UNIVERSIDAD CARLOS III DE MADRID

WORKING PAPERS

Working Paper
Business Economic Series
WP. 17-02. February, 9th, 2017
ISSN 1989-8843

Instituto para el Desarrollo Empresarial.
Universidad Carlos III de Madrid
C/ Madrid, 126
28903 Getafe Madrid (Spain)
FAX (34-91)6249607

*Pricing the quality of an innovative idea**

Silvana Alvarez Iturri†

Universidad Carlos III de Madrid

Abstract

This paper aims to analyze whether the quality of an innovative idea can spur the patent's price. From an economic perspective, we address the question of how the quality of an innovative idea increases the patent's price. We examine the problem for the case of a single innovation rather than patent´s families. Therefore, we follow the assumption that innovative ideas have patents. Nevertheless, the analysis is divided into two stages; first we estimated the quality of the innovation by quantifying information of the patent documents from the patent portfolios of firms of the ICT sector over the period 1996 to 2015. By providing new empirical evidence, we showed that the patent´s quality can be estimate with multiple observed patents' characteristics which are significant related to the utility of the patent in the market and its impact on the follow-on innovation. The analyses also estimate the patent's price in the market for technologies based on the quality index. In the same way, we used information of the patent´s transaction in the ICT sector over the period of 2012-2015 and review the main costs of the American, European and the international patent system. Our finale results indicate the possibility to reduce the asymmetric information of the quality in the patent´s transactions by using public information.

Keywords: cross section, patent, price, quality, SEM.

JEL Classification: C31, C55, O32, O34

† Silvana Alvarez I, Universidad Carlos III de Madrid, email: silvana.alvarez@alumnos.uc3m.es

(*)This work has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731940. Firstly, I would like to express my gratitude to my tutor and advisor Ester Martinez Ros for the continuous support and help in all the time of research and writing of this thesis. I'm also grateful to Raquel Carrasco, Alvaro Escribano and Cesar Alonzo for their comments on an earlier version of the manuscript. I have to express my appreciation to the Patent Office department and the Intellectual Property and New Technologies Department of Telefonica who provided the data and the expertise that greatly assisted the research**.** The dissemination activity of this work reflects only the author's view and that the Commission is not responsible for any use that may be made of the information it contains.

1 Introduction

Innovative new ideas often come from small independent inventors, who can make new scientific discoveries and develop novel products from a combination of already existing technologies in a new context (Žižlavský, 2011). That implies a succession of technological revolutions that lead to higher competition between firms, inventors, startups and among other market participants. In this new trend of innovation full of competitors, inventors are fear of the expropriation of their ideas by other. So, they have the need to protect their innovation by Intellectual Property Rights (IPR), in most of the cases through patents. Whether obtaining a patent is not an easy task, because on the one hand involves the inventor's extra time and effort and also mean large quantity of money. Nevertheless, with a patent the owner ensures that others can only use their invention with a permission and, thus, creates a profit stream by licensing the technology. Therefore, we are in a century based on information and innovation, where a structured market is emerging for patents (Serrano, 2010) in which firms compete the product market and also in the technology market (Arora and Fosfuri, 2003).

In terms of business, been the owner of a patent implies market power and recently patent acquisitions have become a major source of profitability for large corporations in the Information and communications technology (ICT) sector. Therefore, companies are willing to buy patents for several reasons, such as to deter attacks from competitors, to increase the barriers to entry, to extract royalties or to increase equity in their portfolios. That's the reason of the patents transaction increase every year, which in fact, is also a big business today because involves billions of euros. Beside this, the transaction is often confidential. The problem is that there is not a clear patent marketplace for these intangibles due to the spread of price expectation between patent holders. In most of the cases the price of similar patents vary widely from transaction to transaction (Hagiu, Yoffie, 2013).

Despite importance and the increase of patents transaction in world markets, there is no standard model to estimate a patent's sale price, so buyers will never know if the price they pay to acquire the patent is fair in terms of the quality of the innovation or if they have been paid a price over the market rate, so the negotiation is made under enormous uncertainty. Even worse, the buyer will never be able to know the price per patent because the majority of sale transactions are made by "patent families" that means that a product can comprise thousands of patents of which some patents can be very important and protect ubiquitous technology, while many are never used at all. All this is clear evidence of asymmetric information and adverse selection problems between buyers and sellers. In facing up to this problem, the quality of the innovation represents a key factor determining the patent's price.

Since the 90's has been an increased interest in determining which patent's factors can cause the increase in its monetary value. As such, the aim of this paper is to contribute to the growing body of literature. Moreover, we proposed the pricing model for an innovation based in its quality. We assume that only innovative ideas have patents. This concept has also been referenced in previous economic literature, Rogers (1998) relies upon patent data to measure the output of innovative activity. Therefore, each patent contains detailed information on the technological area to which it belongs, their geographical scope, number of inventors, year of the innovation, etc. We built two types of data sets: First *"The technological data-set"* containing European and American granted patents. The data-set has technical information of 61,735 patents from the patent portfolios of the top 50 largest companies in the ICT sector over the period of January 1, 1996 through December 31, 2015. Then the *"Transaction* *data-set"* which compile economical information from patent brokers. We collected information of 6.778 transacted patents on the ICT sector from 2012 to 2015. Once we built the dataset, we estimate the Patent's price. The analysis is made in two stages, first we estimate Patent Quality index with the Structural Equation Model (SEM) using the technological data-set. After the patent's quality variable is constructed, we estimate the Patent's Price by the Ordinary Least Squares (OLS) model with the transaction data-set. Therefore, we measure the effect of the quality in the price.

The main empirical findings of the paper are the following: there is a substantial information gain when we used multiple indicators to measure the quality of an innovation. The number of citations that a patent receives is a variable less informative than in the past due to its truncation problem. When we estimate companies', strategy citing effect, we found that having a citation in recent years (over the period of 2005 - 2015) is more significant and has more impact on the patent's quality than the previous citation. Regarding with the patent's quality we found that innovations in the ICT sector which imply a longer period of research, development and patent persecution made by a large number of innovators will reduce the quality on the patent. Unsurprisingly, another significant variable is the number of extensions a patent has, because companies based on their strategy choose to extend only their most valuable innovations, and they choose to do so in more countries where they can increase profits and increase the barriers to entry to others. Indeed, a patent with a high quality will increase the patent's price by 17 percent, but at the same time, every year the patent will depreciate by 0.3 percent. The price model also found that the patent's price of a pioneer innovation will be 4 percent higher than a follow-on[2] innovation.

This paper is divided into the following sections: section 2 describes the background literature. In section 3, the empirical analysis describes the data-set and the methodology applied. Section 4 we set and construct the quality index by the latent model and the patent's price model. Then we discuss what the results imply about the information content in each of the indicators. The last section concludes our work and provides final commentary on the ramifications of this work.

2 Background literature

The increase of competitors in the innovation market gives enough motivation to inventors to protect their ideas, in fact, they are not only more likely to seek protection for an invention, they are protecting those inventions with more than one patent. The Patent System enables innovators the exclusive control over their intellectual assets. So, companies are changing their patent management style from a single-patent approach to a portfolio approach. Therefore, the Patent Systems is experiencing a constant increase in the number and size of patent applications, especially for the ICT sector. In this scenario, one of the major concern is that the patent office may grant yearly too many patents of which the type of quality they have is unknown.

The greatest goal of the inventors is to make their innovation profitable by using their intangible assets to obtain greater benefits. Therefore, patent holders have strong incentives to charge above marginal cost. Because in terms of patent's transactions there is a lack "comparable" which were used in the patent markets to estimate a given asset's price and also there is not a public body which control the

[2] A follow-on innovation is a technology that supports or extends the truly pioneering original technology.

patent's prices based on the quality. Causing market failures in the market for ideas (Gans and Stern, 2010). Indeed, the market for technology is characterized by information asymmetries (Arora et al. 2001) since innovator possess more information about the value of their innovations (Shane and Cable 2002). Whether problems of asymmetric information and adverse selection into the IPR system is more acute for younger patents because a technology need several years to impact the market. Therefore, well known firms tend to rely on alternative mechanisms, such as greater bargaining power or the threat of reputation power to provide a credible quality signal to possible patent's buyers to enhance their patents' price valuations.

