)	(0.005)	(0.012)
Pat#Year 2	0.006	0.015	0.009	0.034 **
	(0.006)	(0.016)	(0.006)	(0.017)
Pat#Year 3	0.008	0.021	0.012 *	0.041 **
	(0.006)	(0.018)	(0.007)	(0.019)
Pat#Year 4	0.015 **	0.001	0.011	0.013
	(0.006)	(0.024)	(0.007)	(0.022)
Pat#Year 5	0.004	0.022	0.000	0.023
	(0.008)	(0.033)	(0.008)	(0.026)
Cash Flow	1.027 ***	2.036 ***	1.007 ***	1.609 ***
	(0.033)	(0.133)	(0.045)	(0.113)
Age	-0.012 ***	0.005	-0.012	0.079 **
	(0.002)	(0.017)	(0.009)	(0.032)
Size	-0.002	0.859 ***	-0.012 *	0.801 ***
	(0.001)	(0.009)	(0.006)	(0.031)
Leverage	0.039 ***	-0.187 ***	0.106 ***	-0.104 **
	(0.007)	(0.053)	(0.014)	(0.047)
N. of patents	-0.001 **	0.001	-0.002	0.009 **
	(0.000)	(0.001)	(0.001)	(0.004)
Industry effects	Y	Y	N	N
Firm fixed effects	N	N	Y	Y
Year effects	Y	Y	Y	Y
N	16575	16530	16575	16530
R-squared	0.277	0.800	0.186	0.388

Note: Models (3) and (4) include firm fixed effects. The coefficients represent the difference in performance compared to year 0 between firms that filed for a patent which has not (yet) been granted using propensity score matched controls with those that did not file. Significance levels * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; All regressions include a constant, not reported. Standard errors clustered at the firm level in parentheses.

The regression results are reported in Table 5. Pooled OLS estimates are included in Models (1) and (2) and individual fixed effect panel estimates with ID-clustered standard errors are included in Models (3) and (4). As expected, the estimates do not reveal any significant differences between the two groups. The coefficients of both the performance variables that we analysed were very small and never statistically significant.

These results suggest that a successful application does not provide additional benefits over an idle application, hypotheses H2. Indeed, this empirical evidence confirms the difficulties that are often experienced by the owners of small firms in recouping innovation returns through patents, as reported in qualitative studies (Holgersson, 2013). If SME owners were actually able to reap the returns on their innovation investments through patents, we would have seen a significant difference in performance between the two groups, and we did not. The coefficients remained insignificant even when controlling for time-invariant individual characteristics (Columns 3 and 4). This provides robust evidence that granted patents are not able provide small firms with systematically better performance over those who do not hold patents.

4.2. Robustness analyses

Moreover, in line with the suggestion of Maresch et al. (2016), we further look at the impact of patenting on the growth rates of profitability and sales. Indeed, we might expect that a patent application or a granted patent might have an additional impact on a firm that will increase its turnover and profits over time. Therefore, we replace the dependent variables with their growth rates, obtaining the results reported in Table 6 and Table 7. These analyses substantially confirm our previous results, suggesting that Non-granted group can obtain an increase in sales growth that goes from 3.5% in the first year after the application to 3.9% in the fifth year after the application. In line with our main estimates, we still do not find any effect regarding changes in the growth rates nor in profitability for firms that have been granted a patent versus those with an idle application.

In addition, overall consideration must be given to the patent-performance relationship, which is complicated by several identification issues arising in the econometric analysis. We tried to perform a quasi-experimental study by combining matching and DiD, since patenting decisions can be endogenous and controlling for all determinants is extremely difficult because many factors overlap with the decision to innovate. We tried to control the potential bias by adopting a conservative approach, based on the selection of SMEs that had not applied for any other patents for at least three years prior. But this meant we excluded the most prolific innovators, potentially biasing downward the effects of patents portfolios; in order to reduce this bias we introduced a control variable indicating how many patents are held in portfolio by both patentees and the control sample. The results remain stable with or without this control; however, this is a relevant limitation of this paper and should be taken into account when looking at the results.

