Paper to be presented at the DRUID Academy 2012

on

January 19-21
at
University of Cambridge /The Moeller Centre

The role of patents filed as signals for the IPO market: An empirical comparison for the U.S and the European software industry

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Abstract

There is a lack of empirical literature addressing the role of patents in small software firms (Cockburn and MacGarvie, 2009). This controversial topic in innovation economics is particularly underdeveloped, primarily due to the paucity of data (Mann, 2005; Mann and Sager, 2007) and because historically software industry had a weak patent protection (Bessen and Hunt, 2007). However, literature often claims that software firms can reap indirect benefits from the patent system through the information exposed during the patenting process which is usually called ?information spillovers? (Ziedonis, 2008). In this way, ?disclosure of information? about firm?s innovativeness could help firms to attract investors reducing problems of asymmetric information and reducing risky investments.

The purpose of this empirical study is to test whether patenting strategy impacts the way investors perceive the software firms? potential through a higher amount invested at the time of the Initial Public Offering (IPO). This study examines the patenting behavior of software start-ups and medium size firms (USSIC 737) prior to IPO in the U.S. and Europe. The role of software patent protection (patents with priority date) is tested as a way to improve the collected amount at IPO moment including controls for other factors that may influence IPO performance (Kim and Ritter, 1999; Ritter and Welch, 2002; Braw and Fawcett 2006). This study find significant and robust positive correlations between patenting behavior and the amount collected at IPO. The power of patents filed prior to IPO as a signal is strongly different between two different geographical areas.The data shows that (1) the number of patents filed has a positive impact on the amount levered at IPO for the U.S and European software companies. The relationship between the number of patents filed and the amount collected at IPO in the U.S seems to be more linear than in Europe. In contrast, (2) with a threshold of tree patents, the impact of the patent behavior as a signal seems to be stronger in Europe than in the U.S. The data analysis also shows that (3) there are also nonlinear relations between IPO performance, profitability and patents filing. Thus, the probability to be in the 50% of the software companies which raise more money at the IPO is stronger for the profitable companies that file more patents. (4) The support of traditional venture capitalist appears to be related to an increase in

the number of patents filed in average by the software firms prior to IPO.

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Jelcodes:O32,G20

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First draft (don't quote)

This version: January 2012

Abstract

The purpose of this empirical study is to test whether patenting strategy impacts the way investors perceive the software firms' potential through a higher amount invested at the time of the Initial Public Offering (IPO). This study examines the patenting behavior of software start-ups and medium size firms (USSIC 737) prior to IPO in the U.S. and Europe. The role of software patent protection (patents with priority date) is tested as a way to improve the collected amount at IPO moment including controls for other factors that may influence IPO performance (Kim and Ritter, 1999; Ritter and Welch, 2002; Braw and Fawcett 2006). This study find significant and robust positive correlations between patenting behavior and the amount collected at IPO. The power of patents filed prior to IPO as a signal is strongly different between two different geographical areas.The data shows that (1) the number of patents filed has a positive impact on the amount levered at IPO for the U.S and European software companies. The relationship between the number of patents filed and the amount collected at IPO in the U.S seems to be more linear than in Europe. In contrast, (2) with a threshold of tree patents, the impact of the patent behavior as a signal seems to be stronger in Europe than in the U.S. The data analysis also shows that (3) there are also nonlinear relations between IPO performance, profitability and patents filing. Thus, the probability to be in the 50% of the software companies which raise more money at the IPO is stronger for the profitable companies that file more patents. (4) The support of traditional venture capitalist appears to be related to an increase in the number of patents filed in average by the software firms prior to IPO.

Keywords: Software firms, Patents, Signals, Initial Public Offering (IPO), Venture Capital, Start-ups.

JEL classification: O34 intellectual property rights, O32 Management of Technological Innovation and R&D, G2 - Financial Institutions and Services

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1. Introduction

Patents have become particularly controversial in the software industry. There is an important debate about the effect of strengthening patents rights or expanding the scope of the patent system on entrepreneurship and firm performance. Additionally, in recent years there has been increased interest in the role of patents for small and medium size companies especially in high-tech sectors. Proponents argue that patents encourage R&D by granting an innovator a temporal monopoly. It is also argued that the licensing and sale of patents also contribute to the diffusion of technology (Arora, Fosfori and Gambardella, 2001). For small companies, the ability to license or send a patent is essential to maintain their innovation incentives and access to venture capital finance (Baum and Silverman, 2004).

Opponents argue that when research is sequential and builds upon previous discoveries, as in the software industry, the enhanced ability to enforce patents may impede rather than promote innovation. Critics also argue that any positive effect of stronger patents will be annulled by the higher transaction cost, multiplied threat of litigation allowed by several blocking patents (Jaffe and Lerner, 2004 ; Bessen and Meurer, 2008). Indeed, stronger patents may discourage subsequent research on valuable inventions which could be potentially infringing (Merges and Nelson, 1990; Scotchmer, 1991). Bessen and Hunt (2007) suggest that software patents are strategically used, especially by established firms to build “thickets” for anticompetitive reasons. Bessen and Hunt (2007) also found evidence that firms may be substituting software patents for R&D. Noel and Schankerman (2006) found that the market value of publicly traded software firms decreases when firm’s competitors held more patents. Additionally, the cost and frequency of litigation related with the recent spread of patents have raised concerns around the world.

