

# Open innovation and patenting activity in health care

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care

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## Abstract

**Purpose** – The study aims to explore the interplay between open innovation and intellectual property. Differently from previous studies, we argue that open innovation fosters firm's patenting activity.

**Design/methodology/approach** – We use linear regression analysis to test model's hypotheses. Data are drawn from the Eurostat statistics and refer to a large sample of European firms (NACE Rev.2).

**Findings** – The findings confirm that open innovation fosters patenting activity in health care, also thanks to huge governments' expenditures in this market.

**Research limitations/implications** – The study focuses solely on European firms and it adopts a traditional linear approach. So, we cannot exclude that different dynamics may occur across European borders. Future research should address this concern by focusing on multi-country comparative studies.

**Practical implications** – Open innovation is the most suitable model for health industry, because it improves both innovation performance and intellectual capital of firms.

**Originality/value** – The study tackles an existing gap of the literature by considering how the presence of large customers impacts the strength of intellectual property protection.

**Keywords** Open innovation, Health industry, Intellectual property, Patenting activity

**Paper type** Research paper

## 1. Introduction

The aim of this study is to address the effect of open innovation on intellectual property. Broadly speaking, open innovation is a form of collaboration between partners from different organizations and contexts, whose purpose is the co-creation of a novelty by mixing together their different skills, expertise and knowledge (Chesbrough, 2003; Chesbrough *et al.*, 2006; West and Lakhani, 2008; Meissner and Carayannis, 2017; Natalicchio *et al.*, 2017; Santoro *et al.*, 2019; Radziwon; Bogers, 2019). The concept of open innovation emerged in the early 2000s, when Chesbrough (2003a) observed that firms, especially those operating in ICT and movie industries, have started to search for innovation partners, despite the problem of intellectual property protection. As a matter of fact, those firms were experiencing a decline of their innovation capability. So, the only way they had to outgrow competitors was reinventing themselves by gathering external, fresh ideas. Since then, this alternative way of doing innovation was named open innovation. This development strategy is deemed as “the antithesis of the traditional vertical integration model” (Chesbrough, 2006, p. 2), because it is based on leveraging the intellectual capital of the firm through alliances, rather than through dimensional growth. So, since the origins, the concept of open innovation was strongly entwined with that of intellectual property. In the traditional closed innovation model, companies exert a strict control over intellectual property (Chesbrough, 2003b). Though,



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often this approach revealed itself as value destroying, because the capability of a patent to generate value for the company depends on the company's business model. Many patents go wasted because the company is a bad owner/user and it does not have a market for the related products (Chesbrough, 2003a).

Thus, a value creating strategy leverages on intellectual property management. The bedrock of intellectual property management is the consistency between intellectual property and business model. When there is poor consistency between a patent and the company's business model, that patent can be sold out. At the same time, firms can also buy patents on the market, if they are available.

When this route is not viable, a company can expand its business model by searching for external complementary knowledge (Chesbrough, 2003). Unlike closed innovation, the open regimen entails that companies relinquish part of the control over their intellectual property, with the purpose of achieving a superior growth. Environmental and market characteristics plays a fundamental role in this choice.

Nowadays, the complexity and unpredictability of markets, along with the environmental turbulence, has made the logic of the first mover advantage and of closed innovation rather anachronistic and obsolete in several industries. As Suarez and Lanzolla (2005) clarified, the first mover advantage, with a strong control over intellectual property, is a poor strategy when the pace of changes is high and firms navigate in hostile environments. Fast-changing-environments, characterized by abrupt technological discontinuities, better suits the logic of the fast-mover advantage. The fast-mover advantage is based on firm's speed capabilities, or the ability to execute "faster than competitors at the same costs" (Hawk *et al.*, 2013, p. 1351). In this fashion, it is proved that open innovation may foster the firm's race toward the fast-mover position, thanks to the increased innovation speed (Milan *et al.*, 2020). Intuitively, this insight seems to suggest that the traditional strain of research claiming that there is a negative interplay between open innovation and patenting (Lichtenthaler, 2009; Brem *et al.*, 2017) might be wrong. By contrast, open innovation could allow to develop new patents more rapidly than closed innovation and at a more convenient cost.

For instance, the Covid-19 outbreak case taught that speediness, along with openness of information and collaboration are a great source to tackle global challenges, to provide fast-solutions to complex issues, and to buffer against uncertainty by leveraging intellectual property and patenting. This is proved by the existence of a wealth of public and private funding for financing open innovation projects aimed at facing Covid-19. Horizon 2020 calls are, perhaps, among the most famous public finance provisions for open innovation. Henceforth, due to environmental turbulence and time-based competition (Chakravarthy, 1997; Calantone *et al.*, 2003; Bolisani and Bratianu, 2017), such kind of open collaborations seems particularly valuable in the health industry (Robaczewska *et al.*, 2019).

