Internal Firm Characteristics, External Environment, and Innovative Performance: Empirical Evidence from Europe

Master Thesis

Industrial Dynamics & Strategy

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Abstract

Studies on the innovative performance of firms have generally yielded inconclusive results over the years. With the aim to unravel such unconformities, this paper reviews innovative performance by taking into consideration the internal and external characteristics of European firms. Using a sample of 6,118 firms located in Europe from 1978 to 2010, this study seeks to investigate which attributes play an influential role in a firm's innovation performance. In this empirical analysis, (i) firm age, (ii) size, (iii) financial performance, (iv) urbanization degree of location country and (v) educational level of the labor force in the country are examined to explore their effect on innovation. Among the results obtained, it is vital to highlight that the company's size and highly educated human capital favor the innovative activity of firms in Europe.

Keywords: Innovative performance, Firm characteristics, Europe

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1. Introduction

"Innovation" seems to be everywhere you lay your eyes these days. Everybody is eager to find more efficient products and services that save precious time and cost. Firms implement a proliferation of innovative business models and methods of production, in their attempt to be at the forefront of the evolution and adopt an innovative image for their customers (Fagerberg & Verspagen, 2009). Policymakers also focus on innovation by engaging many actors of business, academia, and government to create network effects, knowledge spillovers, and clusters that will foster the growth of the country and attract the very best innovators (Agarwal et al., 2007; van Winden et al., 2014). Yet, do we really know what innovation is? A large body of literature has appeared due to this emerging popularity, with scholars trying to understand the many aspects and forms of innovation (Fagerberg, 2004). But probably, no one could give a better explanation of innovation than its prophet, Joseph Schumpeter (McCraw, 2009). In his work, Schumpeter (1934) described innovation as a disruptive source of energy that brings economic and social change.

How is innovation leveraged might someone wonder. Extensive literature in the past has identified the main drivers of firms' innovative capacity and even further, innovation's significance for economic development (Schumpeter, 2017). In this paper, these drivers are conceptualized as organizational characteristics that apply to any firm, regardless of the business sector or multinational location. More specifically, this research emphasizes the basic features that every company carries, such as the age, size, and level of financial performance. In this way, this study avoids the risk to exclude smaller companies that lack the research and development department, even though its contribution to innovation is undoubtedly accepted. Yet, apart from firms, countries have a primary role in innovation. Previous work by Fagerberg and Srholec (2008) has shown that differences in country innovativeness explain differences in country development. Unambiguous is also the importance of human capital to innovation (Dakhli & De Clercq, 2004; Lund Vinding, 2006). For

example, it is acknowledged that the educational level of a country is highly related to the country's productivity and development. For this reason, this paper also focuses on the external attributes of the business environment that are impacted by the country's policy. In particular, this empirical work takes into account the urbanization degree of different European countries to unveil the importance of country characteristics in firm innovativeness.

Still, how important is it to measure innovative activity? What is the impact of innovation at a societal level and what at a firm level? It seems that previous literature agrees on the fundamental role of innovation at both these levels. At the macro level, Agarwal et al. (2007) developed a framework that recognizes innovation and spillovers as a leveraging mechanism that generates new ventures and economic growth. Moreover, innovation has been identified as a key factor behind the conversion of social capital into higher welfare (Akçomak & Ter Weel, 2009). Rodríguez-Pose and Crescenzi (2008) highlighted the importance of geography for European regions in this growth performance. They found that the proximity of countries contributes highly to the flow of tacit knowledge and technological spillovers. Apart from being one of the major drivers of economic development (Tushman, 1997), innovation is a vital component of growth at the micro-level (Rosenbusch et al., 2011). According to literature, taking into account that every firm has limited resources, firms will have to enhance their abilities to better evaluate, integrate and convert external knowledge into new products and services (Stock et al., 2001). This ability is called "absorptive capacity" in the literature and it is highly dependent on innovative capacity (Cohen & Levinthal, 1990). Absorptive capacity is a key driver for every organization that wants to sustain a competitive advantage against rivals (Zahra & George, 2002), and it differs according to each kind of knowledge that is absorbed by different innovation activities (Schmidt, 2010). Hence, absorptive capacity seems to be a crucial element of any firm's behavior, regardless of its innovation propensity.

Given the fundamental significance of innovation, both on a societal and business level, the research questions that this study explores are: What are the characteristics of firms that attain better innovative performance? Are these characteristics found in the internal or external environment of

firms? The purpose of this research is to identify the attributes of the firms with more enhanced innovative performance in Europe. With this objective, this study uses a sample of 6,118 European companies with patents in the U.S. Patent and Trademark Office and performs an analysis of characteristics from both their internal and external firm environment. In particular, it examines the effects of the firm's age, size, and financial performance, as well as the urbanization degree of the country that is located in Europe, on the firm's innovative capacity. Moreover, the national education level is further analyzed to reveal the effect on firm innovativeness. The findings of this work constitute a contribution to the field by offering a detailed explanation of more innovative organizations in Europe. In addition, this study yields significant business knowledge for the resource-based theory (Newbert, 2007), because it avails firms to recognize the appropriate elements to implement a successful strategy in order to achieve higher innovative performance.