This article aims to contribute to analyze of the role intellectual property in the software industry. There have been many empirical studies dealing with patenting in large companies especially in the U.S. The number of patents studies dealing with small companies is quite limited and particularly underdeveloped, primarily due to the paucity of data (Mann and Sager, 2007). Nevertheless, the global software industry is characterized by the presence of thousands of small companies contributing significantly with the innovation process and the creation of thousands of highly qualified jobs. Literature primary focuses on software patents and its implications on the industry dynamics but rare are the articles which deal with the role of patents in the software industry itself (Mann, 2005). This is probably because historically software industry had a weak patent protection (Bessen, 2003; Bessen and Hunt, 2007). Furthermore, there have no literature that makes a comparison of the role of patents in the software industry in different geographical spaces. Even more, there is a lack of literature addressing the role of patents in the European Software industry. A belief widely established is that European Software companies cannot use patents because computer programs “as such” are excluded from patentability in Article 52(3) of the EPC. However, recent literature clarified this “misconception” (Beresford, 2001) showing that a large number of inventions in this field have been patented through the EPO and through the national patent offices in Europe (Rentocchini, 2011).

The purpose of this empirical study is to test whether patenting strategy impacts the way investors perceive the firms’ potential through a higher amount invested at the time of the Initial Public Offering (IPO). This study examines the patenting behavior of software start-ups and medium size firms (USSIC 737) prior to IPO in the U.S. and Europe. The role of software patent protection (patents with priority date) is tested as a way to improve the collected amount at IPO moment including controls for other factors that may influence IPO performance (Kim and Ritter, 1999; Ritter and Welch, 2002; Braw and Fawcett 2006) This research paper collects all the IPO software’s deals from United-States, Germany, United-Kingdom, France, Sweden, Italy and Spain, from 1st January 2000 to 31st December 2009 in ZEPHIR database. These deals are matched one by one with patents filed (patents with priority date) from Qpad database to analyse IPO amounts collected by 476 software firms (242 from the U.S. and 260 from the EU) – including 52 U.S. firms and 47 EU firms with venture capital support. The information from databases is used to better understand the differences in the patent behavior of software firms and its implications in the amount raised at IPO.

The outline of this paper is as follows. Section 2 briefly reviews the role of patents as signals. The importance of the “information disclosure” contained in patents specially to attract finance founding will be particularly stressed. Section 2.1 reviews the role of signals for IPO markets. Section 3 discusses the methodological design and the data. Regressions results are provided in section 4. A discussion on the results and the conclusions are presented in Section 5.

2. The role of patents as signals

Innovation literature suggests the value of patents as signals (Hsu and Ziedonis 2008). As discussed early, the impact of patenting in software firms performance is a controversial topic in innovation economics. There is special concern in how software firms can reap indirect benefits from the patent system. In line with Ziedonis (2008), one is though information exposed during the patenting process which is usually called "information spillovers". The patent system "*also aims to foster innovation through the disclosure of information about new inventions (in detailed drawings and descriptions contained in published patent documents) that otherwise might be held secret or be more difficult for outsiders to unravel*" (Ziedonis, 2008). The number of patents filed could play an important role as a non-financial signal of firm quality.

In very general, patents could persuade investors that the company may be a good investment because they could provide a competitive advantage. Several factors are pointed out by literature related with this competitive advantage. For example, Olsson and McQueen (2000) summarize seven factors influencing patenting in small computer software producing companies. The first is usual wisdom about that patents are considered effective in discouraging imitators from introducing similar products to the market to take advantage of R&D investments made by others. Second, Patent portfolio may convince investors that a company may be worth investing in since the portfolio may both indicate the technical level of the company and "lock" the rights to the technologies claimed in the patents to the company (Olsson and McQueen, 2000). Third, patents can be an effective mean to reduce the risk and effect of people leaving to become new competitors. Four, software firms could be interested to license out patented technology to generate income from a technology that is not at the heart of the business model. The fifth factor is that filing a patent application, concerning a technology that the company does not intend to exploit, may block or delay a competitor. The sixth factor is related with patenting as a way to motivate and stimulate the inventiveness of employees. The seventh factor is patenting in order to promote the image of the company or its products (Olsson and McQueen, 2000).

Literature has empirically shown the role of patents in venture capital financial support. Mann (2005) reports qualitative empirical works regarding the value of patents in facilitate financing of software firms. Mann's works suggest that patents have a variety of potential positive effects, depending on the stage of firm's development. Mann (2005) also argues that the software industry includes many sectors in which patents have different values. Mann and Sager (2007) found different effects on patenting through the venture capital cycle. Gambardella and Giarratana (2006) report empirical work suggesting that patents have an important positive effect on the probability of licensing at algorithm in the security software industry. They also found that patent *per se* do not play a key role for launching a new product. Cockburn and MacGarvie (2006) found that additional patents held by start-up software companies going public stimulate entry while on the contrary, patents held by incumbents deters entry. Cockburn and MacGarvie (2009) provide evidence that patents significantly affect the likelihood of obtaining funding for early stage firms. They found that firms in "thicketed" markets with large number of patents are less likely to receive funding of Venture Capital or corporate funding compared with those in markets with fewer patents. They also found that the number of patents pending is positively associated to the probability of obtaining funding, while the number of patents already granted is not. Warner and Cockburn (2010) found evidence that patenting is positively associated with survival in Internet related IPOs. Thus, they found that firms with not patent applications had much higher probability to exiting the simple though if the companies obtain unusually highly cited patents they may be a more attractive acquisition target.

Patents could be important signals for venture capital support in the software industry. However, there is little evidence to validate this claim in Europe too. There is a lack of literature addressing the role of patents in obtaining funding in Europe. The literature has highlighted the important differences in patent systems in Europe and the U.S (Hart and alli, 1999; Beresford, 2001; Graham et alli, 2002). The differences between the patents systems especially concerning the patentability of computer programs and the procedures that ensure the "quality of patents" may have a strong impact in the power and effectiveness of the patents as signals for investors. Then we can expect a different role of the patent as a signal through time and space.