By and large, the positive effect of open innovation on firm's competitiveness can also be explained in terms of economic performance (Kobarg *et al.*, 2019; Rauter *et al.*, 2019; Wu and Ding, 2020).

Not surprisingly, literature has constantly been praising the impact of open innovation on firm's performance (Enkel *et al.*, 2009; Lichtenthaler, 2009; Parida *et al.*, 2012; Hun and Chou, 2013; Del Giudice, 2013; Carayannis *et al.*, 2013; Cheng and Huizingh, 2014; Ahn *et al.*, 2015; Greco *et al.*, 2016; Scutto *et al.*, 2017; Martinez-Conesa *et al.*, 2017).

However, scholars' opinions on the effect of open innovation on intellectual property is way more variegated. Intellectual property refers to firm's intellectual capital. Intellectual Capital (IC) is deemed one of the most important drivers of competitiveness (Lev, 2003; Veltri *et al.*, 2011; Lerro *et al.*, 2014).

The ongoing vibrant debate is caused by the fact that, in open innovation, there is a cross-cutting disaggregation between the two moments of value creation and value capture. Such disaggregation is determined by the distribution between partners of intellectual property

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rights and existing law enforcements (Simcoe, 2006; Granstrand and Holgersson, 2014). The consequence is a sort of “tension” between intellectual property rights and open innovation (Bican *et al.*, 2017). This aspect was recursively examined by scholars, with inconclusive findings (Comai, 2019). Some scholars argued that open innovation might inhibit patenting activity (West, 2006; Lichtenthaler, 2009; Arora *et al.*, 2016, Shin *et al.*, 2017), whilst others stated that “pro-patent practices associated with open innovation may stem the free flow of knowledge across organizational boundaries” (Bhaskarabhatla and Hegde, 2014, p. 1744).

The main criticism of prior research on this theme is that scholars failed to understand that there might be other factors that influence the interplay between open innovation and intellectual property (Holgersson and Granstrand, 2017), such as firm’s size and sector (Brem *et al.*, 2017), technology (Zobel *et al.*, 2016), R&D investments (Hun and Chou, 2013; Simeone *et al.*, 2017).

Notably, Da Silva (2019) suggested that this relationship is influenced by the strength of patent protection.

This paper aims to tackle the above gaps by considering how market characteristics impact the relationship between open innovation and intellectual property. Differently from antecedent studies, we argue that open innovation has mostly a positive impact on firm’s intellectual property and on patenting activity.

We focus on health care, in reason of the peculiar characteristics of this industry. The health industry can be described as an aggregation of different sectors that provides goods to treat patients (Bevan *et al.*, 2010). This industry is called to solve particularly complex and risky challenges that are fitting with the very concept of open innovation. In addition, the market has a peculiar structure, for that the largest customers are countries’ governments. Therefore, we conducted a regression analysis on a population of European countries. According to the World Health Organization, European countries are among those with highest health care expenditures. The results we obtained confirm our assumptions: open innovation fosters intellectual property in health care. This result is largely explained by governments’ expenditures. Thus, our original study contributes to provide an unobstructed view of the interplay between open innovation and intellectual property. For the remainder, the paper structure is the following: first, we synthesize information on the literature background; second, we describe our model’s hypotheses; third, we conduct and discuss the empirical analysis; finally, we explain the implications of the study and we provide our conclusions, along with future research suggestions.

## 2. Literature background

### 2.1 *Open innovation and firm’s intellectual property*

Over time, the open innovation field of studies captured the attention of a wealth of scholars. Unlike the closed innovation model, in which the entire innovation process is conducted by the firm totally inside, open innovation offers a different model (Chesbrough, 2003b). In this case, the development of innovative solutions takes place on the basis of internal and external sources of knowledge and in collaboration with various R&D operators, with advantages such as reduction of innovation time (Chiaroni *et al.*, 2011), risk sharing (Brem *et al.*, 2017), costs reduction (West and Bogers, 2014) and preferential access to markets (Chesbrough *et al.*, 2018). In the scenario of open innovation, intellectual property has a new role that no longer reflects the defensive mechanism usually adopted by firms. In the collaborative innovation process, efficient industrial property management is vital for the success of the project (Gassmann *et al.*, 2010). The firm’s success in an open innovation context is determined by the ease of achieving an economic advantage through the exploitation of the IC (Chesbrough, 2003b). Open innovation occurs as “the use of purposive inflows and outflows of knowledge to accelerate internal innovation” (Chesbrough *et al.*, 2006, p. 1). In open innovation, the

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knowledge flow can take different directions: inside-out or outbound; outside-in or inbound, and coupled (Enkel *et al.*, 2009; Huizingh, 2011). Also, the process has three phases: knowledge exploration, knowledge retention and knowledge exploitation (Lichtenthaler and Lichtenthaler, 2009; Chiaroni *et al.*, 2011).