The remainder of this paper is structured as follows. First, the theoretical perspectives that lead to the formulation of the hypotheses are reviewed. Next, the data and methodology used for this research are described. Then, the findings of the paper are analyzed and interpreted. Finally, the conclusion, possible limitations, and recommendations for future research are presented.

2. Literature Review

The notion of innovation has been studied in the past by several scholars and its importance on business performance is unambiguous (Hult et al., 2004). It has been highlighted as the source of competitiveness and profitability (Prajogo & Ahmed, 2006). However, this argument holds only when the commercialization of innovation results in successful innovative performance. Hence, it is vital to understand the meaning of the term "innovative performance" and its measurements.

In previous literature, innovative performance has been determined by the percentage of the introduction of new products or services or the improvement of the existing ones on total sales of the

organization during the last three years (Caloghirou et al., 2004). Therefore, it is essential to take into account the management capabilities of the firm to successfully commercialize innovation in the market (Protogerou et al., 2017), rather than just the ability to value and apply knowledge. However, previous scholars have emphasized that the idea of an innovative organization is not identical to its successful innovative activities. On the contrary, there are different types of innovative organizations that innovate in various ways and commercialize inventions differently (Damanpour & Wischnevsky, 2006). Thus, this is not what this paper examines.

This study measures innovative performance using the widespread approach of Acs et al. (2002), namely to measure innovative capacity with the use of patent counts. According to their work, using this instrument allows this paper to fairly represent innovative activity. Yet, it would be fair to mention other measures of innovative activity identified in the literature. Another instrument that has become a measure to capture innovative performance is patent citations. Moser (2013), however, pointed out that this approach might give a biased picture of innovation for developing countries without patent legislation or for countries that are below the technology frontier. An alternative to measuring innovative activity is through innovation surveys (Archibugi & Planta, 1996). Although this measure sounds more relevant than the previous ones, it still has its downside. For example, the definition of "innovation" might differ from country to country or the interpretation of the findings might vary depending on different cultural backgrounds and managerial overestimations (Fagerberg, 2004).

2.1. Internal Firm Characteristics

2.1.1. Innovation and Firm's Age

While many scholars have emphasized how innovative performance alters with age, others have focused on how age affects the way in which firms gain from innovation. In fact, in the literature firm age is considered both favorable and detrimental to innovative performance (Sørensen & Stuart,

2000). One the one hand, older organizations have the advantage of learning effects, i.e. mature firms innovate more efficiently as they build on a previous solid basis of knowledge and capabilities (Zahra & George, 2002). In the long-term, older firms tend to innovate on the basis of existing routines, resources and competencies and are able to handle uncertainty better than younger firms. That is because older organizations engage in incremental innovation by undertaking less risky projects along with a more diversified portfolio of innovative projects. This assists to achieve a reduction in the uncertainty of the R&D investments. Still, older firms suffer from the phenomenon of organizational inertia that restrains the organization to deviate from routine and change (Sørensen & Stuart, 2000).

On the other hand, as early-stage companies are associated with less organizational inertia, it is expected that entrant companies are more prone to the probability of innovating (Huergo & Jaumandreu, 2004a). In other words, they must be having high-level innovation capabilities that according to Agarwal (1998), are related to their survival. From this perspective, it is estimated that companies who attain a better performance from the adoption of innovations are young and apt to invest in R&D (Coad, Segarra & Teruel, 2016). Furthermore, living in an e-world has contributed to younger and smaller firms being on equal footing with larger firms in terms of obtaining external knowledge and online global recognition (Houghton, & Winklhofer, 2004). Last but not least, the propensity of newborn firms to undertake radical innovation generates an even stronger effect on firm productivity growth (Huergo & Jaumandreu, 2004b). Following the same line of reasoning with the latter authors, the first hypothesis is formed as follows:

Hypothesis 1: *Older firms file, ceteris paribus, fewer patents than younger firms.*

2.1.2. Innovation and Firm's Size

A further characteristic underlined by traditional literature is the organizational size. With respect to the two Schumpeterian theories on firm size and innovation, this is a topic that stirs up controversy. Considering the first vision of Schumpeter, i.e. innovation comes from small firms, a lot of arguments have been raised praising this notion. To begin with, Damanpour (1991), among others, studied the relationship between the determinant of size and organizational innovation and found that small enterprises have been shown as more innovative. In fact, he observed that smaller firms are more flexible and dynamic, and therefore less risk-averse to innovation. On the same page, other authors have noticed that smaller firms may be more alert to new opportunities (Rogers, 2004). Since smaller organizations lack strict lines and structures, they are more easily adaptable to changes and open to revolutionary ideas. Other scholars like Agarwal and Audretsch (2001) have found that small size enterprises can be equally strong as larger firms especially when their entrance to the industry is a result of tackling unseen opportunities, by larger firms, for market niches.