2.1 Information asymmetries and the role of signals for IPO markets

Literature considers IPOs as important events in a firm's life cycle. SMEs go public in order to improve their innovative capabilities through raising a high amount of cash which help to finance valuable projects, gives VCs the opportunity to exit (Black and Gilson, 1998), capture a first-mover advantage (Maksimovic and Pichler, 2001), and facilitate takeover activity, among others (see Ritter and Welch 2002; Brau and Fawcett, 2006). IPO creates information asymmetry between firms and investors, and represents the first opportunity to observe the market's reaction to firms and their strategies (Ibbotson and Ritter, 1995). A mayor issue for SMEs going public is how to signal their value to potential investors. Investors tend to measure investment potential based on analyzing considerable data gathered on the firm‘s history and its perceived market potential. Thus, one way for companies to perform IPO is to convince investors that the company may be worth investing (Wilbon, 1999).

Several studies have sought to determine the relationship between various metrics of firm quality and IPO performance. Some of this metrics of firms value are considered as signals which help to reduce uncertainty and skepticism regarding an IPO firm's performance. For example, many studies have examined the impact that executives and boards of directors have on IPO performance. For an executive digest about the influence of people on the performance of IPO see Certo et al (2007). In very general, theory suggests that the influence of individuals (namely executives and boards of directors) helps to reduce uncertainty surrounding the IPO process. Literature also stresses the role of venture capital as a recognized financial intermediary that overcomes problems of moral hazard and asymmetric information in financial markets (Gompers, 1995; Lerner, 1995). Lipuma (2011) found that solely domestic venture capital backed U.S. technology based new ventures receive higher valuations at IPO that do new ventures with high proportion of foreign sales. Also, Lipuma’s work found evidence that high international intensity new ventures execute IPOs later than solely domestic ventures.

More related with the concept of knowledge and competences, a few studies sought to determine the relationship between various metrics of firm quality in terms of innovation and IPO performance in high-tech sectors. For example Wilbon (1999), using content analysis, empirically found that firm’s technology posture and executive level technology experience influence positively investors reactions to IPO. However, Wilbon’s model indicates that the intellectual property rights variable had a significant negative impact on IPO performance. Wilbon models measure IPO performance as the perceived potential of the firm calculated as the Tobin’s Q = stock price / book value. Thus, Wilbon study concludes that technology experience in computer software companies “*send signals to investors that the firms has the appropriate technical capabilities to maintain a consistent level of competitive and financial success”* (Wilbon, 1999).

Higgins et al(2011), analyse the relationship between various metrics of firms quality and the proceeds the firm is able to raise via the IPO. They found evidence consistent with the status signalling hypothesis (Podolny and Scott Morton, 1999) that considers that the importance of a signal is inversely related to the availability of cogent information on firm quality. Thus, they find that the presence of a Nobel served as a powerful status signal of firm quality for biotech IPO during the first period (1990-1992) when firms going public were less established in terms of number of patents, products in clinical trials, etc. In the second period (1996-2000), the presence of Nobel laureate loses its value when the firms were more mature in the same quality metrics. This change in maturity seems to be consistent with the Pisano (2006) hypothesis that investors in biotechnology become more cautious leading to delayed investment until firms demonstrated more tangible research output. In this way, "disclosure of information" about firm's innovativeness and competences could help firms to attract investors reducing problems of asymmetric information and reducing risky investments, which could be particularly important for innovative start-ups.

To summarize, literature has shown the value of different metrics of firm quality in the IPO valuation. This empirical study expects to find a positive impact of patents filed in the amount of cash raised at IPO for the software industry. It is also expected to find differences in the value of patents and other metrics of "quality" as signals to evaluate IPO's software deals in the U.S and Europe. Coefficients should reflect the differences in the value of patents as signals for investors (receptors of signals) and also the differences in the importance of use of patents for the industry (emitters). Thus, coefficients should reflect that U.S software investors use more the patent behavior as a signal of firm quality replacing others strategic signs as venture capital support. For European software IPO coefficients should reflect patent behavior as an emerging measure of quality for investors. It is also expected a higher number of patents filed prior to IPO for venture backed (VB) companies in comparison with not VB companies.

3. Research design and measures

The approach used to build the dataset was to identify all the IPO software's deals from United-States, Germany, United-Kingdom, France, Sweden, Italy and Spain, from 1st January 2000 to 31st December 2009 in ZEPHIR[2] database. These deals are matched one by one with

[2] ZEPHIR databases coverage is more than 267,217 deals in Western Europe and more 16,447 deals in North America. In ZEPHIR database IPO is *"always just the FIRST time a company's shares are listed on a stock*

the number of patents filed (patents with priority date) from Qpad database[3]. The USSIC code (Standard Industrial Classification system of the U.S. government) is used to identify software activities in ZEPHIR database. Then, we use USSIC737 (Computer programming, data processing, and other computer related services). After having cleaned up the database this study consolidates a sample of 476 software firms (234 from the U.S. and 242 from the EU).

3.1 Econometric model

Traditional measures of IPO performance use the amount of cash collected by the firm at IPO (Chemmanur and Fulghieri, 1994; Ritter and Welch, 2002; Higgins et al., 2011), the pre-money valuation of the firm (Stuart et al., 1999; Gulati & Higging, 2003), the venture's IPO age (Chang, 2004). This study includes the use of two models using the amount of cash collected by the firms at IPO as the dependent variable. This measure of IPO performance avoids potential problems of over allocation in the pre-money valuation (Ritter and Welch, 2002; Higgins et al., 2011). The amount of cash collected at IPO could be particularly important for small and medium size companies which are cash-constrained. A high amount of cash at IPO could be considered as a company reward that can help firms to take a competitive advantage. A successful IPO can raise a high amount of cash which helps finance valuable and innovative projects. It can also help the firm to hire a more skilled and versatile workforce capable to support rapid software innovation process. IPO creates public shares for mergers and acquisitions creating conditions to enhance the competitive advantages of firms, central to the survival of SMEs and the consolidation of leader's positions in some competitive areas.