The search strategy of the firms determines its degree of openness, in breadth and depth, and thus it precedes and informs the open innovation decision (Laursen and Salter, 2006; Dahlander and Gann, 2010). Thanks to the openness of the firm's borders, a company outstrips the limit of its own knowledge endowment and share the cost of knowledge creation with the coordinated ecosystem of partners (Chesbrough and Appleyard, 2007). Currently, the research domain is articulated in various streams of research (Gassmann *et al.*, 2010). Among other perspectives, Chesbrough (2003a), Gassman *et al.* (2010), and West and Bogers (2014), indicated the leveraging perspective – based on the external commercialization of intellectual property – as one of the most promising.

According to existing conceptualizations, open innovation is inherently related to management of intellectual property, because intellectual property is used as the exchange currency to promote knowledge sharing between partners (Arora, 1995; De Silva, 2019). Though, as De Silva (2019) clearly explained, there are some relationship issues between open innovation and intellectual property rights. To explain these issues, let us consider the case of patenting.

As instance, a patent, by definition, guarantees the possibility to take economic advantage of an innovation by excluding others from using or imitating it – the temporal length could vary from country to country – after paying a series of relevant costs for the codification of the novel knowledge. This cost adds up to already huge innovation costs. In the case of open innovation, the company must also consider both huge transaction costs with partners and the possibility that patent rights might be distributed between partners.

So, traditionally, open innovation has been deemed as a strategy that might inhibit patenting (Alexy *et al.*, 2009; Zobel *et al.*, 2016), because of proprietary rights' distribution/overlapping issues and huge costs of patenting -patent thicket – (Shapiro, 2000). More precisely, it has been said that open innovation may either disable or enable intellectual property (Alexy *et al.*, 2009; Arora *et al.*, 2016). At the same time, intellectual property protection is deemed a barrier to open innovation as well (Drechsler and Natter, 2012; Brem *et al.*, 2017; Brunswicker and Chesbrough, 2018). As a matter of fact, selective revealing of information (Henkel, 2006) occurs more frequently than freely revealing (Harhoff *et al.*, 2003; Von Hippel and Von Krogh, 2006).

This knowledge hiding and gatekeeping behaviours are aimed at avoiding unintended knowledge spillovers (Del Giudice *et al.*, 2019; Scuotto *et al.*, 2019).

Upon the previous considerations, it appears that the literature has rather divergent opinions about the nature of the relationship between intellectual property and innovation.

To date, this riddle was recursively intriguing scholars in the research domain (West and Gallagher, 2006; Comai, 2019; Suh and Jeon, 2019).

However, at a pure theoretical level, a strong intellectual property protection system should enable knowledge sharing through open innovation (De Silva, 2019).

The afore-mentioned dilemma can be framed as a trade-off between value creation and value capture, so the firm can choose among four alternatives: value realization, value partaking, value provision, and value negotiation (Chesbrough *et al.*, 2018). Typically, firms behave as net-takers of external knowledge because they are concerned with the intellectual property protection (Brunswicker and Chesbrough, 2018). Yet, firms are also aware that open innovation enables extra-performance (Lichtenthaler, 2009; Parida *et al.*, 2012; Garriga *et al.*, 2013; Carlsson *et al.*, 2011). As a matter of fact, knowledge and technology transfers from external sources could determine a positive impact on firm's intellectual property (Lichtenthaler, 2010; Krylova *et al.*, 2016; Huan *et al.*, 2017; Natalicchio *et al.*, 2019).

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Notably, according to [Granstrand et al. \(2020\)](#), digital technologies enabled both collaborations and technology transfers, thus lowering the transaction cost of open innovation. Also, the authors suggested that several negotiation techniques might be used to solve the problem of overlapping intellectual property rights.

Accordingly, it might be arguable that, over time, a series of factors positively influenced the relationship between open innovation and patenting activity. These factors are generally related to the cost savings of the overall process, the use of digital technologies, new bargaining tools that allow for a fairer distribution of proprietary rights, and strengthened intellectual property protections. However, prior literature mostly got stuck in the idea that the relationship between open innovation and patents is negative or, at least, unclear. In our opinion, they failed to understand that economy went under a massive change that might have positively influenced this relationship. Also, they did not analyse how the market structure impacts this relationship, even if such a factor could have been the game-changer today that fostered both open innovation and intellectual property.