Opponents of this view are supporters of Schumpeter's later argument, i.e. innovation eventually comes from large firms, which was his concluding view on the relationship between firm size and innovation. According to this view, large firms own the necessary funds and skilled human resources to accumulate and exploit the knowledge that leads to innovation, through intensive R&D (Acs & Audretsch, 1988). As mentioned above, high levels of absorptive capacity of larger firms have a direct effect on innovative activity (Kostopoulos et al., 2011). Indeed, the existence of a positive and significant relationship between organizational size and innovative performance is confirmed repeatedly in the literature (Camisón-Zornoza et al., 2004). Another characteristic of big, established companies is the advantage of economies of scale that allow them to spread the costs of innovation over a larger base and avoid sunk costs (Symeonidis, 1996). Overall, it seems that innovative activity is more influenced by better infrastructures of large firms that possess the appropriate assets to capture

important knowledge and commercialize innovation successfully. According to the arguments above, the following hypothesis seems to be supported:

Hypothesis 2: Larger firms file, ceteris paribus, more patents than smaller firms.

2.1.3. Innovation and Financial Performance

Even though prior research explores all the benefits of innovative capacity to firm financial performance in depth, finding that firms with good financial performance tend to file more patents (Geroski et al., 1993; Kostopoulos et al., 2011;), only a few empirical studies examine the effect of profitability on innovative performance (Bhattacharya & Bloch, 2004). Superior economic performance is unambiguously a great advantage for overall enhanced firm performance in terms of competition and recognition, however, is it considered a determinant of innovative capacity? Taking into consideration that innovative capability requires the enhancement of employee skills, continuous development of operations, and improvement of exploiting external networks, it is therefore expected, that successful financial performance is essential. One of the few studies on this matter, conducted by Audretsch (1995), showed that there is a positive and significant relationship between profitability and innovative activity but under the regime of high-tech industries. The present study extends this previous work by examining the effect of the financial performance of European firms from a variety of industries on their innovative performance. Thus, a third hypothesis is now suggested:

Hypothesis 3: Financially successful firms file, ceteris paribus, more patents than less profitable firms.

2.2. External Firm Characteristics

2.2.1. Innovation and Degree of Urbanization

A high degree of urbanization is interwoven with European civilization. The idea of urban areas is deeply connected with the concepts of superior infrastructure, accessibility and labor mobility. This perspective is consistent with the perception of Antrop (2004) who indicated that innovation diffused rapidly in European cities. As already mentioned, there is a strong and significant linkage between economic development and urbanization in Europe (Akçomak & Ter Weel, 2009). From the historical past of Europe, urbanization constituted an instrument influencing economic growth since it leveraged entrepreneurial activity. Until today, it seems that entrepreneurs are drawn to urban regional characteristics. In his work, Fritsch (2013), studied that urbanization economies foster knowledge, innovative activity, and technological evolution. According to his approach, urban agglomeration economies complement innovation by spillover effects. Evidence from several other studies (Van der Panne, 2004; Agrawal et al., 2008) reports the existence of strong knowledge spillovers due to geographic proximity. Taking into account that these clustering externalities cherish entrepreneurial and innovative activity, it is therefore suggested that urbanization economies complement innovation.

In other words, the concept of the location has been found to be critical for innovation (Feldman, 1999; Audretsch & Feldman, 2004). More specifically, urban regional characteristics seem to attract dynamic entrepreneurial movement due to all the advantages they offer to the human capital (Moretti, 2004). Accordingly, firms enjoy large benefits owing to the employment density in cities, and therefore, the growth productivity that it delivers. Moreover, Jaffe et al. (1993) discovered an important indirect effect between localization and innovation. In fact, they found that the knowledge spillovers that occur in urban economies increase the patent citations of firms located in these areas. Given the discussion above, the following hypothesis is proposed:

Hypothesis 4: Firms located in countries with high urbanization degree file, ceteris paribus, more patents than firms located in countries with lower urbanization degree.

2.2.2. Innovation and Country-Level of Education

Many scholars in the past have linked education with economic development (Hanushek & Wößmann, 2007; Pillay, 2011). First, it is commonly alleged that increases in education bring an even higher return on human capital (Moretti, 2004). Second, a higher level of human capital results in economic growth through increases in GDP per capita, respectively. What might not be that widely known, is that one of the links behind this outcome is innovation (Morck & Yeung, 2001; Andersson et al., 2009). The regional impact of high education to regional firm innovative performance has been recorded successfully in the recent past (Caniëls & van den Bosch, 2011). Accordingly, the significant outcomes of innovation, such as internalization, exports, and firm growth, have an influencing role in employment (Calvino & Virgillito, 2018). For this reason, government expenditures on education keep rising with the aim of creating a highly skilled labor force that in turn, will foster national development.