This study use an ordinary least square (OLS) regression on a log-transformed variable of IPO valuation to test the relationship between patent behavior and IPO performance for software start-up and medium size companies in the U.S. and Europe. The log of "dvalue" as the measure for valuation addresses the valuation data skew. Second, a probabilistic model is

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exchange - if a company has a listing on another market or in another country, then the listing is NOT an IPO, merely a secondary, or additional, listing. A secondary listing can be coded as either a Capital increase, if new shares are being sold or as a Minority stake, if old shares are being sold. Often a company raises money through the sale of newly issued shares as part of its IPO". Additionally, the name of the stock exchange must be included if known.

[3] Questel-Orbit QPAT is a database which allows the users to build and organize patent portfolios through the Web, and examine individual patents. This database allows the user to have user-controlled term highlighting, text mapping, sorting, and filtering, document rating and annotating capabilities among others

used to understand the factors that make some companies raise more money to the IPO with different thresholds.

The model for IPO valuation is:

$$Ln(dvalue) = \alpha + \beta_1 (PATENTRFINT) + \beta_2 (PROFITAB) + \beta_3 (SOLVENCY) + \beta_4 (VCAP)$$
$$+ \sum_{5-6} \beta_{5-6} (SIZE) + \beta_7 (NACE58.2) + \sum_{8-12} \beta_{8-12} (period) + \sum_{13-19} \beta_{13-19} (geographical)$$

3.1 Patents filed with priority date

This study uses an indicator variable for whether the software company file at least one patent with "priority date" (PATENTPD =1) or 0 otherwise. A vector of variable for the number of patents filed with "priority date" (PANTENTFINT) by the software companies at the moment of IPO is also used. The "priority date[4]" is considered to be "the effective date of filing" to establish the novelty, inventive step and non-obviousness of a particular invention considering the prior art. In other words, the "priority date" of a patent application is the date which controls what prior art affects the patentability of the invention. The share of software companies with patents filed prior to IPO was 73.5% for U.S while only 24% for 6 European countries selected.

3.2 Financial ratios

Financial literature is drawn to select explanatory variables that are expected to influence the proceeds the firm is able to raise via the IPO. Krinsky and Rotenberg (1989) and Ritter (1984) have shown a positive relationship between historical accounting information and firm value. Indeed, investors usually consider ratios as helpful tools for making an investment decision. This research paper uses commons ratios of profitability and solvability to control firm heterogeneity and financial performance. These ratios are used by investors to analyse financial firm performances.

The profitability ratios were built to comparing the business's ability to generate earnings as compared to its expenses and other relevant costs incurred during an S-1 registration filing at IPO. The analyses include a vector of variable called "PROBITAB" for the profitability ratio defined as a profitability indicator reported to the turnover. Three indicators were used: Profitability after taxes, profitability before taxes and EBITDA. It is

[4] http://www.wipo.int/treaties/en/ip/paris/trtdocs_wo020.html#P83_6610

expected that firms with a high profitability have a greater IPO valuation, and as a result, ceteris paribus, the market value of a firm is positively associated with its profitability performance. A dummy variable called “HPROFITAB” is coded 1 if the company quoted has a profitability ratio superior to 0.1 and coded 0 otherwise.

The analyses include also a vector of variable called “SOLVENCY” for the solvency ratio defined as the shareholders funds reported to the total assets. This ratio can produce a confidence factor for unsecured creditors to the business. Generally speaking, the lower a company's solvency ratio, the greater the probability that the company will default on its debt obligations. The study also includes a dummy variable called “HSOLVENCY” is coded 1 if the company quoted has a profitability ratio superior to 0.2 and coded 0 otherwise.

3.3 Venture capital support

The presence of Venture Capital could be a sign of confidence and performance of the company management, markets and technology. VCAP is a dummy variable that indicates whether the IPO was backed by one or more venture firms (=1) or not (=0). This variable takes into account only Traditional Venture Capital (TVC) and not Corporate Venture Capital (CVC) which generally makes later-stage venture investments. Literature has shown that CVC managers have weaker performance incentives compared to TVC general partners (Masulis and Nahata, 2009). In terms of higher support and quality of effort provided to start-ups, CVC are considered strategically-motivated investors which are endogenously less prone to build value-added support capabilities in comparison to TVC (Hellmann, 2002; Masulis and Nahata, 2009) β_4 (VCAP) as a vector of dummy variable for Traditional Venture Capital (TVC) (TVC effect). It is expected that venture backed companies have greater IPO performance than ventures quoted without similar funding support.

3.4 Size effects

Medium size firms should have a greater IPO valuation than start-ups. The dependent variable (dvalue) should be positively related with the size of the firm. A vector of 2 dummy variables for the size of the company: “SMALLSIZE” coded 1 when the turnover of the software company quoted is less than €10 million Euros for European Software companies and less that €25 millions for U.S companies. “BIGSIZE” coded 1 when the turnover of the software company quoted is more than €150 millions for the U.S[5] software companies and more that 50 millions for European[6] software companies.

3.5 Industry effects

The analysis includes a set of industry dummy variables to control for related differences. β_6(INDUSTRY) as a vector of dummy variable to take in account industrial differences. Industrial differences were included for European companies using the "statistical classification of economic activities in the European Community" (NACE). When a firm is a software publisher, the dummy variable "NACE58.2" is coded 1 and 0 otherwise. Industrial differences could be important because the various levels of present and future profitability and intellectual property appropriability are related to industry differences (Levin, Cohen, & Mowery, 1985). Use a statistical classifications of activities is not without problems because software industry definition is fuzzy. However, this classification can give us a general appreciation of how investors evaluate software publishers with respect to IT services companies.