The high relevance of patents transaction for innovation and the economy have a close association between patent's quality and patent's value. Hall, Thoma, Torrini, (2007) have tried to deal with the variation in the technological and economic importance of patents by constructing indicators of patent quality using patent characteristics that are likely to be positively correlated with their economic value. Indeed, the best way to eliminate the adverse selection problem is by quantifying the quality of an innovation.

The term **quality** is itself so general. Nevertheless, a number of empirical studies (Trajtenberg, 1999, Pakes,1986, Fogarty, 2000, Haroff et al. 2003, Barney, 2010) have attempted to identify the factors which explained the most the level of quality of innovation at the patent level by refining the information drawn from patent data. However, the majority of these studies are based on self-assessed data on innovation and do not take into account the magnitude of introduced innovations. In general, most of the existing literature have been used data such as forward citation, number of countries where the patent is valid and years of renewal. For example, Trajtenberg (1999) and Pakes (1986) estimate the patent quality using data from 1976 to 1995. Whether they found out that the forward citation is the most significant variable to quantify the quality of the patent on the market. Because it is an indicator to measure the technology impact and also generate, respectively, more social and private value (Hall, Jaffe and Trajtenberg 2005). In the other hand, Trajtenberg, Jaffe. A, Fogarty S (2000) show that the cite per patent can increase the likelihood of litigation, based on the intuition that firms cite patent that close in the technological aspect. Then when the patent is granted and is part of any commercial activity there are some probability to infringing any third party’s patent. Litigation often implies patents than are best viewed. In fact, litigated patents receive more citations on average than random patents (Lanjouw and Schankerman 2004). That can be the reason of the decrease in the citation ratio over the last decade. However, Haroff et al. (2003) and Barney (2010) affirm the importance of the citation and also introduced to its study a new measure knows as the number of claims. They found that a patent's quality was a strong function with its number of claims. In fact, they suggest that a patent needs to be well protected by the claims in order to be more valuable for a company. Later on, Lanjouw and Schankerman, (2004) used the number of technological code classification (IPC) assigned to each patent as evidence of the quality and the originality of the innovative invention.

Beside this, based on previous founding Trappey, Charles, C-YiWu and Chi-Wei Lin, (2011) added to the quality analysis all the previous patent's characteristics with some litigation indicators and indicators of investment, then by applying PCA[3] they estimated the patent quality with eleven indicators. Their results were 85% accuracy in comparison to trading broker. All the studies mentioned before took into

[3] PCA - Principal component analysis, which transforms several independent variables into a new set of variables by retaining the most information

account the main limitation produced by the lack of information generated by the Patent System which limits the quantification of characteristics. Nevertheless, the study's conclusion was that the patent quality prediction and methodology can be further refined by adding other criteria and factors for patent quality evaluation. Consequently, Van Zeebroeck (2011) have suggested to make a further step and assess the quality of patents using composite indicators rather than individual proxy. Indeed, by inducing more information from the patents document, it can enhance the ability to provide an accurate quality index.

Taking into account the literature mentioned before and the limitation of the lack of information, in this study we address the concept of patent quality according to the perspective of the previous results and the fundamental requirements for patentability. By using patent's characteristics which are **public information**, we created the quality index based on the estimation of the patent quality in two stages: first we measured the quality taking the information and characteristics on the innovation's a priori-art[4] and later the posteriori[5]. We focus in eight leading characteristics: Number of claims, forward and backward citation from other patents and literature, number of international extensions, the effort applied to obtain the patent and the technological classification type. And rather than treat these measures as independent direct variables, we analyze them together in a latent variable framework.

> ***Hypothesis 1 (H1)****: The eight patent's characteristics are strong indicators to identify and measure the priori and the posteriori patent's quality.*

To estimates the patent´s price it´s important to distinguish between the owner´s value of innovation and value of patent protection. The inventors value of innovation is the wiliness to pay for the persecution of the idea, (Bessen 2007) defined as the quality adjusted R&D, while the value of patent protection is the legal justification to generate returns to his innovation. Under this framework previous studies estimated the patent value at the firm level as the following.

A pioneer work showed a positive correlation between citations received and the economic value of patents (Trajtenberg; 1990) based on the intuition that patents with large number of citations are valuable to the market due to contains knowledge spillovers which was used in many subsequent technologies. Hall et al.(2005) found that the market value of the firm would increase by 3 percent, if the quality of patents increases. Likewise, Bessen (2007) studied the firm incentives to increase the patent´s price by adding information of the patent renewals decisions. His approached was that firms will only renew their patent if the value of patent protection, over the renewal period, is larger than the renewal fees. He measured the patent value distribution based on its mean-to-median value ratio, the approach was useful for understanding the changes of the patent's value over its life utility. Another stream infers to identify which types of patents are more valuable. (Lanjouw, Schankerman 2004; Allison, Mann 2007) Demonstrated that litigated patents were more valuable than non-litigated patents.

Building upon these previous findings, we constructed the price model by combining data on patent sale, quality and cost. And by extending the (Hamilton-Jacobi-Bellman) R&D cost function for the different types of innovation and the productivity index for an innovation (Abrams, Akcigit and Popadak) in a competitive market. Nevertheless, the research takes into account that the greatest challenge for economists, that is eliminated the endogeneity on the patent price, because quality is correlated with

[4] Any evidence of the invention that is known, the technology information contains patent's characteristics before the patent is granted
[5] Information of the patent after the prior art was examined

the error term and unobserved by econometrician (Trajtenber, 1989). Once we construct the quality parameter, we show that the model no longer suffers this endogeneity.

Hypothesis 2 (H2)*: The patent's quality has positive effect on the patent's sale price.*

This paper contributes to two strands of the literature on the economics of innovation. We first contribute to the measurement of the quality of the innovation reducing the adverse selection problem between patent holders. Then contribute with the proposal of a standard price model for innovations.

3 Empirical analysis

We define the two types of data-sets used in the analysis, called as the "*Technological data-set*" used for the estimation of the patent's quality and the *"Transaction dataset"* for the estimation of the patent's price.

The *"Technological data-set"* included eight observed patents characteristics, wherein we quantify the most relevant information from the patent documents. The data consist of a set of European and US granted patents over the period of January 1, 1996 through December 31, 2015 (20 years which represent the life of a utility patent). We obtained the patent's information on the Thomson Reuter[6] data base. We identified 61,735 patents from the patent portfolios of the top 50 largest companies in the ICT sector[7].

A depth explanations and justification of each variable is defined in the following subsections. The data-set include (1) Number of Claims, (2) number of IPC designated, (3) Effort applied in obtain the innovation, (4) Number of patent extensions, (5) Backward patent citation, (6) Backward non-patent citation, (7) Forward citation, and the (8) Citing effect.

For the estimation of the patent's price model we constructed another data-set called as "*Transaction data-set*" which compile information of 6.778 transacted patents on the ICT sector from 2012 to 2015. To build the data set we collected the information from patent brokers' databases. In particular, they provided us the information of (9) the name of the companies involved in the transaction (patents' buyer and seller), (10) the year of the transaction, (11) the technological patent classification (IPC), (12) the number of patents transacted and (13) the total price of transaction.

Due to the lack of information in the brokers' data sets, we could not obtain the patent's ID, nor the technical characteristics. We solved the problem by matching the information of the IPC type and year of the change of ownership of the sample with the Thompson Reuter database. By this procedure we obtained all the technical characteristics of each patent. Therefore, we estimated the (14) patent's quality (as we explain in quality latent model) treating the error associated with the estimated value, (15) the cost of patenting and annual patent fees, (16) the R&D cost and (17) the litigation dummy variable. In-depth explanations of each variable of the formulas is defined in the following subsections.

[6] Thomson Reuter database: the world's most comprehensive database of enhanced patent documents: (http://ipscience.thomsonreuters.com/product/web-of-science/).