One famous example of a European country that has harnessed the fruits of education, is Sweden. The Swedish government realized the fundamental returns of education early and decided to decentralize education three decades ago. The results of this strategic move were numerous, with the three most significant ones being the accessibility to higher education in all parts of the country, the aggregate growth in productivity and the stimulation of local innovation (Andersson et al., 2009). Apart from decentralization, other countries in Europe invest large parts of GDP in the quality of higher education as a means to achieve competitiveness. Thus, this paper tests the following final hypothesis:

Hypothesis 5: Firms located in countries with a more educated labor force file, ceteris paribus, more patents than firms located in countries with a less educated labor force.

3. Data Description & Methodology

3.1. Sample Construction

To perform the analysis, data on all U.S. patents granted by the U.S. Patent and Trademark Office (USPTO) between 1978 and 2010 are assembled. The USPTO sample comprises around 74,000 firms with at least two years of patent output. To incorporate firm financial information in the analysis, patent data are merged with Compustat data on publicly listed companies. Next, European regional characteristics for the period 1978-2010 are obtained from the World Bank Database and merged with the dataset. After combining the three datasets, the final dataset consists of panel data with 6,118 European firms with patent applications in the U.S. within the years 1978-2010. The sample includes important firm variables such as firm age, size, return on assets, R&D expenses, and operating income. Regarding the firm location, regional characteristics like population, urbanization degree, educational level, and employment rate are also comprised.

3.2. Variable Description

Table I describes the measures used for the firm and regional characteristics.

Table I: Variable Description

Variable	Description
Innovative Performance	Number of patents in year *t* at firm *j*.
Internal firm characteristics	
Firm Age	Difference between 2010 and the year of the organization's establishment.
Firm Size	Number of employees for firm *j* in year *t*.
Financial Performance	Return on assets (ROA) calculated as net income per total assets in year t for firm j.
External firm characteristics	
Urbanization Degree	Urban population (% of total population).
Education Level	Labor force with advanced education (% of total working-age population with advanced education).
Control variables	
R&D Expenses	R&D spending in year *t* for firm *j*.
Dummy R&D	Indicator = 1 if R&D spending > 0 for firm *j* in year *t*, 0 otherwise.
Operating Income Change	Change in operating income of firm j averaged over years *t - 2* to *t*.
Patent Stock	Sum of patents at firm j in years *t - 2* to *t*.
GDP	GDP per capita.
Population	Total population.
Education Expenditure	Government expenditure on education, total (% of GDP).
Employment Rate	Employment to population ratio, 15+, total (%) (national estimate).

In the following section, the summary statistics will be discussed as observed in a firm-year level. Table II below provides means, standard deviations, minimum and maximum values. Furthermore, Table III and IV (see Appendix) present the correlation of variables in the two models. The independent variables are not highly correlated, all below 0.60, except for the highest correlation that is found between the number of patents and the number of patents on stock, at 0.939, and between the GDP per capita and urbanization degree at 0.692.

For the internal characteristics of the firms as discussed above, this study measures innovative performance by the number of patents filed in year t at firm j. The average number of patents is 377. In the sample, all companies have filed at least one patent with the maximum number of patents being 27058. The youngest firm found in the sample is 3 years old, while the oldest firm is 35 years old. With regards to the size of firms, there are different types of size measurements like revenue metrics or the amount of capital investment, however, this study sticks to the traditional classification that determines company size by the number of employees. More specifically, early-stage companies with just 1 employee are included, among larger ones with more than 800 people under their employment.

To assess the financial performance of the firms in the sample, the present study makes use of the metric of return on assets (ROA). This choice of measurement is supported by two arguments stated by Hagel et al., (2010). First, ROA demonstrates the firm's ability to generate long-term returns on asset utilization to maintain business operations instead of showing the net income or short-term profitability. Second, ROA underlines the uniqueness of firm management to leverage the firm options under unpleasant economic circumstances. Therefore, ROA constitutes a fair metric of the financial performance of the companies in the sample. With the average ROA being 0.02, most companies have negative ROA in the sample.

Following prior literature using Compustat data to study innovation output (Bhaskarabhatla, Hegde & Peeters, 2017), R&D expenses, operating income change, and patent stock are used as control variables. Including a dummy variable that indicates whether a company spends on R&D investment, it is revealed that most of the firms in the sample have positive R&D expenses with the

average being 0.96. Surprisingly though, the R&D expenditures are not as high as expected, with 558 dollars being the average amount spent. Regarding the net income of the companies, it is observed that some firms declared negative revenues with the minimum observations being -27446. Another interesting factor that is taken into consideration is the patent stock of firms from the previous two years. In the sample, there is a huge gap observed regarding the patent stock. On the one hand, some firms have no patent stock and on the other hand, others have stated to have over 58 thousand, with the average number being around 1075.