3.6 Temporal and Geographical effects

Finally, temporal and geographical differences in IPO deals are used. Literature has documented that IPOs tend to come in waves, characterized by periods of hot and cold markets. A vector of the five dummy variables to take in account temporal effects is included: "t00" (1 if the IPO deal was in 2000, 0 otherwise). "t01t02" (1 if IPO deal was from 2001 to 2002, 0 otherwise). "t03t04" (1 if IPO deal was from 2003 to 2004, 0 otherwise). "t05t06" (1 if IPO deal was from 2005 to 2006, 0 otherwise). "t07t09" (1 if IPO deal was from 2007 to 2009, 0 otherwise). It is expected that periods of hot markets have greater IPO performance than periods of cold markets. A vector of the seven dummy used to take in account geographical effects in the dependent variable. Six dummy variables coded 1 or 0 depending on the country, where used to differentiate companies according to the different geographical locations. "UK" (1 if the IPO deal was in British stock market, 0 otherwise). "GE" (1 if the IPO dealwas in German stock market, 0 otherwise). "FR" (1 if the IPO deal was in French stock market, 0 otherwise). "SE" (1 if the IPO deal was in Sweden stock market, 0 otherwise). "ITES" (1 if the IPO deal was in Spain or Italy stock market, 0 otherwise). "US" (1 if the IPO

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[5] For the SBA definition of SBE for U.S see: http://www.sba.gov/content/table-small-business-size-standards

[6] For the EUROSTAT definition of SME for Europe see: http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-NP-06-024/EN/KS-NP-06-024-EN.PDF

deal was in U.S stock market, 0 otherwise) and "NASDAQ" (1 if the IPO deal was in NASDAQ stock market, 0 otherwise).

3.7 Summary Statistics

Table 1 reports descriptive statistics for the U.S and the European software companies. The summary statistics are separated in order to emphasize differences on firm's characteristics between the U.S and European IPO deals. Some characteristics should be pointed out: first, 74% of the U.S. software companies filed at least one patent prior to IPO while only 24% of European software companies did it. Second, U.S. software companies filed in average 17,7 patents prior to IPO while European companies filed only two patents. Third, the share of software venture backed companies at IPO was 23% in the U.S and 19% in Europe. Fourth, 90% of the U.S venture backed companies at least one patent while 30% did it in Europe.

Table 1

Table 2

Summary statistics

Variable	U.S software companies n =234			European software companies n = 242		
	Mean	Min	Max	Mean	Min	Max
LOGDVALUE	4,86	3,70	7,10	4,88	1,36	7,78
PATENTPD	0,74	0,00	1,00	0,24	0,00	1,00
PATENTFINT	17,75	0,00	565,00	1,99	0,00	134,00
MPATENTFINT	0,49	0,00	1,00	0,07	0,00	1,00
HPROFITABT	0,17	0,00	1,00	0,28	0,00	1,00
HSOLVENCY	0,64	0,00	1,00	0,66	0,00	1,00
VCAP	0,23	0,00	1,00	0,19	0,00	1,00
SMALLSIZE	0,41	0,00	1,00	0,58	0,00	1,00
BIGSIZE	0,13	0,00	1,00	0,14	0,00	1,00
NACE(58,2)				0,34	0,00	1,00
t01t02	0,17	0,00	1,00	0,08	0,00	1,00
t03t04	0,21	0,00	1,00	0,12	0,00	1,00
t05t06	0,30	0,00	1,00	0,33	0,00	1,00
t07t09	0,21	0,00	1,00	0,19	0,00	1,00
NASDAQ	0,86	0,00	1,00			
GE				0,12	0,00	1,00
SE				0,08	0,00	1,00
FR				0,26	0,00	1,00
ITES				0,05	0,00	1,00

Table 2

Pearson correlation for variables used in the analysis of U.S IPO deals

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1.LOGDVALUE														
2.PATENTPD	0.1305*													
3.PATENTFINT	0.4321*	0.2167*												
4.MPATENTFINT	0.1464*	0.5953*	0.3481*											
5.HPROFITABT	0.2328*	-0.1132*	0.1816*	0.0039										
6.HSOLVENCY	0.0339	-0.1365*	0.0240	-0.0600	0.0480									
7.VCAP	0.0786	0.3017*	0.1632*	0.3620	* -0.028	-0.0733								
8.SMALLSIZE	-0.2758*	-0.0755	-0.1655*	-0.1583	* -0.213	* 0.0783	-0.1979*							
9.BIGSIZE	0.4541*	-0.0510	0.2116*	-0.0597	0.1574	* -0.1093	-0.0006	-0.3231*						
10.t01t02	0.0175	0.0753	-0.0252	-0.0253	-0.0413	-0.0469	-0.1156*	-0.2221	0.1587*					
11.t03t04	-0.1105*	0.0087	0.1335*	0.0153	-0.0508	0.0641	0.0594	-0.0895	-0.0056	-0.1512*				
12.t05t06	-0.1664*	-0.1027	-0.0474	0.0043	0.1348	* -0.0483	0.2308*	-0.1183	0.0512	-0.1717*	-0.2272 *			
13.t07t09	0.1033	0.0295	-0.0133	0.0462	0.1233	* -0.1416	0.1165*	-0.2399	0.0116	-0.1762*	-0.2331 *	-0.2648 *		
14.NASDAQ	-0.1619*	0.0628	-0.0460	0.0334	-0.1096	* 0.0884	-0.0448	0.1850*	-0.4574*	-0.0654	-0.0165	-0.0678	-0.1482*	