[7] ICT firms patent portfolios: ICT Companies: AT&T, Apple, Amazon, Accenture, Atos, British Telecom, Cisco System, Ericsson, Deutsche Telekom, Oracle, Google, Microsoft, NTT, Trance Telecom, Telefonica, IBM, HP, Samsung, Verizon, Vodafone, Qualcomm, Alcatel, Lenovo, Intel, Toshiba, NEC, Hitachi, TCS, SAP, EMC, Capgemini, Sony, Facebook, Infosys, Wipro, Cognizant, Sage, systematic, Amdocs, Siemens, Nokia.

3.1 Models description

The aim of this part is to explain the methodology used for the estimation of the patent's quality index and the patent's price model.

The unobserved characteristic denoted as the *quality* of the patent is estimated in two stages, first we used the factor analysis to identified common patterns between the variables and then we applied the Structural Equation Model (SEM).

Each factor describes the variability among the observed variables by finding a common covariance[8] . Once we applied the factor analysis over the eight variables we obtained: two factors to measure the *priori patent quality*, each of these factors quantified the intrinsic characteristics of the patent at the time of its application and one factor to measure the *posteriori patent quality*, which quantify the innovation impact on the market. Once we know the composition of each factor we constructed the Patent Quality index with the SEM. However, we define the patent quality as an exogenous latent variable, which depends on the three factors.

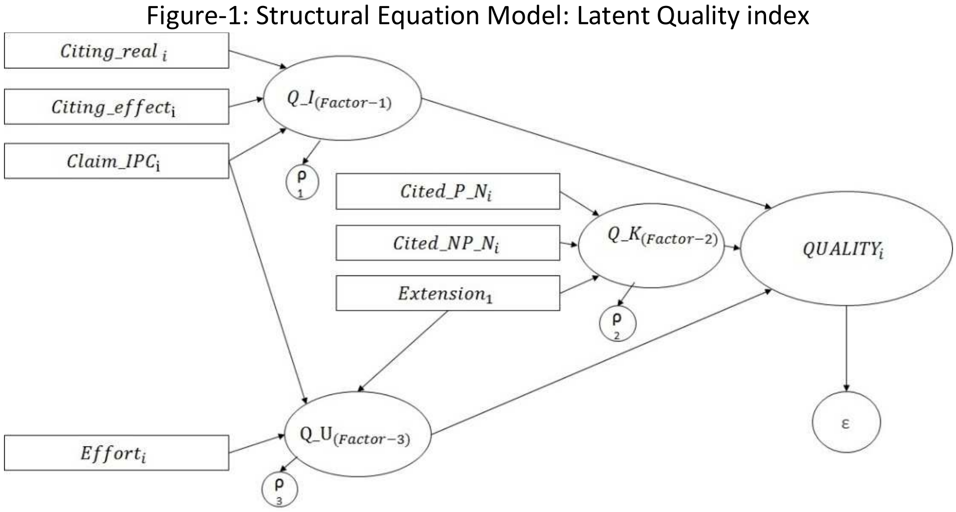
The model of the patient's quality index is written as:

$$Qualiti_i = B_0 + +\beta_1 \mathrm{Q_{Ki}} + \beta_2\ \mathrm{Q_{Ii}} + \beta_3 \mathrm{Q_{Ui}} + \varepsilon_\mathrm{i} \qquad [1]$$

Where $Quality_i$ is the dependent variable which measure the quality of the patent i . Q_{Ki} it is the priori quality factor that measures the quality of knowledge. Q_{Ui} the second prioi quality factor that measure the quality of the patent utility. And the porteriori quality factor denoted as Q_{Ii} which measures the quality of impact.

The formula [1] provides an estimation of the latent variable for each patent (i). The conditional mean of the latent variable is a linear combination of the set of factors, where weights depend on the factor loading. The proposed model is shown in Figure 1, the influence of a *posteriori patent quality* relative to the a *priori patent quality* may also be assessed.

Figure-1: Structural Equation Model: Latent Quality index



Q_I: quality of impact (factor-1), Q_K: Quality of knowledge (factor-2) and Q_U: the quality of utility (factor-3).

[8] the correlation matrix of the variables is presented in Annex B table 7

Using this framework, we test *H1* by evaluating the model fit by the goodness of fit statistics indicators [9]: the chi-squared test, the root Mean Square Error of Approximation (RMSEA), the root mean square residual (RMR) and the comparative fit index (CFI). The results establish the significance of the analysis in the quality model.

After the patent's quality variable is constructed, we estimate the patent's price, by founding a link between the indicators of patent's quality estimated and the costs.

Thus, we estimate the patent's price by the following equation for each patent i :

$$\log(\mathrm{Price}_i) = \varphi_0 + \varphi_1 \mathrm{Quality_i} + \varphi_2 \mathrm{Age_i} + \varphi_3 \mathrm{Age_i^2} + \varphi_4 \mathrm{RD_i} + \varphi_5 \mathrm{LIT_i} + \varphi_6(\mathrm{US_i} * \log(\mathrm{EUS_i})) + \varphi_7(\mathrm{EP_i} * \log(\mathrm{EEP_i})) + \varphi_8(\mathrm{WO_i} * \log(\mathrm{EWO_i})) + (\varphi_{9j} * \mathrm{IPC_{ij}}) + \rho_i \quad [2]$$

Where $log(\ Price_i\ )$ is the dependent variable which represents the sale price at the current year of the estimation per the patent i measured with an OLS regression. The model includes all relevant variables in the equation, as $Quality_i$ measured by the quality index. RD_i ratio which measured the cost if innovate a prioner innovation. Age_i , is the patent' age at the time of the transaction. LIT_i is a dummy variable which indicates if the patent has been sued. We also introduced dummies variables IPC_{ij} . [10] to identify the different patent technologies ($j\{\ 1,...18\ \}$). Moreover, we identify three regions where the patent was extended with dummy variables, we analyzed the American, European and International extensions (US_i, EP_i and WO_i) which one take the value 1 if the extension has been done and zero otherwise, Each dummy multiplies respectively with the cost of obtaining patent and the cumulative cost of maintenance, until the sale year respectively ($log(\ EUS_i\ )$, $log(EEP_i\ )$ and $log(\ EWO_i\ )$).

In addition, test *H2* by determining if $\varphi_1 > 0$. The result will measured the impact of the quality on the price model.

3.2 Variables description

3.2.1 Variables of the "technological data-set"

Annex-A Table -5 explains the descriptive statistics of the variables. The results indicate that some variables are very heterogeneous and asymmetric.

Grant date: is the day when the patent information becomes public. Each patent document includes the day when the Patent Office granted the intellectual property right to the inventor, which takes on average about 2 years from the patent's application's submission. From that day competitors can benchmark the technological trends of companies allowing others to improve their innovations; this effect is common due to spillover information.

Claims: the most important characteristic of a patent, because the number of claims indicate the breadth of a patent in its technological field. Previous papers found a positive effect on the quality, indeed, patents essential to technological standards have more claims (Köhler, Blind and Thumm, 2010). This has also been positively associated with the private value of patents (Bessen 2008; Moore 2005).

[9] The results of the test are on Annex B, Table 8

[10] The eighteen IPC classes for the relevant technologies (j) on the ICT sector used in this paper are specified on Annex C

IPC: the technological code classification that each patent can be assigned by the patent examiners of the Patent Offices, the decision depends on the technical areas where the innovation can apply. Each patent is assigned to one class and many sub-classes. Nevertheless, there are cases where a patent can be assigned to more than one class.[11]

Effort:[12] the incentives for companies to engage in their inventive activity. The variable is calculated as the number of inventors working on the innovation (patented) divided over the time taken to complete the investigation. We assume that the investigation lasts from the time the start[13] of research is declared to the day when the information of the innovation is filed at the patent office (application year minus the earliest priority year)

Number of Extensions (PEXT [14]): The number of patent offices in which the patent is filed to have the right of protection, also known as "family". The decision of the geographical scope of the invention depends on the inventor's strategy because each extension involves a fee, transaction, maintenance and legal cost, but companies are more likely to pay higher fees to protect the valuable inventions in more than one jurisdiction (Harhoff et al.,2003). We assume that the quality of a patent is greater if the time spent to obtain extensions is short, therefore the variable is computed by dividing the number of extension that each patent has over the age of the patent.

Backward citation: The inventor of the innovative idea must cite all related prior patents in the application. There are two types of citations in patent documents, citation to other patents ($BCIT$) and citation to non-patent literature ($BNCIT$)[15].

Both allow for study of the innovation's novelty. When there is a lack of prior citation, it is more probable that incited influences are discovered, rendering a patent invalid (Allison and Tiller 2003). A high number of backward patent citations per claim is indicative of technologies in well-developed areas (Lanjouw and Schankerman 1999, 2002). Nevertheless, empirical studies have found a positive

---

[11] We constructed a variable $ClaimIPC_i$ it by mixing the two indicators, based on the assumption that the ratio will tell as how the patent is protected by technological type. We used the following formula:

$$\mathrm{ClaimIPC_i} = \frac{\mathrm{Claim_i}}{\mathrm{IPC_i}}$$

Where, $ClaimIPC_i$ it is the relative deviation in number of claims of application i, $Claim_i$ it is the number of claims contained in the patent´s application i .and IPC_i is the number of classification assigned to the patent i .

[12] The formula to estimate the innovation effort is the following:

$$\mathrm{Effor_i} = \frac{\#\mathrm{inventor_i}}{(APP_{year\,i} - Epriority_{yeari})}$$

[13] The filing date is the date when a patent application is first filed at a patent office. The priority date, sometimes called the "effective filing date", is the date used to establish the novelty and/or obviousness of a particular invention relative to another art.

[14] The formula to estimate the extension index for patent *i* at the year *t* is the following:

$$\mathrm{PEXT} = \frac{\#\mathrm{ext_{it}}}{\mathrm{Age_{it}}}$$

[15] citations non-patent are citation from the academic and trade journals, company publications, government reports, software documentation. The OECD Patent Statistics Manual (2009) states that "[the more scientific references are found in patents, the closer the technology is considered to be to basic research]"

association between the number of prior references in a patent and its economic value (Moore 2005; Harhoff et al. 2003).

The coefficients of the variables are not directly comparable, due to the over dispersion of distribution. We thus normalized both indicators separately by dividing the number of citations included in a patent over the average number of citations of a patent belonging to the same grant year (Y=1996,…,2015) and technology classification $(j = 1, \dots \dots . J)$ by the formulas [3] and [4]

$$NBCIT_{ijy} = \frac{BCIT_{ij}}{\Delta BNCIT_{ijy}} \qquad [3]$$

$$NBNCIT_{ijy} = \frac{NBNCIT_{ij}}{\Delta BNCIT_{ijy}} \qquad [4]$$

Forward citation : are the number of times that one patent is cited by later patents. Previous research suggests that on average each additional citation reflects the economic value of inventions and increases patent quality (Trajtenberg, 1990; Hall, et al., 2005; Harhoff et al., 2003). Thus, forward citations are another positive measure of patent quality (Trajtenberg 1990). Nevertheless, the citation variable has "truncation" issues caused by the significant changes over time in the rate of patenting and in the number of citations received. The extent of the truncation problem can be clearly seen in figure 2. The distribution of citations lag for the years 1996 to 2015 of the average citation that a patent receives by year.

Figure-2 Average forward citation

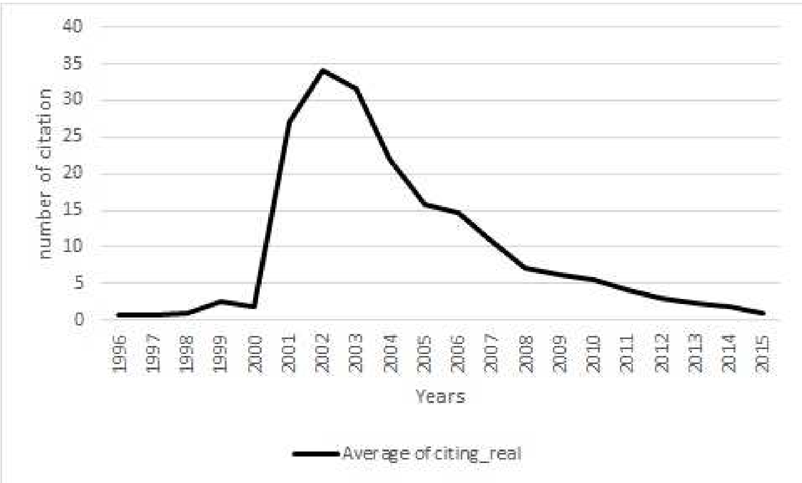


Figure 2 shows that the number of citations received for patent granted until 2000 remained roughly constant; notice the steep rise in the number of citations in 2000 with an average of about 2 citations per patent to over 48 citations in 2001 (a year later). This increase is partly due to the fact that from 1990 novel studies show that the value and quality of the patent increased with the number of citations, influenced by the notion that: *"if citations keep coming, it must be that the innovation originating in the cited patent had indeed proven to be valuable"* (Trajtenberg 1990). Then the prior inventions cited in new patents tend to be the relatively important precursors that best define the state of the art (Harhoff, Narin, Scherer, and Vopel 1999), so companies started to increase the value of their patents due to the improved citation rate. Another reason is that between 1997 and 2000, the World International Property Organization (WIPO) as the Patent Offices started to digitized and make more information public available on their web-pages. Likewise, access to information was easier because of the "internet boom", so the patent examiners and inventors were able to find potential references much more easily.

Beyond that, we cannot tell the extent to which some of the rise until 2004 may be "real" or artificial which reflects the companies' strategy to show that their intangible assets more valuable.

Later on, that strategy changed when litigation on patents started to increase primarily on patents of the ITC sector. Studies asserted that litigated patents on an average tended to have more forward citation than un-litigated ones (Breitzman & Mogee, 2002), so companies failed to cite patents to reduce the likelihood of being sued, since the probability of legal challenges to a particular patent is influenced by its position in the citation network apart from its characteristics. In our data-set the decline in the number of citations received from 2004 until recent years is due to this effect.

We believe that the changes in the number of citations received per patent is a pure effect of companies' strategies and the differences in the citation criteria in the Patent Office across time and across technological areas. So, in order to reduce the truncation issue, we infer the nature of these effects by constructing citation-year impact, where we assume that we quantify the changes in citation intensity by applying the fixed effect model. The model is write as:

$$CIT9615_{\mathrm{kt}} = \gamma_0 + \gamma_1 \mathrm{CIT}_{\mathrm{kt}} + \gamma_2 \mathrm{D}_{\mathrm{kt}} + \gamma_3 (\mathrm{CIT}_{\mathrm{kt}} * \mathrm{D}_{\mathrm{kt}}) + \varepsilon_{\mathrm{k}} \quad [5]$$

To implement this approach, we model this citation strategy effect as a function of citing year effect. In the analysis, we do not take into account the number of self-citing that each company does, because we assume that self-citing introduces error to the model. Let $CIT9615_{kt}$ be the total number of citation that each granted patent (*K=1……,N*) received until 2015, let CIT_{kt} be the total number of citation that patent *K* receive in year *(t=1996, …… T*) and dummies variables D_{kt}. This variable takes value 1 whenever the patent K takes a citation in year t and zero otherwise.

We found the problem of over dispersion in the variable $CIT9615_{kt}$. In order to deal with the problem, we assume the negative binomial distribution where we allowed the variance to exceed the mean. In the estimation, the parameter γ_3 will captures the citing effect which varies by year. We estimate separate γ_3 controlling year by year. The results are shown in Annex-D Table-10 which shows that citing year effect[16]

increases from 1996 to 2014 and all the coefficients are significant ($p - value < 0.01$). In column 1 we present the citing effect for the full mode, whether there is only patent with a life utility of 20 years.

We found an increasing effect on the citation base on the companies' strategy. From 1996 to 2000 the citing effect is almost constant, which can represent the citation criteria of the Patent Offices, where the companies impact is less important. From 2000 to 2004, the citing effect has a rough increase, as a peak. Our estimates explain the strategic change of companies once they start to cite each other in order to monetize the intangible assets. After 2005 while the number of citations on a patent decreased, the citing effect has an unexpected increase, this result explains that having a citation in recent years has a more significant effect on the patent than in the past. In other words, having a citation from 2014 will increase the total effect by 20% while a citation from 1997 has an effect of 5%. In fact, currently companies cite only the most relevant patent base on strategy, even when they have the risk of litigation.

Furthermore, by applying the formula we capture all the citing effect in a variable ($CitingEffect_i$) to see how the effect can affect the quality.

[16] In Annex-D, we also provide the graphs of the citing effect on the number of citing per patent.

3.2.2 Variables of the "Transaction data-set"

Annex-A Table -6 shows the descriptive statistics of the variables which are describe next:

Age: The total number of years that the patent has been active is vital. The variable is calculated by subtracting the year of the transaction minus the year that the patent was granted.

Cost of patenting and the annual Fee: ($log(EUS_i)$, $log(EEP_i)$ and $log(EWO_i)$ the total amount that a patent holder has to spend to obtain and maintain its patent during its life utility. To estimate the cost, we analyzed the patenting process and fee structure, across the patent offices (USPTO, EPO, WIPO)[17] , taking into account that each patent office has its own fee structure. Nevertheless, we assume that all the offices charge the fees in three steps[18]. Table 1 summarizes the type of fee per Patent Office. Each one implies a specific fee and a particular timing since the three offices rely on claim base fees: Entry cost (short term cost on the process which includes the fees of filing, search and examination of the patent), granting cost (fee paid by applicant in order to have a patent granted) and maintenance fees (annual fee that each patent must pay in order to keep the patent valid. So, the computation of the fee is based on the age of the patent).

Table-1. Summarize of the patenting fees

Extension region	Patent Office	Entry cost	Granting Cost	Maintenance fees
EP (European Union)	EPO	Filling fees*	Grant Fees	Year Tax*
		Search fees		
		Examination fees		
US (United States)	USPTO	Filling fees*	Grant Fees	Year Tax*
WO (International)	WIPO - PCT''	Filling fees*		

* indicates when claim-based fees have to be paid; PCT: The Patent Cooperation Treaty is an international patent

The computation of the total cost of patenting and annual fee is made by the region covered by the patent system.

R&D costs: the total amount of money than the inventor spend per innovation on the development process. This information is private, firms are not willing to publish the R&D costs by innovation, so in our case is an unknown variable. Nevertheless, we solve this issue by creating a ratio from the R&D cost innovation function [6], based on the strategy that most of the companies follow when they tried to innovate and replace any existing incumbents. Therefore, when a company is investing in the R&D, it may invest in two types of innovation: *Pioneer innovation* (who start a new technology) and the *follow-on innovation* (when inventors build and improve an existing technology). However, each new innovation utilizes the spillover from previous patents from the same technology class (IPC), in fact, it has to cited the previous patent to acknowledge that the patents are technologically related. So we will

[17] USPTO- United Stated Patent and Trademark Office (http://www.uspto.gov/); EPO-European Patent Office (https://www.epo.org/index.html); WIPO- World International Patent Office (www.wipo.int)

[18] The first step consists of the filing of a patent, which includes a filing fee and a search fee. When the search for prior art is performed and the search report published (in general 18 months after the priority date), it is followed by the examination fees if a request for substantive examination is filed. Then, if the patent is granted, the assignee must pay granting and publication fees

define the cost of R&D based on the citations of previous patents which was defined by Hamilton-Jacobi-Bellman (HJB)[19] as on the follow equation.

$$RD_i = Z_{ij} \rho Q_t \overline{ZC_{ijt}} \qquad [6]$$

The expression says that the R&D cost depend on four variables: Z_{ij} individual innovation rate, $\overline{ZC_{ij}}$ competitors trying to innovate in the same product line (IPC technology), Q_t Productivity index and ρ the estimate cost parameter. We calculate each variable by the intuition of the productive innovation model of Abrams, Akcigit and Popadak, where we assume that a pioneer innovation is costlier than a follow-on.

Individual innovation rate: we compute the variable per patent (i) by dividing 1 over the number of self-citations that the patent receives belonging to the same technology classification ($j = \{1,\ldots..J\}$). at the

$$Z_{jit} = \frac{1}{1+\text{BSelfC}_{it}} \qquad [7]$$

Competitor's rate: the outside entrepreneurs innovating in the same technological line. The variable is calculated by the sum of the division of one over the number of citations (backward citation and forward citation) by other companies belonging to the same technology classification by the formula:

$$\overline{ZC_{ijt}} = \frac{1}{\text{Back}_{\text{citing}}\, Z_{\text{ijt}}} + \frac{1}{\text{Fow}_{\text{citing}}\, Z_{\text{ijt}}} \qquad [8]$$

Productivity index: Abrams, Akcigit and Popadak[20] proposed in their paper the model based on labor and the innovation type[21] for the static production. [22] on the cournot competition between the new monopolist and the previous incumbent:

$$Q_t = \int \frac{1}{1+n_j} d_j * exp^{\int ln\,(\frac{q_{it}}{1+n_j})d_t} \qquad [9]$$

According to this, the R&D production depends on two variables, q_i t the number of inventors working on the innovation and n_i a dummy variable which takes value 0 if the innovation is the pioneer type and 1 if is the follow-on.

[19] The function gives the minimum cost for a given dynamical system with an associated cost function. Where during a small Δt, the innovation in a cluster delivers a monopolist profit until a new follow-on entry appears.

[20] More detail information, in the Paper: Patent Value and Citations: Creative Destruction or Strategic Disruption?. (http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2351809).

[21] Innovation is produced in a perfectly competitive market whether each one is produced by a monopolist who owns the latest patent. The monopolist production function is defining by the formula $y_{it} = q_{it} * l_{it}$. whether l it represent the labor employed in the R&D process and q it the labor productivity. The paper assumes that the marginal cost of producing 1 innovation is $M_i = \frac{w_t}{q_{it}}$, where the w_t is the market wage rate.

[22] They solved the static production assuming that the final innovation has a Cobb-Douglas form, whether the demand for each innovation i is: $y_{it} = \frac{Y_{it}}{P_{it}}$; where p it is the monopolist price in a beltrand competition between the monopolist and the incumbent ($p_{it} = M_i$). Therefore, they normalized the expressed the equilibrium profit of $\pi(q_{it}) = [\,P_{it} - M_{it}\,] * y_{it}$ by adding the assumption that $Y_t = Q_t$.

Litigation: (LIT_{it}) Over the years the number of lawsuits between patent holders increases, especially in the ICT sector. Concerning this effect, previous studies suggested that the patent values increase, and the number of patent sales increase as the result of growing litigation, so many believe the only effective way of monetizing a patent is through litigation. We characterized the patents which were litigated with a dummy variable which takes value 1 whenever the patent i was involved in a patent lawsuit and zero otherwise.

4 Result

The results of the latent variable regression analysis to test H1 appear in table 3. Therefore, the results of the OLS paten's price model to test H2 are in the table 4.

4.1 Patent's quality latent model

The aim of this part is to estimate the unobserved characteristic denoted as the "quality" of the patent by constructing a latent variable which combined influences of common factors. We identify factors which combined the most correlated[23] between our observed variables. The following table summarizes the loading for each factor.

Table-2. Factor analysis: The total variance Explain of the rotated factors

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor-1	1.895	0.209	0.271	0.271
Factor-2	1.686	0.611	0.241	0.512
Factor-3	1.075	0.105	0.154	0.665*

*display the 66.5 percent of the total variance could be explain at three stages for factors affecting the quality of the patents

Variable	Factor-1	Factor-2	Factor-3	Uniqueness
Forward_citation	0.909			0.170
Citing Effect	0.913			0.161
Claims_IPC	0.556		0.500	0.772
Extension		0.586	0.511	0.599
Effort			0.860	0.256
Back_citation_Nopatentt		0.899		0.191
Back_citation_paten		0.894		0.196

From our result, we highlight the presence of three factors. Each one quantifies the quality by stages. Therefore, the first factor explains the influence of the *posteriori patent's quality*. Meanwhile, the second and third factors may give us the idea of a *priori patent's quality*, because they quantify the intrinsic characteristics of the patent at the time of its application along with the patenting strategy of the company in the priority period.

The first factor explains the *"quality of impact"* and it is mainly linked to the later technological impact of the patent on competitors (the post innovation), because the significant loading are on the forward

[23] Annex B Table 7 contains the correlation matrix of the variables

citation, the citation effect and the IPC indicators. A plausible interpretation would be that this factor measures the incremental innovations, by showing the marginal contribution of the innovation on the market since innovations come in technology clusters and each new innovation utilizes the spillover from the previous patents from the same technology class.

The second factor is mainly correlated with the extensions, backward patent citation and backward non-patent citation indicators. The factor explains the *"quality of the knowledge"* that was used on the research process (previous to obtaining the patent). Indeed, the patent holder has to invest a lot of time in the patent refinement, because they have to discriminate in complex technologies between patents, screening out low quality patents.

Our last factor has significant influence on the effort, IPC type and number of claims indicators, which represent the companies' protection strategy. The factor will measure *"quality of the utility"* by giving information about the technological applicability that each patent has based on the level of labor that an innovation requires and the level inventiveness.

We estimate the quality latent variable based on the equation [1]. The Table-3 summarizes the loading for the reflective model of patent quality by the SEM estimator and t-values. The loading and weights reveal the relationship between the variables and latent variables, where all are significant at 0.01 level. The finding is completely different from previous studies where they only considered the case of two observed variables per latent variables which combination produced good estimation (Chin et al.). However, in our model the magnitude of the weights are large enough to infer that there may be a formative relationship between indicators and factors.

The results show that the patent's quality is positive associated with the *quality of impact* and the *quality of knowledge* ($\beta 1 = 0.111, p < 0.01$ and $\beta 2 = 1.042, p < 0.01$) , but with a decrease relationship with *quality of utility* ($\beta 3 = -0.323, p < 0.01$). The results suggest that the patent's quality can be estimated since the patent has been granted, because the estimation takes into account the patenting strategy of a company and the characteristics of the patent at the time of filing the patent's application, but the quality index can change during its life utility which means that the variation over the years of the number of citations and the number of extensions will have a positive effect on the quality. Perhaps these variables are more related to the quality of the invention because of its importance on the impact that given technology is having. Companies can assess the importance of their inventions and use this as a tool for improving the strategy of developing new products and inventions. Furthermore, this result suggests that the effort has a negative impact on the quality, meaning that an innovation in the ICT sector which implies a longer period of research, development and patent persecution made by a large number of innovators will reduce the quality of the patent.

The determination coefficient for patent quality is 0.83 so the model fit the data is acceptable taking into account the literature review and the exactitude of fit obtained in the analysis of patent data in the model. In Annex-B we attach the model's fit test. Nevertheless, the magnitude of the relationship of the latent variables and the indicators is the following:

The coefficient of the number of claims and IPC has a positive and significant direct effect on the patent's quality index. The patent the quality will increase by the 35 percent for every extra claim. Also, the largest coefficient on the quality of impact show the patent's holders worked taking care the most valuable innovation by delineating his property rights in crowded technological areas, where the potential infringement and probability of being sued by other competing innovators is particularly likely.

While the negative coefficient on the quality of utility explain that having large number of claims could increase the probability to been suit by competitors.

Table-3. Standardized loadings and weights for the model of the patent quality

Construct	Indicator	General model
Quality_patent	Q_I	0.11170*** (0.2536)
	Q_K	1.04261*** (0.0276)
	Q_U	-0.32321*** (0.0880)
Q_I	Claims_IPC	1.05941*** (0.0060)
	Forward_citation	0.11202*** (0.0087)
	Citing Effect	0.11616*** (0.0085)
Q_K	Back_citation_patent	0.17992*** (0.0100)
	Back_citation_Nopatent	0.12749*** (0.0093)
	Extension	0.62235*** (0.0097)
Q_U	Effort	0.43966*** (0.0092)
	Extension	0.18253*** (0.0206)
	Claims_IPC	-0.73979*** (0.0099)

P-values based on robust standard errors in parentheses. * p<10%; **p < 5%; *** p < 1%

The number of backward citations to other patents and literature appears as a significant indicator to the quality of knowledge. Moreover, the quality will increase by 11 percent and 12 percent, respectively. The finding shows that a patent increases its quality if they are citing more to others, this result suggests a change in the current citing behavior of companies. On the other hand, the forward citation and the citation effect are significant but both have a small effect on the patent quality (1.4 percent each). If we compare our results with previous studies where they found that the quality of patents increases when these patents receive one additional citation, then the firm's market value would increase by 4 percent (Lanjouw and Schankerman, 2004). We are still maintaining the positive increase by citation on patent quality, but now we take into account that the variable is less informative than in the past.

In addition, the number of extensions will increase the most the quality index. So for every extension that the patent holder has, the patent quality will increase its quality by 59 percent. This result is based on its positive effect with the quality of impact and the quality of knowledge. Our result contradicts the previous literature, where they found that the extension is less important than forward citations or claims and is directly related to the expected (private) value of protecting an innovation than the quality. (Lanjouw O, 1999). We proved that it is more relevant for a patent to have been extended than to have been cited. Indeed, firms in the ICT sector, besides protecting the invention in the local country are more likely to patent the most valuable innovations abroad, in order to expand the barriers to prevent the entry of others and to increase profit by implementing their technology (either by introducing a product or licensing the patent).

To summarize, we found that there is a substantial information gain when we used multiple indicators to measure the quality of an innovation. Moreover, these empirical results also appear consistent with *H1.*. Nevertheless, we prove that using public information we can measure the technological quality of an innovation, eliminating the asymmetric uncertainty about the quality of the innovation. In the next section, we will look at the price of the quality.

4.2 Estimation of the patent's price

To estimate the patent's price based on its quality, we regress the econometric model [2]. We used the translog functional form, with the variables in monetary units, both the dependent variable and independent variables specified in natural logs. Table-4 presents the results focused on the heterogeneity of patent characteristics. In column 1 we present the simple model, which indicates price of the patent base on its quality, age and the total innovation cost. In column 2, the cost of the extension activity is proxies by the dummy variables (US_i , EP_i and WO_i). In column 3, overall technological activity is separated into the most relevant technology categories in which most firm work in the ICT sector[24] : as the Transmission, Voice application, Internet, Applications, Computer, Data process, Broadcasting, Digital transmission and Wireless, etc.

Results presented in Table -4 offer an informative picture on how the patent's quality, the R&D and Extension cost matter on the patent's price. Indeed, their coefficients are positive and highly significant across all the models, while an unexpected result has been shown on the patent age, which is significant but affects the price negatively. Nevertheless, the model also suggests a lack of importance for overall the litigious activity on the patent's price.

We measure if the price for a given patent is age-related[25]. The results show the negative effect on the patent's price. The negative coefficient explains that every year it's price will decrease by 0.5 percent which may reflect the depreciation of the patent over a technology.

The quality coefficient allows us to prove the main second hypothesis assumption (*H2*), whether the quality can drive the price of a patent up. We found on column 1 that 17 percent of the patent's price is explain by its quality. Therefore, if we compare two patents with similar market characteristics but different quality index (one higher than the other), the patent's price will be 17 percent higher for the

[24] The IPC classes for the relevant technologies on the ICT sector are listed at the Annex C

[25] The age-related is measure by derivative the formula as: $\frac{\partial Price}{\partial age} = \varphi_2 + 2\varphi_3\, Age_{it}$. The equation gives us the turning point of the relationship reflecting an inverse U-shape

patent with higher quality. While in column 2 and 3 when we add more characteristics on the model the impact is reduced to 15 percent and 12 percent respectively, however, the results have still been significant. Indeed, a deeper interpretation is when we analyzed how the changes in patents characteristics affect the price. Regarding with the number of citation, every time that a patent received one additional citation its sell price will increase by 0.9 percent. Nevertheless, from the Priori of art, an extra claim will increase the patent sell price by 4.5 percent while the price reduces by 3.6 percent in the event that the Patent Office determined that innovation belongs to more than one IPC classification.

On the other hand, the coefficient of the R&D's cost explains that the price of a pioneer innovation will be 4,5 percent higher than a follow-on innovation, we were expecting this results due to the researching cost of successive innovation tend to be always less. If we take into account the number of extension and its direct effect on the quality, we found that patent which have an additional extension will increase its sell price by 10 percent, in that case, the total extension's cost, will only increase the price by 1 percent. Separating the extension by region in column 2, we found that the patents price increases by 1.4 percent when the patent has an international extension and by 2.6 percent when it has an extension into United States, while having an extension in Europe has a negative effect and reduces the price in 2.7 percent.

This result is baffling, and it is possible that the variables are affected by the fact that most of the transactions in our data-set were from American patents.

In column 3 we analyzed how the patents price is affected by the technology type, so we introduce the individual indicators for the technological patent classification (IPC number). Each classification affects the price differently- The technologies which have a positive effect on the patent price are: the mobile application, innovation base on global positioning, back innovation as the electronic payment, broadcasting communication, etc. For instance, the patent price will increase by 1.3 percent for mobile application patent. 1.1 percent for cellphone patents, while for broadcast technology the patent increases the price by 15.9 percent. Nevertheless, we analyzed the sell price for patents belonging to the same emerging technologies. For example, in the Big Data technology, the sell price of a patents used for the data processing are 3 times higher than the patent price of the algorithms.

Table-4. Standardized loadings and weights for the model of the patent quality

Dependent variable:	Simple model	Region Extension	Technology class
Log(Patent's Price)	(1)	(2)	(3)
_cons	13.2713*** (0.0321)	13.0061*** (0.0603)	12.9710*** (0.0553)
Quality	0.1581*** (0.0133)	0.1431*** (0.0137)	0.1137*** (0.0124)
Lit	-0.0071 (0.0079)	-0.0072 (0.0079)	0.0077 (0.0076)
Age	-0.0040*** (0.0001)	-0.0052*** (0.0012)	-0.0024*** (0.0003)
Age_squared	0.00003 (0.0001)	0.00001 (0.0001)	-0.00002 (0.0001)
R&D	0.0438*** (0.0042)	0.0449*** (0.0042)	0.0345*** (0.0040)
log(ext_cost)	0.0089** (0.0006)	0.0344*** (0.0062)	0.0117** (0.0031)
US		0.0261** (0.0128)	
WO		0.0135* (0.0072)	
EP		-0.0277* (0.0147)	
cellphone			0.0110*** (0.0029)
Intelecom			0.0378*** (0.0028)
App			0.0153** (0.0056)
Trans_dig			-0.0021 (0.0022)
Data_proces			0.0322*** (0.0096)
Games			-0.0141 (0.0505)
BigData			-0.0158** (0.0072)
M2M IoT			-0.0095 (0.0123)
Broadc			0.1474*** (0.0092)
Wireless			-0.0031 (0.0030)
imag_Proc			-0.0295 (0.0253)
Network			-0.0080*** (0.0134)
Recogn_data			-0.0140** (0.014)
N	6777	6777	6777
R 2	0.551	0.591	0.477

P-values based on robust standard errors in parentheses. *p < 10%; ** p < 5% and ***p<1%

5 Conclusion

Using two types of database, we estimate the sell patent's price base on its technological quality; we analyzed the patent characteristics over the last 20 years (from1996 to 2015) for the ICT sector. The patent's quality index model is estimated by using a sample of 61,735 patents from the patent portfolios of the top 50 largest firms in the ICT sector. And the patent's price is estimated base on the current market place using a sample of 6675 transacted patents over the last 4 years also from the ICT sector.

Our study offers four lessons. First, our research shows that we can eliminate the asymmetric information and adverse selection problems of the quality on the patent´s transactions (between buyers and sellers) by using public information from patents documents. Beside this, we show that patent's quality is strongly associated with the sell price patent in the innovation market. Second, we found a result which contradicts the knowledge in the patents and quality literature. We show that the composite quality index is significant related to the utility of the patent in the market and its impact on the follow-on innovation, where the number of extension of the patent is more relevant than the number of forward citations. This happened because the changes on the cite strategies, where firms try to cite other less in order to reduce the risk of been sued. In fact, the number of forward citation is less informative than in the past. This is an important consideration for scholars who wants to investigate the relation between citation and patenting. Third, in the ICT sector there is a strong evidence of the huge incentive that patent holders have in terms of increase the patent´s price when the patent is in the American market. Thus, in the short run, it is very likely to increase the probability to sell a patent to a higher price, rather than, others countries. Finally, when we analyzed the price for each the patent's technological type. We found that innovation belonging to technologies, in which the relevant patents tend to be essential. The sell price will be higher than the patents for applications. Nevertheless, when we analyzed the emerging innovation, we showed that the sale price will depend on the utility of the patent, that means, patent which can be apply in more than one technology will be more value.

Due to the lack of information on the Patent System, this study had some limitations. The information obtained for the Transaction Data-set did not allow us to construct a panel data; because, we only had information for four years (2012-2015) from three patent brokers. Besides, not every variable was available. So, we match assignee names and the transaction year with different source (The Thompson Reuter Database). Since we needed both of those variables, we had to drop any observation missing.

The results have important policy implication for the entire Patent System. It is necessary the support the information transparency between players, this will reduce the market failures on the innovation market. Currently the European Commission through the CIFRA project[26]. is trying to promote more effective and efficient collaboration in the innovation. Perhaps, the Patent System also needs to reform a new regulation regarding transaction price. By the implementation of the single price model for patents.

[26] CIFRA analyses and characterize issues in current patent ecosystem in the ICT sector with practical solutions that could make this patent system to be more aligned with the concepts of a Responsible Research and Innovation. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731940

References

[1] Allison J. Tiller E. (2003) The Business Method Patent Myth. Berkeley Technology Law Journal. 18(4):987-1084.

[2] Allison J., Mann, R (2007) The Disputed Quality of Software Patents. Washington University Law Review 85(2).

[3] Arora A., Fosfuri A., Gambardella A.(2001) Specialized Technology suppliers, international spillovers and investments: evidence from the chemical industry, in Markets for Technology -Journal of Development Economics 65(1): 31–54.

[4] Arora A., Fosfuri A.,(2003) Licensing the Market for Technology. - Journal of Economic Behavior & Organization. 52(2):277–295.

[5] Breitzman Anthony and Mary Ellen Mogee (2002) The Many Applications of Patent Analysis - Journal of Information Science 28(3):187-206.

[6] Bessen, J. (2007) Estimates of firms' patent rents from firm market value - Boston Univ. School of Law Working Paper No. 06-14.

[7] Gans, Joshua S., and Scott Stern. (2010). "Is There a Market for Ideas?" Industrial and Corporate Change 19(3): 805– 837.

[8] Hagiu A., Yoffie D.. (2013). The New Patent Intermediaries: Platforms, Defensive Aggregators, and Super-Aggregators. Journal of Economic Perspectives 27(1):45-66.

[9] Hall, B.H. (2002) The financing of research and development - National Bureau Of Economic Research; Working Paper 8773.

[10] Hall B.H., Jafee A., Trajtenberg M., (2005) Market Value and Patent Citations - RAND Journal of Economics. 36(1):16–38.

[11] Hall. B, Thoma G., Torrini S., (2007) The market value of patents and R&D: Evidence from European firms. NBER Working Paper No. 13426.

[12] Harhoff, D., Scherer, F.M., Vopel, K., (2003). Exploring the tail of the patent value distribution. Grandstrand, O. (Ed.), The 1291 Economics of the Patent System, in press.

[13] Kohler F., Blind K. and Thumm N. (2009), Keep 'Em In, Make 'Em Fit : An Analysis of Patent Filing Behaviour for Essential Patents in Standards, Working Paper.

[14] Lanjouw J.O.(1998) Patent protection in the shadow of infringement: simulation estimations of patent value - Review of Economic Studies 65(4):671-710.

[15] Lanjouw, J.O, Schankerman,M.(1999) The quality of ideas Measuring innovation with multiple indicators - NBER Working Paper No. 7345 .

[16] Lanjouw J.O., Schankerman M. (2004). Patent quality and research productivity: measuring innovation with multiple indicator - The Economic Journal . 114(95): 441–465.

[17] Moore, Kimberly A. (2005) Worthless Patents - Berkeley Technology Law Journal 20(4) .

[18] Pakes, Ariel and Margaret Simpson.(1991) The Analysis of Patent Renewal Data - Brookings Papers on Economic Activity, Microeconomic Annual.

[19] Schankerman M. (1998) How valuable is patent protection: estimates by technology field - The RAND Journal of Economics. 29(1): 77-107.

[20] Serrano C. J.(2005) The Market for Intellectual Property: Evidence from the Transfer of Patents - University of Toronto and NBER .

[21] Serrano, CJ. (2010) The dynamics of the transfer and renewal of patents. Rand Journal of Economics. Forthcoming 41(4): 686-708.

[22] Shane, S., D. Cable. (2002) Network ties, reputation, and the financing of new ventures. Management Science 48(3) 364-381.

[23] Trajtenberg M. (1990) A Penny for Your Quotes: Patent Citations and the Value of Innovations. The RAND Journal of Economics. 21(1):172-187.

[24] Trajtenberg M, Jaffe. A (1999) International Knowledge Flows: Evidence From Patent Citations. Economics of Innovation and New Technology 8(2):105-136.

[25] Trajtenberg M, Jaffe. A, Fogarty S. (2000) The Meaning of Patent Citations: Report on the NBER/Case-Western Reserve Survey of Patentees. NBER Working Paper No. 7631.

[26] Trappey JC., Charles V., C-YiWu and Chi-Wei Lin (2011) A patent quality analysis for innovative technology and product development. Advanced Engineering Informatics 26 26–34.

[27] Rogers M. (1998) The definition and measurement of innovation. Melbourne Institute of Applied Economics and Social Research; Working Paper 1328-4991.

[28] Van Zeebroeck N. (2011) The puzzle of patent value indicators. Economics of Innovation and New Technology 20 (1), 33-62.

ANNEX - A: Variables Statistical Description

Table-5 Statistical description - Technological dataset

Variable	Obs	Mean	Std. Dev.	Min	Max
Forward_citation	61733	8.299	28.248	0.000	994.000
Citing Effect	61733	1.066	2.414	-0.006	45.744
Claims_IPC	61733	7.324	8.209	0.000	191.000
Extension	61733	0.457	0.585	0.050	6.000
Effort	61733	0.480	0.757	0.000	16.000
Back_citation_Nopatentt	61733	1.000	2.099	0.000	47.624
Back_citation_paten	61733	1.000	2.965	0.000	115.029

Table-6 Statistical description -Transactional dataset

Variable	Obs	Mean	Std. Dev.	Min	Max
Age	6777	12.195	4.525	0	25
Age_squared	6777	169.203	103.357	0	625
RD	6777	0.153	1.165	0	30.039
US	6777	0.950	.2173	0	1
EP	6777	0.050	.2186	0	1
WO	6777	0.032	.1772	0	1
log_ExtWO	220	7.364	0.555	6.851	8.625
log_ExtEP	341	10.732	1.213	8.546	12.677
log_ExtUS	6777	9.890	0.159	9.475	10.535
log_TotExt	6777	9.959	.3741559	9.475	12.74
Litigation	6777	.0205	0 .141	0	1

ANNEX - B Latent Patent Quality Variable

Table-7 Correlation matrix

Variable	**Citing** Effect	**Forward_** citation	**Claims_** IPC	**Extensio n**	**Effort**	**Back_citation** _Nopatent	**Back_** citation_paten
Citing Effect	1						
Forward_citation	0.7685	1					
Claims_IPC	0.1496	0.1189	1				
Extension	-0.1041	-0.1342	-0.088	1			
Effort	-0.0556	-0.0549	0.0469	0.1212	1		
Back_citation_Nopatentt	0.0945	0.057	0.0025	0.1159	-0.0169	1	
Back_citation_paten	0.0594	0.035	-0.0275	0.1228	-0.0244	0.6648	1

Table-8 Model fit for quality latent variable

Test	Model - figure2	Recommended level	References
R-square	0.806		
CFI	0.995	>0.97	Schumacker & Lomax (2004)
TLI	0.986	>0.95	Schumacker & Lomax (2004)
SRMR	0.011	<0.08	Hu & Bentler (1998)
RMSEA	0.033	<0.07	Hair et al. (2006)

CFI=Comparative Fit Index; TLI=Tucker-Lewis Index; SRMR=Standardized Root Mean Residual; RMAES= Root Mean Square Error of Approximation;

ANNEX C- Pricing the Patent's quality

Table-9 IPC classes for the relevant technologies on the ICT sector

Technology category	**IPC-class**
Transmission	H04B, H01Q, H01P, H04J, G01R
Switching	H04Q, H01H
Voice applications and equipment	H04M, H94R, G10L
Data and applications	G06F, H04L, G06N
Encrypting and security	H04K
Impedance Networks	H03H
Broadcast Communication	H04H
Wireless Communication Networks	H04W
Recognition of Data	G06K
Image Data Processing	G06T
Pictoral communication	H04N
Positioning	G01S
Games	A63F
Electronic payment	G07G
Mechanical technologies	B23K, B29C, G06N, H05K, H01B
Big data and algorithms	H03M, H03L
(M2M-IoT) Machine to Machine	G08C
Photography	G03B

ANNEX – D Citing Effect

In column 1 we present the citing effect for the full mode, there are only patent with a life utility of 20 years. Nevertheless, we also analyzed if younger patents are still having the same problem. In column 2 and column 3, we present the citing year effect for patents with less than 10 and 5 years of utility, respectively.

Table-10 IPC classes for the relevant technologies on the ICT sector

Variable: *Citting_effect*	Age=20 (1)	Age>10 (2)	Age>5 (3)
_cons	1.5949*** (0.0059)	2.6987** (0.0092)	0.6430*** (0.0103)
cit15	-0.0056 (0.0011)	0.0233** (0.0021)	0.0487** (0.0020)
cit14	0.2622** * (0.0179)	0.4598*** (0.0531)	0.2702*** (0.0168)
cit13	0.2200*** (0.0072)	0.4457*** (0.0228)	0.2298*** (0.0072)
cit12	0.1973*** (0.0050)	0.2822*** (0.0154)	0.2064*** (0.0055)
cit11	0.1491*** (0.0040)	0.2236*** (0.0118)	0.2060*** (0.0050)
cit10	0.1360*** (0.0037)	0.1854*** (0.0097)	0.2142*** (0.0061)
cit09	0.1019*** (0.0030)	0.1824*** (0.0080)	
cit08	0.1149*** ((0.0028)	0.1884*** (0.0064)	
cit07	0.1064*** (0.0026)	0.2043*** (0.0057)	
cit06	0.0849*** (0.0023)	0.2046*** (0.0050)	
cit05	0.0737*** (0.0022)	0.2541** (0.0044)	
cit04	0.0532*** (0.0019)		
cit03	0.0739*** (0.0019)		
cit02	0.0719*** (0.0019)		
cit01	0.0593***		
	(0.0019)		
cit00	0.0426*** (0.0019)		
cit99	0.0568*** (0.0026)		
cit98	0.0570*** (0.0033)		
N	45779	2511	2626
Pseudo R2	0.1530	0.1599	0.1854
alpha	0.6183	0.3233	0.3700

P-values based on robust standard errors in parentheses.*p<10%; **p < 5%; *** p < 1%