To assess the external firm characteristics, this study makes use of country data such as urbanization degree and total working-age population with advanced education of Europe from 1978 to 2010. In more detail, the average degree of urbanization in Europe is 75.8%, illustrating the astonishing density of European cities. In the sample, Belgium is the country with the highest degree of urbanization on average, while Liechtenstein has the lowest. Another interesting fact is that 81% of the total working population on average has an advanced educational level. On average, United Kingdom is the country with the highest educated labor force. Following past studies with regard to Europe, the present study uses GDP per capita, total population, government expenditure on education and employment rate as control variables. In the sample, the minimum value of GDP per capita is 946 euros, when the average of the European citizens have a more prosperous standard of living, valued above 36 thousand. Despite the fact that Europe is the second most flourishing economy in the world, the GDP per capita is respectively low because it is spread in almost 150 million people in this sample years. Therefore, the highest GDP per capita, on average, is found in Monaco. Regarding the public expenditure on education, European countries spend on average 4.9% of the GDP, with Denmark spending the largest amount on average of 8% of GDP. Lastly, the average employment rate in Europe for this period is 54.2%, with Iceland being the country with the most available labor resources.

Table II: Descriptive Statistics

Variable	Min	Max	Mean	Std. Dev.	Obs.
Number of patents	1	27058	377	1045.9	6118
Operation Years	3	35	14.9	8.66	6118
Number of Employees	1	821	40	64.3	5957
Return On Assets	-13.6	0.8	0.02	0.27	6048
R&D Expenses	0	12183	558	1193.7	5092
Dummy R&D	0	1	0.96	0.18	6118
Net Income	-27446	45220	774.7	2405	6118
Change in Operating Income	-12.27	405.38	0.47	8.1	6118
Number of Patents on Stock	0	58784	1075	2981.2	6118
Urbanization Degree	14.68	100	75.8	14.7	6118
Labor force with advanced education (% of total working-age)	60.8	94.2	81.8	5.64	4115
GDP per capita	946.4	143128	36156	12235.8	6058
Total Population	28747	149M	2.67M	3.38M	6118
Education Expenditure (%GDP)	1.24	9.89	4.9	0.69	4443
Employment Rate (%)	37.53	80.8	54.2	5.65	5715

3.3. Methods

In this paper, two estimation models are designed for the analysis of the panel. That is because of the two different levels of aggregation - firm, and country level. Therefore, the first model is formed for

the analysis of internal firm characteristics and the second one is shaped for the analysis of the external firm characteristics. To perform the analysis on the panel data, two models are considered suitable regarding the nature of the independent variables. These are the models of random and fixed-effects. To test which model is more appropriate, this study makes use of the Hausman test. The outcome of this test shows that a random effects approach is more appropriate for the panel analysis of the firm-level model, whereas a fixed effects model would be more suitable for the country-level analysis (See Tables V and VI in Appendix).

Taking into consideration that the variance of the variables in the models does not vary a lot over time, e.g. think of urbanization degree, the use of a third, simpler cross-sectional model is required to explore any differences in results. The formula versions of the models are presented accordingly below. For the first submodel (Model Ia), the number of patents per firm is used as the dependent variable and all the control variables are included as listed above. Whereas in the second submodel (Model Ib), the same dependent variable is used, however, only the variables of interest are included. The same framework applies for the second model, albeit, the use of the average number of patents as the dependent variable is more appropriate to examine the effect of external characteristics.

Model	Formula
Model Ia	*Number of patents = constant + β1*age + β2*ln(size) + β3*ln(roa) + β4*ln(R&D expenses) + β5*Net Income + β6*Change in Operating Income + β7*Dummy R&D + β8*Patent Stock + ε*
Model Ib	*Number of patents = constant + β1*age + β2*ln(size) + β3*ln(roa) + ε*
Model IIa	*Average number of patents = constant + β1* % Urbanization + β2* % Labor force with advanced education + β3*ln(GDP per capita) + β4*ln(Population) + β5*Education Expenditure + β6*% Employment + ε*
Model IIb	*Average number of patents = constant + β1* % Urbanization + β2* % Labor force with advanced education + ε*