Table 3

Pearson correlation for variables used in the analysis of European IPO deals

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1.LOGDVALUE																	
2.PATENTPD	0.0385																
3.PATENTFINT	0.1370*	0.3206*															
4.MPATENTFINT	0.0989	0.5049*	0.5511*														
5.HPROFITABT	0.0174	-0.0544	-0.0478	0.5819*													
6.HSOLVENCY	-0.1260*	0.0134	-0.1187*	0.2883*	0.4155*												
7.VCAP	0.0840	0.0669	0.0611	0.0201	0.0370	0.1308*											
8.SMALLSIZE	-0.2804*	0.0433	-0.1179*	-0.5035*	-0.4196*	-0.1523*	-0.1141*										
9.BIGSIZE	0.2801*	0.0590	0.2137*	0.7419*	0.5867*	0.2613*	0.0789	-0.6655*									
10.NACE(58,2)	-0.0233	0.1041	0.1619*	0.1269*	-0.0128	-0.0345	-0.0687	0.0290	-0.0081								
11.GE	-0.1243*	0.0825	-0.0214	0.0367	0.0679	0.1898*	0.1323*	-0.0376	-0.0033	-0.0076							
12.SE	0.0202	0.0073	-0.0434	-0.0851	-0.0234	0.1198*	-0.0715	0.1323*	-0.1193*	0.0993	-0.1129*						
13.FR	-0.5236*	-0.1172*	-0.0515	-0.0629	0.0986	0.1521*	0.0135	0.1275*	-0.1018	-0.0977	-0.2256	-0.1800*					
14.ITES	-0.0153	0.0501	-0.0223	0.0078	0.1087*	-0.1180*	-0.0640	-0.2313	0.2420*	-0.0046	-0.0859	-0.0686	-0.1370*				
15.t01t02	-0.0313	-0.0630	-0.0489	-0.0851	0.0764	-0.0071	-0.0715	0.0714	0.0119	0.0361	-0.0674	-0.0901	0.0582	0.0006			
16.t03t04	0.1752*	0.0313	0.1332*	0.0894	0.0488	-0.1391*	-0.0525	-0.1263	0.1500*	-0.0254	-0.1388	-0.1108*	-0.1347*	-0.0257	-0.1108*		
17.t05t06	-0.1531*	0.0993	0.0253	0.1021	-0.0741	-0.0166	0.2323*	-0.0643	0.0023	-0.1006	0.0555	-0.1471*	0.0765	-0.0391	-0.2109*	-0.2593*	
18.t07t09	-0.2575*	0.0302	-0.0440	-0.0141	0.0040	0.0504	-0.0736	-0.0047	-0.0352	0.0798	-0.0509	0.3966*	0.0506	0.0865	-0.1435*	-0.1764*	-0.3359*

* P<0.1

4. Results

Several Chow tests were performed to determine whether the independent variables have different impacts on different subgroup of the population. The chow tests confirm that separate regressions for both U.S and Europe deliver a better modelling than a combined regression. Additionally, Chow tests indicate that there are not significant differences between the different European countries and through the period of analysis. Table 2 and Table 3 reports the results of the Pearson Correlation analysis for the independents variables for the U.S and the European IPO deals respectively. A review of the correlations concludes that several of the variables are correlated to another, but none of the correlations exceeds 0.7 and no model uses highly correlated variables.

A test of multicollinearity was performed to confirm that the proposed explanatory variables are independents. Table 4 show that the Variance Inflation Factor for U.S (Models 1 and 3) and for Europe (models 2 and 4) are not an extremely high value and the tolerance of variance are not close to cero, so one can conclude that explanatory variables are independent and multicollinearity is not an issue.

Table 4

Results of collinearity test

	Model 1		Model 2		Model 3		Model 4	
Variables	VIF	TOLERANCE	VIF	TOLERANCE	VIF	TOLERANCE	VIF	TOLERANCE
PATENTPD	1.25	0.800736	1.20	0.835053				
PATENTFINT	1.21	0.825031	1.24	0.804675				
MPATENTFINT					1.20	0.830609	1.08	0.927279
HPROFITABT	1.16	0.860097	1.16	0.861692	1.12	0.895809	1.16	0.864009
HSOLVENCY	1.08	0.922823	1.25	0.800548	1.06	0.940076	1.23	0.810332
VCAP	1.33	0.751168	1.12	0.895618	1.34	0.747975	1.11	0.899280
SMALLSIZE	1.63	0.612369	1.43	0.701596	1.66	0.603366	1.38	0.726639
BIGSIZE	1.50	0.668745	1.41	0.711502	1.45	0.690529	1.37	0.732276
NACE(58,2)			1.07	0.934993			1.05	0.948406
t01t02	1.52	0.658590	1.22	0.817537	1.51	0.660516	1.22	0.817375
t03t04	1.55	0.645217	1.42	0.703494	1.55	0.645705	1.42	0.706434
t05t06	1.85	0.541896	1.60	0.625772	1.80	0.555942	1.59	0.628727
t07t09	1.94	0.514368	1.60	0.623851	1.94	0.516032	1.59	0.628727
NASDAQ	1.34	0.743832			1.34	0.746478		
GE			1.26	0.794102			1.25	0.797264
SE			1.42	0.706465			1.42	0.701903
FR			1.35	0.742292			1.34	0.748093
ITES			1.20	0.833055			1.19	0.843009
Mean VIF	1.45		1.35		1.45		1.29	

All models are significant at the 0.01 level and are robust which indicates that they are not problems of heteroskedasticity. Potential problems of endogeneity that might come from correlation between the regressors and the residuals have been also tested. Nakamura Nakamura test in two stapes were performed for each of the potential endogeneity regressors.