## 2.2 Intellectual capital and health industry

The main concepts and definitions of IC have been broadly studied by scholars. IC was defined as the set of all the competences and knowledge that can configure the firm's competitive advantage ([Stewart, 1997](#)). IC refers to all cognitive and intangible resources that play a fundamental role in creating value in an organizational system ([Stewart, 1997](#); [Roos et al., 1998](#); [Lev, 2003](#); [Lerro et al., 2014](#)). This implies that IC involves experience, knowledge, intellectual property, intellectual material, customer relationship, professional skills that create value in a firm ([Ross et al., 1998](#)).

Economic and managerial literature has been paying an increasing attention on the role of IC in a firm's sustainable advantage ([Van Beveren, 2003](#); [Wall, 2005](#); [Cavicchi, 2017](#)). In fact, IC's studies have focused on multiple different angles. Several academic researchers, for example, have focused on the study of IC in service organizations ([Habersam and Piber, 2003](#); [Chen et al., 2005](#); [Nimtrakoon, 2015](#)), while only few contributions have focused on healthcare organizations (HCOs) ([Van Beveren, 2003](#); [Evans et al., 2015](#); [Pirozzi and Ferulano, 2016](#); [Cavicchi and Vagnoni, 2017](#)). This literature gap in the healthcare industry is significant. Our paper is positioned precisely on this crucial issue, because it takes into consideration the context in which HCOs operate – a sector characterized by advanced technologies and high relational complexity ([Habersam and Piber, 2003](#); [Pirozzi, Ferulano, 2016](#); [Cavicchi, 2017](#)).

HCOs are often knowledge-intensive systems, where IC management plays a crucial role for value creation dynamics ([Veltri et al., 2011](#)). HCOs operate on multiple levels of complex relationships: between different healthcare professionals ([Yang and Lin, 2009](#)); between clinical and managerial components ([Veltri et al., 2011](#)); between the set of HCOs and the complex of social and institutional aspects in which they are inserted ([Evans et al., 2015](#)). Analyzing IC in the healthcare industry means focusing on the quality and intensity of these relationships and on the processes that activate strategic synergies. Thus, IC in the healthcare industry is also used for developing the relationships with stakeholder, including governments ([Wall, 2005](#)). As a matter of fact, HCOs are capable of generating value only through the exploitation of these specific relationships ([Mouritsen et al., 2004](#); [Cheng et al., 2010](#); [Nimtrakoon, 2015](#)).

A synergistic evaluation of the IC in the healthcare industry is particularly relevant due to the role that IC has in the high knowledge-intensity HCOs, characterized by a high degree of management complexity ([Wass and Vimarlund, 2016](#)). In particular, in the healthcare industry, the ability to exploit IC and know-how represents an essential driver for achieving high innovative performance, obtaining patents and creating value for the whole social system ([Mouritsen et al., 2004](#); [Cavicchi and Vagnoni, 2017](#)). Patent protection allows HCOs to

market their solutions and safely by entering into research and development collaborations (Van Beveren, 2003; Nimtrakoon, 2015; Pirozzi and Ferulano, 2016). Therefore, the peculiarity of health industry is that there is a strong relationship between IC, open innovation and government stakeholders: several researches highlighted the fact that a public intervention in the health industry has a strong impact on the innovative performance of HCOs (Van Beveren, 2003; Qiu and Yu, 2010; Cavicchi and Vagnoni, 2017). Public intervention makes the open innovation regimen particularly convenient because it reinforces the appropriability of value through legally protected tools, such as patents (Pirozzi and Ferulano, 2016).

In brief, the value created in the HCOs through the open innovation requires innovative models able to combine traditional economic information with new elements. These strategic patterns might be able to capture the firms' unique aspects to promote and support technological development through patents, and creating shared-value for all the stakeholders (Yang and Lin, 2009; Arora *et al.*, 2016; Wass and Vimarlund, 2016).

### *2.3 Intellectual property in health care and governments' role*

In recent decades, intellectual property and its role in the economic issues have been examined by an increasing number of scholars (Chesbrough, 2003a; Murray and Stern, 2007; Bican *et al.*, 2017).

Generally speaking, technological, social and learning conditions might either foster or hinder innovation diffusion or acceptance at an individual level (MacVaugh and Schiavone, 2010). Though, intellectual property is largely deemed a driver of innovation, especially in the health care (Peng *et al.*, 2007; Evans *et al.*, 2015; Pirozzi and Ferulano, 2016). Health research represents an activity of relevance not only for their primary objectives, that is, linked to caring of citizens, but also for economic development and innovation at country level (Cavicchi, 2017). The importance of intellectual property for innovation in the health care seems confirmed by the concomitance between the introduction (or the strengthening) of innovators' rights protection in various countries and the growth of investments in research and development in the industry (Kremer, 1998).