4. Results

4.1. Analysis of the Internal Characteristics that Influence Innovative Performance

Table VII: Innovative Performance and Internal Firm Characteristics

Innovative Performance	(1) Firm Age (RE)	(2) Firm Size (RE)	(3) Firm Financial Performance (RE)	(4) Model Ia (RE)	(5) Model Ib (Cross-sectional)	Hypotheses
Age	-2.139*** (0.575)	-	-	-2.139*** (0.580)	17.82*** (1.267)	H_1
Size	-	0.936 (3.466)	-	0.228 (3.807)	128.0*** (7.503)	H_2
Financial Performance	-	-	21.40 (24.53)	30.99 (26.96)	-266.9*** (57.46)	H_3
R&D Expenses	17.84*** (3.199)	13.52*** (4.044)	14.52*** (3.178)	16.68*** (4.146)	-	
Net Income	-0.000362 (0.00212)	0.000878 (0.00213)	-0.000835 (0.00215)	-0.000207 (0.00218)	-	
Operating Income Change	0.899 (0.584)	0.967* (0.579)	0.965* (0.578)	0.918 (0.580)	-	
Dummy R&D	-52.81 (163.0)	-40.63 (161.5)	-42.63 (161.2)	-50.03 (161.7)	-	
Patent Stock	0.326*** (0.00180)	0.326*** (0.00179)	0.326*** (0.00179)	0.327*** (0.00181)	-	
Constant	25.21 (162.4)	-1.171 (160.8)	-0.884 (160.4)	26.06 (161.1)	-238.7*** (25.07)	
Observations	5,902	5,773	5,797	5,739	5,923	
R-squared:						
within	0.6722	0.6691	0.6690	0.6700	0.0624	
between	0.9826	0.9834	0.9841	0.9818	0.1318	
overall	0.8834	0.8846	0.8847	0.8850	0.1310	
Number of groups	973	961	960	955	985	
Max no. of obs. per group	32	32	32	32	32	

Standard errors in parentheses

* $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table VII presents five different columns with the estimations of two analyses. In the first four columns, the findings regarding the effect of firm age, firm size, financial performance and all internal firm characteristics tested in this paper are presented respectively with the use of random effects analysis. The results of the simplistic approach as discussed in the methods section are illustrated in column 5. First, the results of the random effects analysis will be interpreted. To begin with, there is evidence that supports the first hypothesis (H_1), namely that the number of patents is more likely to be higher when applied for a younger firm. In fact, in column 1, it is found that one additional year decreases the innovative performance by 2.14 patents, ceteris paribus. This effect is significant at a 1% significance level. This effect remains strong and statistically significant in column 4 (full model) highlighting the negative relationship between age and innovative performance.

With respect to the second hypothesis (H_2), the coefficient supports the hypothesis that organizational size is positively correlated with innovative activity. In fact, firms with one more employee tend to file 0.94 more patents, ceteris paribus. However, this result is not significant. In addition, this finding remains consistent and insignificant when firm age and financial performance are added in column 4. The third column provides the findings for the third hypothesis of this study. The results indicate that firms with better financial performance tend to produce 0.45 more patents, ceteris paribus. This effect is not statistically significant. Therefore, there is no strong evidence to support the third hypothesis (H_3), namely that the number of patents is more likely to be higher when applied for a firm with higher financial performance. In column 4, the same condition applies to the third hypothesis.

The findings with respect to the control variables appear to be consistent in all four columns of the random effects analysis, except for the effect of changes in operating income. More specifically, the effect of changes in the operating income loses significance when the variable of firm age is added to the regression. Whereas, in columns 3 and 4, it is observed that alterations in the operating income have a contributing role by increasing the firm innovative activity by 0.96 patents approximately. On the other hand, the effect of the net income does not seem to have an influential

role in the innovative performance since all the effects are insignificant at a 10% significance level. Furthermore, there is support that R&D expenditure is positively associated with firm innovative performance. In most of the findings, there is strong and significant evidence yielded that a slight increase in R&D expenditures increases the number of patents immensely. Taking into consideration that only 3.61% of the firms in the sample do not invest in R&D, the result with regards to this finding is statistically insignificant. Interestingly, the findings regarding the presence of patent stocks are strong and significant in all four random effects analyses. This suggests that past innovative experience of the firm plays a fundamental and influential role in the future innovative performance.

When the findings of the simpler, cross-sectional model are studied, there are major differences noticed concerning the significance and the sign of the coefficients. To start with, when all control variables are excluded, it is observed that one additional year increases the innovative performance by 17.8 patents, ceteris paribus. This effect is also significant at a 1% significance level. Yet, this effect stirs up controversy according to the result that the random effects analysis yields. According to the latter, no conclusion can be made with reference to the first hypothesis. Moreover, there is strong and significant evidence that supports the second hypothesis of this study. Indeed, a 1% increase in the firm size, increases the innovative performance of the firm by 1.28 patents, ceteris paribus. This effect is significant at a 1% significance level. When the estimations of the two different analyses are compared, it can be concluded that there is quite, a positive relationship between the organization size and its innovative performance. In relation to the third hypothesis, this model reports a negative and significant effect of financial performance to innovative activity. As a matter of fact, a 1% increase in the return of assets decreases firm innovative performance by 2.66 patents, ceteris paribus. This effect is significant at a 1% significance level. This negative relationship between innovative performance and prosperous performance can be interpreted by specific intellectual property (IP) strategies that firms adopt, in order to be prepared for any patent pools or hold-up technologies that may arise after the patent application (Shapiro, 2000).