1) Each suspected endogenous variable is regressed on its instruments and the exogenous variables. 2) The residuals of the first step were recovered and introduced on the full model. If the coefficients of the residuals are significant so it can not be rejected the endogeneity of variables tested. Additionally, an overidentification test of Sargan/Hansen were performed to validate the instrumental variables used. Test of Nakamura Nakamura indicates that endogeneity is not an issue for models presented in Table 5. Solvency and profitability ratios were not used to avoid potential problems of endogeneity on ordinary least square (OLS) regressions.

Table 5

Panel A: Ordinary Least Squares
Dependent Variable: log(dvalue)

Variables	1		2		3		4	
PATENTPD	0,0995		0,3214					
PATENTFINT	0,0051	***	0,0112					
MPATENTFINT					0,1755	*	0,9619	**
HPROFITAB	0,3008	*	0,4789	*	0,4032	***	0,4220	
HSOLVENCY	0,1026		-0,1988		0,1123		-0,1863	
VCAP	0,1810		0,8488	**	0,2540	*	0,8911	**
SMALLSIZE	-0,4398	***	-1,2453	***	-0,4669	***	-1,2144	***
BIGSIZE	0,9191	***	1,4043	***	1,0887	***	1,4479	***
NACE(58,2)			-0,5274	*			-0,5268	*
t01t02	-0,6650	***	-1,6317	***	-0,7145	***	-1,6061	***
t03t04	-0,8109	***	-1,7353	***	-0,7709	***	-1,7352	***
t05t06	-0,8730	***	-2,2910	***	-0,9667	***	-2,3158	***
t07t09	-0,4376	**	-2,9817	***	-0,4973	**	-3,0007	***
NASDAQ	-0,0222				0,0220		-2,9834	
GE			-2,9901	***			0,1208	***
SE			0,0499				-3,8072	
FR			-3,8083	***			-2,6928	***
ITES			-2,7315	***				***
cons	11,4206	***	14,8481	***	11,4370	***	14,8523	***
R-square	0,4794		0,5849		0,4113		0,5869	
observations	234		242		234		242	

**p<0,05
*p<0,1

Table 5 presents the results of the linear regression analysis for IPO valuation with a dependent variable log (dvalue). Models 1 and 2, for U.S and European IPOs deals respectively, indicate that file at least one patent does not impact IPO valuation, nevertheless an increment of one patent filed prior to IPO seems to impact positively the amount raised at IPO for U.S software companies but not for European ones. Consequently, for a U.S software company, an increment of one patent filed prior to IPO increase the amount of cash raised on the stock market by an approximate 0.51%, holding other factors fixed. Nevertheless, the most striking result for the analysis is the very large positive effect of having filed more that tree patents rather than less of tree patents prior to IPO in Europe (Model 4). Holding other factors fixed, the difference in the amount raised at IPO between a European company with more of 3 patents filed and another with less of 3 patents filed is 0.9619. This means that a European company with more of 3 patents filed, rather than less of 3 patents filed, prior to IPO is predicted to raise approximate 96.19 % more cash, holding other factors fixed. This is certainly related to the difficulty of European firms to file at least three patents before going public. In contrast, a U.S company with more than 3 patents filed, rather than less of 3 patents filed, prior to IPO is predicted to raise only 17.55% more money at IPO, holding other factors fixed.

Models 2, 3 and 4 show the importance of venture capital support on IPO valuation especially for European deals. Holding other factors fixed, a European venture backed IPO raise approximately 87% more cash than a comparatively company not supported by venture capitalist (models 2 and 4). This result confirms that venture capitalist are considered by investors as increasingly recognized as financial intermediaries that overcome problems of moral hazard and asymmetric information in financial markets (Gompers, 1995).

Finally, an important result of the different models is the importance of temporal and geographical effects on the amount raised at IPO. In fact, as claimed in earlier literature, market conditions strongly influence a firm decision to going public (Lerner, 1994) and the amount collected at IPO. A company introduced in “hot” period as the bursting of the Internet bubble in 2000 has raised significantly more money than a comparable company quoted in the years that followed, holding other factor fixed. This consistent with the idea that IPO firms take advantages of bull markets and attempt to capture attractive stock prices (Brau and Fawcett, 2006). For European companies, being quoted in the French, German, Italian or Spanish markets is related with lowers amounts of cash in comparison with the UK stock market, IPO holding other factors fixed.

4.1 Alternative models

Table 6 and 7 present the results of models for IPO valuation with a probabilistic model, using heteroskedasticity-robust standards errors, with a dependent variable dvalue = 0 if the IPO deal value is below the median of the simple and dvalue = 1 if the IPO deal value is above the median (models 5 and 9 for the U.S. and 6 and 10 for Europe). We analyze another threshold looking for the characteristics of the 25% of the companies which raise more money compared with the others. Then dvalue = 0 if the IPO deal value is below the third quartile of the distribution and dvalue = 1 if the IPO deal value is above the third quartile of the distribution (models 7 and 11 for the U.S. and 8 and 12 for Europe). The difference between table 6 and 7 is the use of profitability and solvency ratios in table 7 and indicator variable for high solvency (ratio superior of 0.2) software companies and for companies with a profitability ratio superior to 0.1.

With this more detailed analysis, we confirm the important of patents filed for IPO performance. It is found that for European software companies the number of patent filed is significant for companies who raise more that median of the distribution (model 6 and 10). In other worlds, the probability to be in the 50% of the companies which raise more money at the IPO is stronger for the companies that file more patents (models 6 and 10). This is also true for U.S software IPOs. Additionally, Models 5 also show that file at least one patent improve in 24% the probability to be in 50% of the companies which raise more money for the U.S. For European software companies file at least one patent improve in 11% the probability to be on the 25% of the companies which raise more money (model 8).