Various scholars (Smarzynska, 2002; Pugatch, 2004) shared the opinion that greater protection of intellectual property in health care has mainly positive effects. However, many other authors (Amado and Gewertz, 2004; Papa *et al.*, 2018) argued that the situation is complex, because of various economic and social aspects. Among the publications that in recent years have critically examined the strengthening of industrial property protection in the pharmaceutical sector, a mention should be made to Lexchin (2005). Lexchin observed that, in the pharmaceutical contest, most of the new products would therefore have been made up of drugs of the type sarcastically called "me-too", that is products that aim to replicate the commercial success of drugs already established by substantially treating the same diseases and without particular therapeutic improvements. The analysis also examined the economic effects deriving from the intellectual property policies. Therefore, in this case, open innovation and the management of intellectual property rights in health care also increase governmental expenditures in this sector (Bokhari *et al.*, 2007). The public acquisition of patents by government is a typical example of such kind of expenditures (Elton and O'Riordan, 2016; Ferraris *et al.*, 2019). Each new invention is subject to patent rights and its commercial value must be properly assessed (Evans *et al.*, 2015). The public regulator (government) proceeds to purchase the related rights from the inventor, making it publicly accessible. In this way, innovators would maintain a satisfactory economic advantage, simultaneously avoiding the inefficiencies of the intellectual property rights system (Finkelstein *et al.*, 2006). In brief, the public regulator buys the rights of invention to make it publicly available. Furthermore, the public acquisition of patents tends to incentivize the development and marketing of new products, thus triggering a virtuous circle between

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intellectual property and government operations in the health sector (Bokhari *et al.*, 2007; Peng *et al.*, 2007; Ferraris *et al.*, 2019).

Property rights provide firms with the incentive to invest billions each year in the search for new treatments (Brander *et al.*, 2017). Europe is a global center for innovation, with around €35 billion invested in R&D only in 2017 (Brunswick and Chesbrough, 2018; Vahyanan *et al.*, 2019). New treatments are always needed, whether it is to contain epidemics of communicable diseases, such as Ebola or Coronavirus, or to treat non-communicable diseases such as heart disease and diabetes. These activities require the involvement of personnel that, in various capacities, work at universities, public research organizations, health institutions, and governments (Bokhari *et al.*, 2007). Also, the public sector plays a leading role in the financing of health services (European Commission, 2018). In two-thirds of EU Member States, over 70% of health expenditures is financed by the public sector.

The Member States with the highest share of government-financed healthcare expenditure (European Commission, 2018) are the Czech Republic (83%), Denmark (84%), Germany (85%), Luxembourg (83%), the Netherlands (81%) and Sweden (84%). Finally, public interventions to promote research and development play a fundamental role in the most advanced countries (Laursen and Salter, 2006). These interventions can take various forms, from carrying out research activities directly at government institutions, to financing these activities at private research centers or academic institutions. Therefore, they promote the development of new products (Cavicchi, 2017).

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### 3. Model and hypothesis

As clarified in Section 2.1, literature mostly suggests that open innovation may kill patenting (Zobel *et al.*, 2016).

However, when innovation challenges are particularly complex, expensive and risky, the need for innovation Allies may help to overcome the fear for knowledge spill-overs. In addition, we argue that industry and market characteristics exert a strong influence on open innovation decisions (Jin *et al.*, 2019).

Thus, we adopt a contingent approach to open innovation (Zhou *et al.*, 2019). We originally argue that open innovation may foster patenting and intellectual property. Consistently, hypothesize that:

*H<sub>p1</sub>*. open innovation expenditures have a positive, linear effect on patenting.

The effect of open innovation on patenting is particularly strong in those industries characterized by extreme innovation complexity and a stable and consistent demand, such as the health industry. In the case of health care, governments' expenditures in health represent a large quote of the annual GDP. In addition, health care is one of the largest industries, characterized by continuous innovations and complexity of challenges. Innovation expenditures are extremely high, and the process can last several years. As a consequence, firms find it convenient to search for partners and to protect the outcome of the research.

### 4. Research design and empirical analysis

The model we are going to test is summarized in the block diagram shown in Figure 1.

To test the above model, we run a linear regression analysis with ordinary least square (OLS). In our case, such an approach appears to be the most suitable, due to several reasons. First, all the employed variables are quantitative and perfectly measurable (there is no latent construct to deal with) and thus their association can be directly analyzed and determined by means of a linear regression. Moreover, the OLS technique, especially when it is applied

together with a robust standard error estimator (see, e.g. [White, 1980](#)), allows us to perform a straightforward and efficient assessment of the significance of the relations between the dependent and the independent variables ([Hellwig, 1963](#); [Kennedy, 1998](#); [Wooldridge, 2002](#)), i.e. we can easily test the validity of our hypothesis [Hp1](#).

Finally, it should also be observed that several studies ([Henkel, 2006](#); [Lichtenthaler, 2009](#); [Carlsson \*et al.\*, 2011](#); [Inauen; Schenker-Wicki, 2012](#); [Scuotto \*et al.\*, 2020](#)) in the field of innovation have adopted the regression analysis for hypothesis testing, also with applications in the healthcare industry ([Yang and Lin, 2009](#)).

Let us outline the methodology employed: as a first step, we contextualize our analysis in Europe. This is motivated by the fact that, in Europe, the number of patent applications have increased dramatically in the past years, reaching its maximum of about 170,000 in 2018 (see the European Patent Office website). Thus, in particular, we focus on a set of European countries.

Then, for each one of these countries, we collect data relative to patent applications, to the expenditure in open innovation and to the governments' expenditures in health.

Finally, we apply the statistical techniques. In particular, first of all, we focus on the Pearson correlations, which show the links among the variable employed, and then we run the regression analysis, in order to determine the extent to which the number of patent applications is related to the expenditures in open innovation.

#### 4.1 Sample

Data for the analysis are drawn by the Community Innovation Survey (CIS).

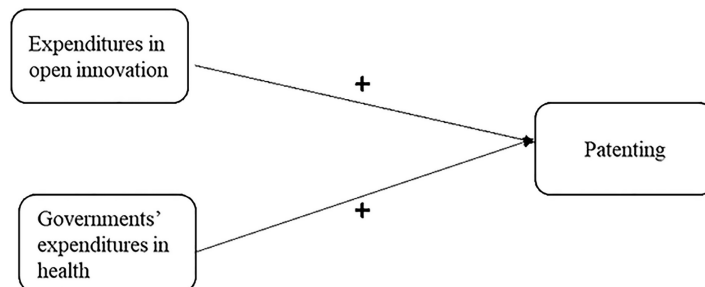
The CIS is aimed at exploring the various dimensions of enterprises innovation, according to the conceptualization proposed by the [OECD \(2005\)](#).

The use of CIS data is extremely frequent among open innovation scholars ([Laursen and Salter, 2006](#); [Faems \*et al.\*, 2010](#); [Arora \*et al.\*, 2016](#); [Keupp and Gassmann, 2009](#); [Brem \*et al.\*, 2017](#)), in reason of its accuracy, the high quality of data, and the high reliability of constructs.

Data are released every two years by the Eurostat, the Statistical office of the EU within the European Commission, whose mission is to gather and offer statistics at the European level in various different areas, including economics, finance, society, industry, trade, transport, environment and energy.

The last available survey – used in current analysis – refers to the years 2014-2016, and it was updated in 2019.

This survey contains micro-data of European firms, grouped by size, Country, and per activity classification code (Nace 2). We filtered the data available. In particular, we considered the entire population. However, there were few missing data. We removed those countries for which data were very incomplete. After doing that, we end up with the following 34 nations: Belgium, Bulgaria, Czechia, Denmark, Germany, Estonia, Ireland, Greece, Spain,



**Figure 1.**  
Research model



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France, Croatia, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Hungary, Malta, Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden, United Kingdom, Iceland, Norway, Montenegro, North Macedonia, Serbia and Turkey.

#### 4.2 Regression analysis

Consistently, we use the following linear regression model to test our research hypothesis:

$$\text{PatOrTrad} = \beta_0 + \beta_1 \text{ExpInn} + \beta_2 \text{ExpHealth} + \varepsilon$$

where the  $\beta$  coefficients are computed by standard OLS estimation.

Then, to test the statistical significance of the computed coefficients, we use robust standard error estimation, corrected for heteroskedasticity (see, e.g. [White, 1980](#)).

#### 4.3 Operationalization of variables

Patenting activity were long been considered as a proxy of firm's innovation activity ([Acs and Audretsch, 1989](#)).

Thus, our dependent variable is the number of enterprises that applied for a patent or registered a trademark (PatOrTrad). However, we do mention that we also tried to employ (as the dependent variable) the number of enterprises that applied for a patent, a European utility model or that registered an industrial design right or a trademark. The results obtained (not reported, in order to save space) are qualitatively very similar to those experienced by using the number of enterprises that applied for a patent or registered a trademark.

The independent variables are the expenditures in open innovation (ExpInn) and the average of the governmental expenditures on health (ExpHealth) ([Holemans and Sleuwaegen, 1988](#)).

Data were considered in million Euros. For the reader's convenience, all the employed variables are listed in [Table 1](#).

#### 4.4 Results

Descriptive statistics for all the employed variables are shown in [Table 2](#). As we may observe, the differences between minimum and maximum values are very large. For instance, the number of patent applications ranges from a minimum of 51 to a maximum of 20075. Nevertheless, for each variable, the standard deviation is never greater than 2.5 times the mean, that is the dispersion of the data is rather contained (in other words, data tend to concentrate around their average values). Thus, data are affected by a relatively small degree of variability, which, as we are going to show, can be captured very well by the regression analysis that follows ([Table 2](#)).

[Table 3](#) reports the Pearson's correlations among the variables. As we may observe, PatOrTrad is strongly and positively correlated with both ExpInn and ExpHealth. In particular, the correlation between the number of patents and the expenditures in open innovation is very large (0.9884), which is in favour of our assumption [Hp1](#). Therefore, we continue our analysis by performing the final regression step, so as to precisely quantify the dependence of PatOrTrad on ExpInn.

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Variable name	Description
PatOrTrad	Number of enterprises that applied for a patent or registered a trademark
ExpInn	Expenditure in open innovation
ExpHealth	Average of the governmental expenditure in health care

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**Table 1.**  
Variables

The results of the linear regression analysis are reported in Table 4. First of all, we may observe that the regression is, on the overall, statistically very significant. In fact, the  $F$ -statistic is statistically significant at the 1% level, which indicates that the number of patent applications is influenced, at least, by one of the independent variables employed.

Furthermore, the  $R^2$  is equal to 0.9889. Therefore, even if we are employing only two regressors, we can capture almost all the variability of the dependent variable. In other words, the employed regression model, albeit very simple, provides a very accurate fitting of the empirical data and turns to be particularly suitable to describe the relationship between patenting and open innovation.

Furthermore, as we may observe in Table 4, both ExpInn and ExpHealth are significant at the 1% level. In particular, there is a strong association between patenting and expenditures in open innovation. Moreover, the regression coefficient  $\beta_1$  is positive, which indicates that the larger the number of patent applications, the larger the expenditures in open innovation. Thus, in summary, the empirical evidence supports our research hypothesis H<sub>p1</sub>.

#### 4.5 Discussion, originality and limits of the work

The analysis proves that intellectual property and the degree of innovation of European firms (as measured by the number of enterprises that applied for a patent or registered a trademark expenditure on innovation) are associated not only to expenditures in open innovation, but also to governmental expenditure in health care. In brief, the empirical test confirms the model's hypothesis.

Differently from prior research, we argue that the impact of open innovation on intellectual property is contingent on industry and market specific characteristics. Also, we argue that open innovation has a general positive impact on firm's intellectual property. Complexity of innovation may exert a strong influence on firm's decision to open its R&D system. However, high complexity and long development time require a careful consideration of innovation appropriability. The presence of a large, stable market for innovation justifies

	Mean	St. Dev	Min	Max
PatOrTrad	2796.318	5414.232	51	20075
ExpInn	12127.72	28880.63	105.869	154204.7
ExpHealth	269.2295	543.5572	0.344	2635.14

**Table 2.**  
Descriptive statistics

	PatOrTrad	ExpInn	ExpHealth
PatOrTrad	1	0.9884	0.6582
ExpInn		1	0.133
ExpHealth			1

**Table 3.**  
Pearson's correlations

Variable	$\beta$
Constant	280.732**
ExpInn	0.111***
ExpHealth	2.173***
$F$ -stat.	2780.84***
$R^2$	0.989

**Table 4.**  
Regression result

**Note(s):** \*\*and \*\*\* denote significance at the 5 and 1% levels, respectively

the cost for intellectual property protection, enabling scalable returns. These factors jointly foster firms' patenting activity. Such conditions are verified in health industry, where knowledge spill-overs may be mostly undesired. Hence, our original study shows a greater consistency of results than previous evidences. We contribute to the largest innovation field of research by bringing clear evidence of the relationship between open innovation and intellectual property. Also, this study contributes to research in health care, by providing insights on the relationship between firms' expenditures in open innovation and the governments' role.

As we specified throughout the paper, the very concept of open innovation is built upon the logic of intellectual property management. Despite this, for long time, scholars argued that open innovation causes intellectual property rights issues. In a nutshell, the idea was that due to high transaction costs and high patenting costs, along with intellectual property rights issues due to overlapping ownership between partners, open innovation is poorly linked with increased patenting activity.

In an original fashion, we argue that, by contrast, open innovation fosters patenting activity, at least under peculiar conditions and in specific markets. Precisely, we explore the case of health industry. Unlike previous literature, we take into consideration market contingencies, such as governments' expenditures in terms of R&D investments. This factor is of the utmost relevance because it makes very convenient to develop innovation jointly with other partners and, then, patenting the innovation. Simplifying, this factor reduces transaction costs, reinforces intellectual property protection, and incentivizes knowledge sharing between partners. It allows for an expansion of the firm's business model and for the achievement of a fast-mover advantage. The case of the Covid-19 outbreak is giving a further confirmation, at an anecdotal level, of the validity of current model.

In a fast-changing, turbulent environment, characterized by unpredictable shocks, where there are various interests at stake, such as the public wealth, economic interests and other social interest, fast and effective innovations are essential. However, their character of extreme complexity and uncertainty makes it hard to achieve this innovation in isolation. Open innovation is the only viable alternative.

However, without appropriate external and public interventions, the cost of open innovation would be enormous and not supported by a consistent future reward, also because of the shared property rights. In addition, patents, in this field, are often cumulative, many innovations are unsuccessful, or they must be sold at a price that is far below the costs.

All these factors explain why market matter enormously in the relationship between patenting and open innovation. Clearly, this result has a general validity for health industry, but it can be extended to those sectors that have health-like characteristics, for example all the structure and infrastructure providers, extremely complex and costly technologies, etc. By converse, sectors where innovation is more easily achievable and that navigate in stable markets could not have such interest in open innovation or could present a different relationship between open innovation and patenting.

Besides the simplicity of the model and the analysis, the main limitation of the study is that it is focused on European firms. A multi-country comparison should help to gain a fine-tuned view of the phenomenon

## 5. Implications for academia, managers, and policy makers

The healthcare sector is a stimulating context to investigate strategic patterns because of its relevant role in society (Bevan *et al.*, 2010; Papa *et al.*, 2018). On the other hand, health care is very difficult to evaluate, due to high management complexity and diversity in terms of size, ownership, funding type, mission, internal processes, managerial style and results. In particular, the debate on intellectual property in the health care is particularly lively, both in

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academia and between managers/policy makers. Theoretically, intellectual property rights exist to promote a higher level of well-being collective (Amado and Gewertz, 2004; Lexchin, 2005). In this sense, the paper wanted to highlight that open innovation and patenting are both convenient when large customers compose the market structure. Traditionally, governments have used many tools to promote science and technology, including the system of patents. This tool promotes R&D and increases the potential profits from innovation. Since an innovation is expensive to develop but often not expensive to duplicate, the patent system grants a temporary monopoly to the innovator (Zobel *et al.*, 2016).

The debate on the healthcare sector and economic implications of intellectual property rights has arisen more and more incisively over-time. In fact, several scholars investigated the role of patenting activities in health care and the respective implications for society (Amado and Gewertz, 2004). This scenario opens up to several practical implications. First, innovation in the health industry is more influenced by intellectual property rights protection than other sectors. In fact, Hassan *et al.* (2010) and Qiu and Yu (2010) highlighted that the absence of patent protection would lead to a 64% reduction in investment in R&D in the health care sector, and only 8% in other sectors. Second, patents are a very important asset for firms, because they are a stimulus for the development of ideas and for further research activities. Though, patents are very complex, expensive and subject to risks of infringement and circumvention, especially for small businesses. For this reason, many firms have equipped themselves with external consultants who deal with patent surveillance (Bican *et al.*, 2017). Third, Amado and Gewertz (2004) underlined that patenting activity must be encouraged in health care.

The ability to patent one's innovation is important not only as a source of intellectual protection and potential income, but, above all, because it stimulates the firm to codify its knowledge and it amplifies the ability to share and exchange knowledge. HCOs are able to create and share value among all stakeholders through open innovation (Pirozzi and Ferulano, 2016; Veltri *et al.*, 2011).

Academic research is increasingly focusing on the study of determinants of open innovation and intellectual property (Ahn *et al.*, 2015; Del Giudice *et al.*, 2019). At the level of theoretical models, the paper develops a new perspective in the health sector: the results proved that intellectual property and the degree of firms' innovation are associated not only to expenditures in open innovation, but also to governmental expenditure in health care.

Finally, at the time of Covid-19, the social implications of the present paper need to be made explicit. The health sector has the highest number of innovations (Cavicchi and Vagnoni, 2017). For example, scientists are currently attempting to find a vaccine against Covid-19 that affects all the research centers and HCOs, regardless of specific factors that characterize them. The best way to find cures and vaccines is to innovate jointly, share the knowledge, relying on public support for patenting.

### *5.1 Conclusions and future research avenues*

This study detangles the intricate relationship between open innovation and intellectual property. Our original findings show that the relationship is positive. However, this contingency could depend on market characteristics. When innovations are very complex, patenting is necessary to guarantee the sustainability of economic returns. At the same time, sharing the burden with other partners might also be necessary, because the cost of the process is high and so is uncertainty. In such cases, the market structure determines the expected pay-off and the viability of the project. Health industry may rely on high public expenditures. This varies the rule of the game and makes patents in open innovation very convenient.

Future studies should examine this relationship more in-depth, using more complex models and analyses than the current one. In particular, future research should find out other

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factors that impact the relationship and how. In addition, it could be of interest to verify the possibility to extend the present results by focusing on other sectors and industries. Importantly, open innovation and patenting can have relevant implications for knowledge management, knowledge sharing and transfer. Future scholars should try to understand the effects of co-patenting at a knowledge management level.

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### Webgraphy

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