4.2. Analysis of the External Characteristics that Influence Innovative Performance

Table VIII: Innovative Performance and External Firm Characteristics

Innovative Performance	(1) Urbanization (FE)	(2) Labor force with advanced education (FE)	(3) Model IIa (FE)	(4) Model IIb (Cross-sectional)	Hypotheses
Urbanization	-210.0 (132.5)	-	-104.3 (319.2)	55.44 (73.48)	H_4
Labor force with advanced education	-	98.84 (220.4)	104.6 (221.7)	511.2*** (147.8)	H_5
GDP per capita	6,950*** (2,238)	14,308*** (4,992)	14,664*** (5,123)	-	
Total Population	29,117** (13,178)	-7,508 (19,466)	-5,813 (20,197)	-	
Public Expenditure on Education (%GDP)	-55.87 (716.1)	-1,407 (1,123)	-1,300 (1,173)	-	
Employment Rate	-6.749 (113.1)	123.1 (255.3)	134.7 (258.4)	-	
Constant	-527,546*** (198,089)	-26,613 (306,088)	-52,074 (316,665)	-36,885*** (12,397)	
Observations	325	192	192	248	
R-squared:					
within	0.1481	0.0864	0.0864	0.0115	
between	0.3054	0.0133	0.0133	0.0949	
overall	0.2072	0.0544	0.0544	0.0339	
Number of groups	26	24	24	25	
Max no. of obs. per group	10	7	7	10	

Standard errors in parentheses

* $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

Table VIII above represents the results of two different research methods. In the first three columns, the findings regarding the effects of urbanization degree, labor force with advanced educational level and all external firm characteristics tested in this paper are illustrated. Column 4 shows the effects reported in the analysis without the control variables. One of the main observations in this model is that it suffers from attrition. Evidently, there is a loss of follow up in the observations as they drop considerably. Therefore, this might have an effect on the representativeness of the sample as its composition may change over the years.

Following the same outline as above, the findings of the fixed effects analysis will be presented first. With regard to the fourth hypothesis (H_4), there is no strong evidence that supports that urbanization degree is positively correlated with innovative performance. In fact, countries with a one percent more urbanization tend to file 210 more patents, ceteris paribus. This finding is not statistically significant. Additionally, this result remains insignificant (column 3) when the education level of the labor force is added to the model. In column 2, the findings regarding the fifth hypothesis (H_5) are presented. The results indicate that countries with a one percent more educated labor force tend to produce 98.84 more patents, ceteris paribus. This finding is not statistically significant. In addition, it is found consistent and insignificant in the full model in column 3.

An additional interesting result that this model yield is the effect of GDP on the innovative performance of the firms. More specifically, there is a significant and positive relationship between GDP per capita and the average number of patents. One possible explanation behind this result could be that sometimes innovation is triggered during upturns in economies, mainly because there is the availability of funding R&D and innovative activities ("Downturn, start up", 2012). A controversy is raised with regard to the findings of the population result in innovative performance. In the first column, the effect seems to be positive and statistically significant, whereas, in columns 2 and 3, this effect becomes negative and statistically insignificant. With regard to the relationship between the employment rate and innovative activity, there is no significant effect on explaining the role of human resources to the average number of patents. Considering the insignificance of the finding of the public

expenditure on education in all three columns, it is presumed that these expenses do not play a major influence in innovation. That can be the case mainly because, nowadays, people get educated using their private financial resources and undoubtedly, the internet sources.

Subsequently, a second model is elaborated, including only the variables of interest for hypotheses four and five (H_4 & H_5). With regard to the effect of the urbanization degree on innovative activity, the estimation shows that there is no particular influence as it lacks significance. However, it should be noted that the sign of the coefficient changes, indicating the positive relationship between urbanization and innovative performance. In the case of the fifth hypothesis, there is support for a positive correlation between the advanced educated labor force and the aggregated innovative activity in Europe. In other words, countries with a one percent more educated working population tend to file 511.2 more patents, ceteris paribus. This effect is statistically significant at a 1% significance level.

5. Concluding Remarks

This study examined the internal and external characteristics of firms located in Europe with the aim to explore their influential role in a firm's innovation performance. Using a sample of 6,118 European firms, this research work uncovered a variety of outcomes. Starting with the effect of a firm's age on innovative activity, this empirical work finds contradicting results. In continuation of this controversy over the years as discussed in the literature review, this study also finds no strong evidence that supports that younger firms tend to innovate more than older firms in Europe. On the other hand, this empirical analysis finds strong support that larger firms attain better innovative performance as anticipated. This result is consistent with the early work of Schumpeter and the most recent literature (Kostopoulos et al., 2011). In addition, it is interesting to point out the effect of superior financial performance on a firm's innovation activity. While someone would assume that there is a positive relationship between these two, the analysis reported the opposite. One possible explanation behind

this could be found in the work of Harhoff et al. (2007), where they studied a variety of IP strategies and patent pools. In this sense, firms do not devote all their profits and resources into filing new patents, as sometimes the implementation of patents hides thickets and brings losses. The relative significance of R&D and the patent stock appears in the analysis, as these findings highlight the importance of technical experience within a firm (Singh & Fleming, 2010).