Table 6

Panel B: Probit regression, reporting marginal effects

Variables	5		6		7		8	
PATENTPD	0,2486	***	-0,0455		0,0156		0,1106	*
PATENTFINT	0,0035	**	0,0230	***	0,0015		-0,0022	
HPROFITAB	0,0455		0,0597		0,2052	**	-0,0169	
HSOLVENCY	0,1157		0,0231		0,0767		-0,1043	**
VCAP	-0,0138		0,1568		0,1500	*	0,1052	
SMALLSIZE	-0,1959	**	-0,1270		-0,1703	**	-0,1849	***
BIGSIZE	0,4616	***	0,3891	***	0,5147	***	0,2121	**
NACE(58,2)			-0,3198	***			-0,0650	
t01t02	-0,4274	***	-0,2217	*	-0,1863	***	-0,0745	
t03t04	-0,4272	***	-0,1951		-0,2384	***	-0,0844	
t05t06	-0,4176	***	-0,3796	***	-0,2562	***	-0,1672	***
t07t09	-0,2222	*	-0,4452	***	-0,1975	**	-0,1720	***
NASDAQ	-0,1090				-0,1585			
GE			-0,4773	***			-0,1811	***
SE			-0,0035				-0,0310	
FR			-0,6681	***			-0,2506	***
ITES			-0,3939	***				
obs, P	0,50		0,50		0,25		0,26	
pred, P	0,52		0,49		0,20		0,11	
Pseudo R2	0,21		0,39		0,27		0,39	
Observations	234		242		234		230	
Wald chi2(16)	55,59		81,58		59,85		82,46	
Log pll	-128,89		-102,42		-95,86		-80,88	
Correctly classified	0,692		0,814		0,795		0,830	

**p<0,05
*p<0,1

Table 7

Panel C: Probit regression, reporting marginal effects

Variables	9		10		11		12	
PATENTPD	0,2355	***	-0,0450		-0,0004		0,1068	
PATENTFINT	0,0037	**	0,0230	***	0,0017	*	-0,0016	
PROFITAB	-0,0017		-0,0009		-0,0019		0,0025	
SOLVENCY	0,0628		0,0260		0,1008		-0,0269	
VCAP	-0,0279		0,1579		0,1105		0,0853	
SMALLSIZE	-0,2042	**	-0,1253		-0,2047	***	-0,1767	***
BIGSIZE	0,4517	***	0,3914	***	0,4765	***	0,1815	***
NACE(58,2)			-0,3170	***			-0,0681	
t01t02	-0,4254	***	-0,2220	*	-0,1864	***	-0,0681	
t03t04	-0,4208	***	-0,1873		-0,2337	***	-0,0757	
t05t06	-0,3948	***	-0,3764	***	-0,2230	***	-0,1626	***
t07t09	-0,2195	*	-0,4422	***	-0,1792	**	-0,1755	***
NASDAQ	-0,1082				-0,1771	*		
GE			-0,4737	***			-0,1876	***
SE			-0,0067				-0,0437	
FR			-0,6626	***			-0,2641	***
ITES			-0,3865	***				
obs, P	0,50		0,50		0,25		0,26	
pred, P	0,52		0,49		0,20		0,12	
Pseudo R2	0,20		0,39		0,25		0,38	
Observations	234		242		234		230	
Wald chi2(16)	55,74		83,14		51,48		81,76	
Log pll	-129,58		-102,53		-98,29		-81,82	
Correctly classified	0,709		0,798		0,816		0,810	

**p<0,05
*p<0,1

5. Discussion and conclusion

This study contributes to the literature in several ways. An original database, matching IPO deals from ZEPHIR database and the patent filed from Q-pad database, in two different geographical areas is used. We consolidate a large simple of 476 completed IPO deals in computer based industries (SIC 737) from 1st January 2000 to 31st December 2009. Other studies analysing the relation of IPO performance and firms quality present much smaller samples as for example Wilbon (1999) and Wilbon (2003) presents respectively 31 completed U.S IPO deals in computer based industries by the of 1996 and 168 completed U.S IPO deals in high tech industries by the end of 1992. Higgings et alli (2011) consolidate a simple of 89 IPO deals in biotech industries in the U.S: 44 IPO deals from 1990-1992 and 45 IPO deals from 1996-2000. Lipuma (2011) consolidate a simple of 184 privately held venture capital-backed U.S. technology-based new ventures that executed an IPO in the period 1997–2003.

This study also contributes to the literature of innovation by analysing the relationship between IPO performance and patent behavior not only in the U.S software industry but in the

European one too, which means to take in account institutional and geographical differences. The results of the analysis indicate that patent behavior impacts the amounts of cash collected at IPO not only in the U.S but also in Europe. U.S IPO analysis seems to present a more linear relationship between the patent filed with priority date and the amount collected at IPO. In contrast, with a threshold of tree patents, the impact of the patent behavior as a signal seems to be stronger in Europe than the U.S. This means that the power of a signal, in this case the patents filed prior to IPO, is strongly different between two different geographical areas. This is probably the result of differences in the conditions of patentability of technologies associated with software industries in both geographical areas. This suggests also that the importance of a signal is consolidated when their conditions of use are spread between the emitters of signals and their receptors. That is to say that an additional patent filed is consolidated as a signal when investors seem to understand the importance of this signal in the evaluation of the firms and when firms understand the importance of this signal for investors. This can also suggests that the importance of a signal can also decrease when it is widely used by most of the players or when getting the signal becomes less expensive.

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