At last, our sample of non-granted patents includes both patents that have been withdrawn and patent that were still pending.

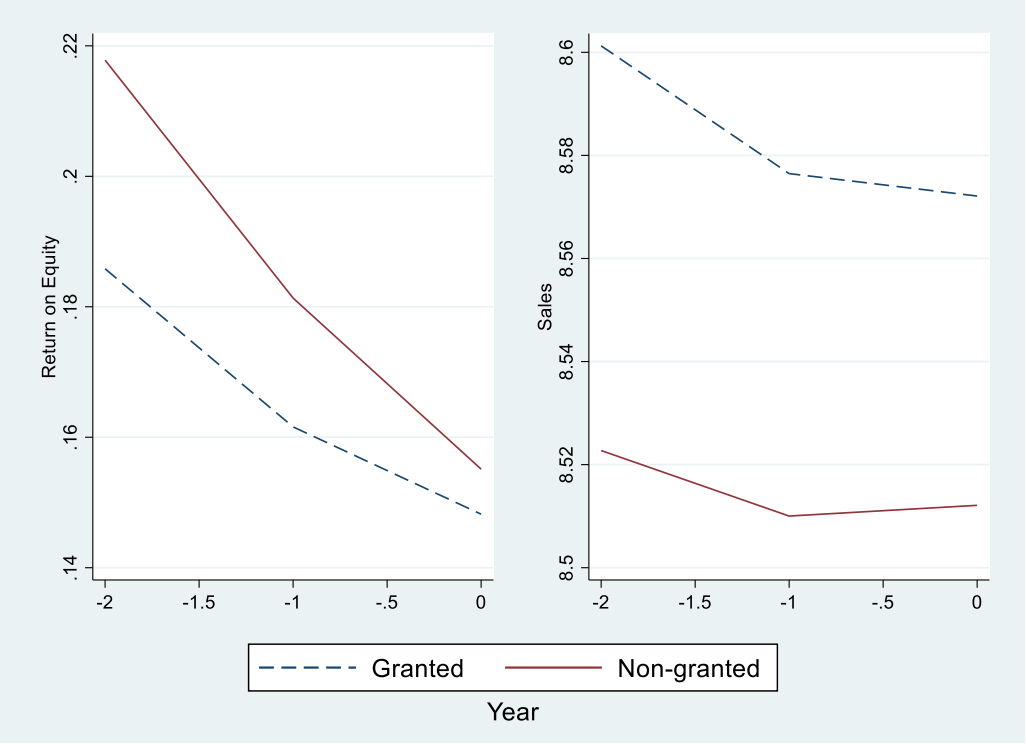

Fig. 7. Graphic analysis of the parallel trends assumption for the sample of firms that were granted a patent versus firms whose patent was not granted. The visual inspection suggests that the parallel trends assumption is satisfied.

Table 5
Difference-in-differences regression on performance of Granted vs Non-granted.

	Return on Equity (1)	**Sales** (2)	**Return on Equity** (3)	**Sales** (4)
Year 0	Base Year - Patent granted			
Grant#Year 1	0.000	0.015	-0.003	0.016
	(0.008)	(0.021)	(0.008)	(0.020)
Grant#Year 2	0.010	0.017	0.009	-0.002
	(0.010)	(0.035)	(0.009)	(0.028)
Grant#Year 3	0.004	-0.088 *	0.007	-0.041
	(0.012)	(0.048)	(0.011)	(0.033)
Cash Flow	1.837 ***	3.817 ***	2.025 ***	2.106 ***
	(0.059)	(0.363)	(0.092)	(0.227)
Age	-0.003	-0.028	0.057	0.066
	(0.007)	(0.048)	(0.071)	(0.199)
Size	0.001	0.872 ***	0.003	0.870 ***
	(0.003)	(0.018)	(0.019)	(0.085)
Leverage	0.086 ***	0.052	0.152 ***	-0.273 ***
	(0.016)	(0.118)	(0.036)	(0.093)
N. of patents	-0.001 *	0.002	-0.001	-0.002
	(0.000)	(0.003)	(0.002)	(0.006)
Withdrawn Patent	-0.143	0.144		
	(0.093)	(0.227)		
Industry effects	Y	Y	N	N
Firm fixed effects	N	N	Y	Y
Year effects	Y	Y	Y	Y
N	3034	3030	3034	3030
R-squared	0.440	0.792	0.364	0.362

Note: Significance levels * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. All regressions include a constant, not reported. Models (3) and (4) include firm fixed effects. The coefficients represent the difference in performance compared to year 0 between firms that were granted a patent and propensity score matched controls with patent applications not granted. This regression is estimated on three rather than five years because we expect to observe the effect of a granted patent after the decision has been communicated. This process takes usually around two years, and, accordingly, we shifted our base year forward. Withdrawn/Abandoned is time invariant and is therefore dropped within individual fixed-effect models. Standard errors clustered at the firm level in parentheses.

Table 6
Difference-in-differences regression on the growth rates of performance of Non-granted vs Non-filers.

	% Change in return on equity (1)	**% Change Sales growth** (2)	**% Change in Return on Equity** (3)	**% Change Sales Growth** (4)
Year 0	Base Year - Patent was filed			
Pat#Year 1	-0.105	0.038 ***	-0.133	0.035 ***
	(0.301)	(0.009)	(0.298)	(0.009)
Pat#Year 2	-0.104	0.053 ***	-0.191	0.028 ***
	(0.287)	(0.010)	(0.300)	(0.011)
Pat#Year 3	-0.112	0.039 ***	-0.269	0.010
	(0.292)	(0.010)	(0.316)	(0.011)
Pat#Year 4	0.058	0.045 ***	-0.269	0.013
	(0.314)	(0.010)	(0.348)	(0.012)
Pat#Year 5	-0.232	0.052 ***	-0.562	0.039 ***
	(0.358)	(0.012)	(0.390)	(0.013)
Cash Flow	7.938 ***	0.593 ***	9.616 ***	0.810 ***
	(0.803)	(0.025)	(1.311)	(0.039)
Age	-0.085	-0.036 ***	-0.766 *	-0.177 ***
	(0.073)	(0.002)	(0.415)	(0.013)
Size	0.057 *	0.013 ***	-0.293	0.117 ***
	(0.034)	(0.001)	(0.184)	(0.010)
Leverage	0.073	0.001	1.106 ***	-0.031 *
	(0.188)	(0.007)	(0.415)	(0.017)
N. of patents	0.020 ***	0.000	0.028	0.002
	(0.008)	(0.000)	(0.075)	(0.002)
Industry effects	Y	Y	N	N
Firm fixed effects	N	N	Y	Y
Year effects	Y	Y	Y	Y
N	16158	16146	16158	16146
R-squared	0.018	0.201	0.009	0.116

Note: As in Table 4, Models (3) and (4) include firm fixed effects. The coefficients represent the difference in performance compared to year 0 between firms that filed for a patent which has not (yet) been granted using propensity score matched controls with those that did not file. Significance levels * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; All regressions include a constant, not reported. Standard errors clustered at the firm level in parentheses

Table 7
Difference-in-differences regression on the growth rates of performance of Granted vs Non-granted.

	% Change in return on equity (1)	% Change Sales growth (2)	% Change in Return on Equity (3)	% Change Sales Growth (4)
Year 0	Base Year - Patent was granted			
Grant#Year 1	-0.001	0.018	-0.001	0.001
	(0.004)	(0.017)	(0.004)	(0.018)
Grant#Year 2	0.005	0.002	0.005	0.012
	(0.004)	(0.018)	(0.005)	(0.021)
Grant#Year 3	0.003	0.021	0.001	0.008
	(0.004)	(0.021)	(0.005)	(0.023)
Cash Flow	0.061 ***	0.944 ***	0.078 **	1.839 ***
	(0.018)	(0.064)	(0.037)	(0.135)
Age	-0.001	-0.024 ***	0.006	-0.375 **
	(0.002)	(0.008)	(0.024)	(0.153)
Size	-0.001	0.014 ***	0.009 *	0.234 ***
	(0.001)	(0.003)	(0.005)	(0.036)
Leverage	0.000	0.012	-0.013	-0.080
	(0.004)	(0.016)	(0.011)	(0.058)
N. of patents	0.000	0.000	-0.001	-0.001
	(0.000)	(0.000)	(0.001)	(0.004)
Withdrawn Patent	0.003	-0.127		
	(0.004)	(0.132)		
Industry effects	Y	Y	N	N
Firm fixed effects	N	N	Y	Y
Year effects	Y	Y	Y	Y
N	2911	3025	2911	3025
R-squared	0.026	0.241	0.009	0.150

Note: As in Table 5, Models (3) and (4) include firm fixed effects. The coefficients represent the difference in performance compared to year 0 between firms that were granted a patent and propensity score matched controls with patent applications not granted. This regression is estimated on three rather than five years because we expect to observe the effect of a granted patent after the decision has been communicated. This process takes usually around two years, and, accordingly, we shifted our base year forward. Withdrawn/Abandoned is time invariant and is therefore dropped within individual fixed-effect models. Significance levels * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; All regressions include a constant, not reported. Standard errors clustered at the firm level in parentheses

Clearly, these outcomes do not have the same consequence in terms of performance, since a pending patent might become granted and monopoly rights might be exercised starting from the publication date. However, further analysis of the sample show two interesting insights. We find that only 3.26% of the entire sample of patents is granted after the timeline that we observe. In addition, the number of withdrawn patents is extremely small compared to the sample of Non-granted. We validated this information by crosschecking a subsample of patent applications on PATSTAT and ORBIT Intelligence database. Taking into account that previous studies suggests that the most benefits of patents are concentrated in the first three to five years after patent filing (Cefis and Ciccarelli, 2005), our results are likely to be robust to this issue.

5. Discussion and conclusion

With this study, we investigate the relationship between the outcome of a patent application and the financial performance of SMEs. The need for additional evidence on this issue is emphasised by a body of literature that is both scant and stricken with contradictory results. Our focus on SMEs is particularly significant since, despite the importance of small firms to the global economy, only a few studies provide cross-industry and longitudinal empirical results on this sector of industry.

Although we cannot fully control for each of the specific factors that contribute to the performance of a firm, estimating the difference in financial performance between matched samples composed of firms with different outcomes of the patenting process we can argue that SMEs associated with an idle patent application, Non-granted, perform better than those who never apply. The difference in sales growth starts immediately after filing and is significant for two years. Overall, these results indicate that firms who applied for (but were not granted) a patent are still able to reap some benefits from the process in the form of sales growth, in line with the result obtained by with Ernst (2001). This additional growth might be caused by an increase in the firm's knowledge stocks and absorptive capacity, which can be triggered during the patent application process.

We also investigated the differences between firms that had been granted a patent and firms that had not, exploring a perspective that has seldom been investigated. We are driven to this analysis by the recurring observation that SME managers do not trust patents and find it difficult to recoup their outlays in the process. Assuming that SMEs are rational and withdraw or abandon less promising patent applications, the exercise of comparing granted patents to idle patent applications should provide – in case of similar performance between the two groups – a strong evidence on the lack of impact of the monopoly rights.

Confirming entrepreneurs' concerns, we do not find any significant difference between the two groups, with observed differences among the two samples being very small and never statistically significant. Therefore, small firms that hold a patent seem unable to capture returns from the innovation patented compared to firms that go through the process unsuccessfully after the same number of

years from the filing date.

From a theoretical perspective, these results could be explained taking into account that the process of simply applying for a patent can provide an increase in a firm's knowledge stocks and absorptive capacity (Cohen & Levinthal, 1990; DeCarolis & Deeds, 1999), resulting in increases in financial performance. Among the activities associated with filing for a patent, we include the positioning of the patent in the state-of-the-art, the study of competing technological solutions and the learning derived from interacting with patent attorneys and technology experts. We argue that those experiences improve professional skills and add to the knowledge stocks of the firm, indirectly triggering better performance.

Our findings also support a sceptical view of patent protection held by many managers of small firms. Overall, this results would be in line with the preponderance of reasons to patent other than financial performance benefits, as highlighted in several previous studies (Blind et al., 2022).

5.1. Theoretical implications

From a theoretical perspective, our main contribution to innovation management and knowledge management literature is investigating the added value of patents. Our results are in line with recent studies that highlight how the primary function of patents for SMEs is not, as traditionally thought, in monopoly rights, but that patenting has many implications, including a better ability to participate in exchanges with the external environment and to improve the firm accumulated knowledge stock (Agostini et al., 2022; Holgersson, 2013; Holgersson & Granstrand, 2021). The activities associated with the patent application process in SMEs include positioning the invention in the state of the art of technology, performing a prior art analysis and interacting with specialists, including patent attorneys and technology experts. We discuss that these activities can have a relevant impact on a small firm, setting the stage for a knowledge spillover between individuals within the firms involved in preparing the patent application. In turn, this might lead to an increase in the firm absorptive capacity and, at last, in the firm financial performance.

5.2. Managerial implications

Several studies surveyed SMEs managers to investigate the motives to patent, often discovering that SMEs managers are sceptic towards patenting as a way to appropriate returns (Athreye et al., 2020; Jee & Sohn, 2021). Our analysis confirms that the innovative activity underlying the patent application is actually linked to superior performance in terms of sales growth, but the patent protection per se is not significantly associated to an increase in financial performance. This lack of financial value associated to monopoly rights is a piece of relevant information for companies since it confirms the doubts of small firm managers about the value of monopoly rights, instead shifting the value added towards activities that are not necessarily linked with a positive outcome of the patent application process. As a result, for SMEs, innovation managers could carefully consider the cost of the granting process and the patent maintenance costs in developing their IP management strategies.

5.3. Conclusion and limitations

Our results show that significant value can be created during the patent application process, independently from the granting. In addition, the lack of additional performance attached to granted patents supports the view of many small firm entrepreneurs that the patenting system is a large firms' game, and that the monopoly power that support the intellectual property do not deliver a significant positive outcome for small firms (Holgersson & Wallin, 2017; Ullah, 2021).

However, our study has some limitations that should be considered when looking at results. We matched patent filers with the best determinants of patent propensity allowed by our data and controlled for unobservable characteristics by using firms fixed effects. However, we do not claim causality in the patent-performance relationship, rather, we merely offer a descriptive result that could be a starting point for future research in investigating what happens in the grey area of patents rejections. Upcoming research should overcome these limits by assembling a dataset that allows one to explicitly compare inventions that have been patented with inventions that were not, although these data are notoriously difficult to obtain.

In addition, with this research, our aim is to highlight how a specific patent application is tied to performance improvements. However, we did not observe whether a firm might have used other means to protect its intellectual property alongside patenting. Using other IP protection strategies might create synergies with patents and potentially contribute to an SME's performance. Also, recent literature has highlighted the relevance of patent quality in explaining the performance of SMEs (Appio et al., 2019), and future research could take this dimension into account when analysing patent data.

Once the limitations have been considered, our results should be useful to the managers of SMEs that must evaluate how to protect the intellectual property generated inside their firms. We find that small firm performance can benefit from simply applying for a patent. This suggests that performing applied research targeted to patent applications can be a springboard to higher sales. Regarding policy design, our results suggest that small firms should be supported in covering the upfront costs of patent applications, which is where we observe the most significant performance difference, instead of providing support to cover patent fees in the medium term.

Declaration of Competing Interest

No potential competing interest was reported by the authors.

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