The second contribution of this paper is related to the regional attributes of a firm's location. First, with regard to the urbanization degree of a country, there is no significant influence on a firm's innovation activity. This finding may be justified by the overall high urbanization that characterizes Europe, and therefore, there is no discrepancy between countries to signal any effects. In contrast, this study supports the evidence that firm innovative performance is enhanced by a highly educated labor force. In other words, this empirical work underlines the fundamental role of human capital on innovation and indicates its avail as a competitive advantage (Bhaskarabhatla et al., 2017). This is a valuable finding as it draws the attention of policymakers to the vital importance of education to innovation. A final remark derived from this study is that firms located in more prosperous countries in Europe tend to obtain a better innovative performance.

6. Limitations & Future Research

As all research works, this study is subject to a series of limitations. First, as this analysis makes use of panel data, the representativeness of the sample might be affected due to attrition. For instance, in this study, firms will only be observed if they apply for patents. As such, this will underestimate the effect, because many non-innovative firms are not in the data. Second, patents application is not always the best measure of innovation. Although widely accepted, this choice might be flawed, as it is more suitable for inventions, rather than innovations (Fagerberg et al., 2010). Taking into account the tremendous cost of applying for a patent, this choice of measure can be seen more intensively in some

industries, such as high tech and pharmaceutical, than in other industries. Other biases can be caused by the distinction between small and large enterprises as there are a lot of different methods to categorize the size of firms. In addition, this analysis is biased from endogeneity as prior research explores and addresses all the benefits of innovative capacity to firm financial performance (Geroski et al., 1993; Rajapathirana & Hui, 2018). For instance, a previous study has demonstrated that firms maintain high business performance by first-mover advantages that yield from innovations and continuously introduce new products with innovative features to their customers achieve a higher return on their cash flows (Srinivasan et al., 2009). Lastly, the focus of this research work is focused on European firms, and for this reason, the findings can only be inferred within this context.

Future researches could incorporate financial restrictions of firms or the economic state of the countries; economic development or financial crisis; to enhance characterization. Furthermore, it would be interesting to compare the effects of European regional attributes on innovation to other continents. Given the relevance of these factors, the present limitations undoubtedly open new horizons for fruitful areas to be explored.

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Appendix

Table III: Correlation Matrix for Firm-Level Model

	No. of Patents	Firm Age	Firm Size	ROA	R&D Exp.	Net Income	Oper. Income Change	Dummy R&D	No. of Patents on Stock
No. of Patents	1.000								
Firm Age	0.211	1.000							
Firm Size	0.506	0.093	1.000						
ROA	0.062	0.163	0.104	1.000					
R&D Exp.	0.458	0.302	0.590	0.177	1.000				
Net Income	0.285	0.169	0.366	0.179	0.381	1.000			
Oper. Income Change	0.020	-0.023	-0.005	0.010	0.001	0.001	1.000		
Dummy R&D	0.057	-0.003	-0.038	-0.044	-0.079	0.013	-0.010	1.000	
No. of Patents in Stock	0.939	0.237	0.517	0.058	0.466	0.298	0.014	0.059	1.000

Table IV: Correlation Matrix for Country-Level Model

	Average no. of Patents	Urbaniza-tion	Labor with adv. Educati on	GDP per capita	Total Population	Public exp. on Education	Employment Rate
Average no. of Patents	1.000						
Urbanization	0.195	1.000					
Labor with adv. Education	0.182	0.305	1.000				
GDP per capita	0.188	0.692	0.332	1.000			
Total Population	0.431	0.268	-0.167	0.043	1.000		
Public exp. on Education	-0.053	0.181	0.305	0.246	-0.173	1.000	
Employment Rate	0.055	0.074	0.551	0.367	-0.287	0.371	1.000

Tables V and VI below show the results after performing the Hausman test to decide on the appropriate model for the panel data used in this study. For the firm-level model, it is observed that the p-value is not significant (>0.05) and therefore, the null hypothesis (that the preferred model is random effects) cannot be rejected. Hence, this finding indicates that the use of a random effects model is more appropriate. On the other hand, the results of the Hausman test for the country-level model suggest that the use of a fixed effects model is more suitable since the p-value is significant (<0.05), and therefore the null hypothesis is rejected.

Table V: Hausman test for Firm-Level Model

Test: Ho: difference in coefficients not systematic

chi2(6) = (b-B)'[(V_b-V_B)^(-1)](b-B) = 9.30
Prob>chi2 = 0.1572

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Table VI: Hausman test for Country-Level Model

Test: Ho: difference in coefficients not systematic

chi2(6) = (b-B)'[(V_b V_B)^(-1)](b-B) = 16.39
Prob>chi2 = 0.0118

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg