IPO performance and strategic management of IPRs: evidence from the US semiconductor industry

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Financial support from the EIBURS Programme of the European Investment Bank (Research Project EVPAT "The Economic Valuation of Patents") is gratefully acknowledged.

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1. INTRODUCTION

R&D and innovation are critical factors to succeed in high-tech industries. Nevertheless, the inherent uncertainty on the economic returns to innovation leads to substantial information asymmetries between corporate insiders and external investors (Aboody and Lev, 2000). Within the context of a potential IPO, above all in high-tech industries, the presence of such information asymmetries might result in potential inefficiencies and in higher risks of underpricing for the firm going public (e.g., Guo et al., 2006).

Some recent studies have focused on the role of patents in reducing the information asymmetries, analyzing the relationship between patent-based measures and the pricing of IPOs. These cross-sectional studies have shown that patents represent a positive quality signal for investors and may reduce underpricing and increase long-term returns. Specifically, Chin et al. (2006) found a positive association between number of patents and long-term IPO performance. Besser and Bittelmeyer (2008) showed how this result holds even controlling for patent quality. Besides, Heeley et al. (2007) documented how the number of patents significantly reduces IPO underpricing in industries characterized by stronger appropriability regimes.

Despite the results of the previous studies, however some aspects of the effect of patents on stock market valuation at the moment of an IPO have still to be clarified. For example, although in high-tech and science-based industries patents represent fundamental assets, firms generally adopt different strategies to exploit and commercialize them. In the specific case of the semiconductor industry, Hall and Ziedonis (2001) showed that patents play multifaceted role: patenting is motivated by "patent portfolio races" for large-scale and capital intensive semiconductors, whereas for specialized design firms patents facilitate the entry and attract venture capital funds. Thus, stock market valuation of high-technology companies might not be influenced by the simple possession of patents, but it could be affected by the strategic use which is made of them to create and capture value.

In order to complement previous literature, we intend to analyze whether and to what extent the choice of a given patent commercialization strategy by a high-technology company affects its pricing at IPO. We focus on the impact of commercialization strategy because, *ceteris*

paribus, it can significantly affect the uncertainty over the firm value and therefore information asymmetries and underpricing. We will analyze such research questions in the semiconductor industry and we refer in particular to two different commercialization strategies (Hall and Ziedonis 2001, Linden and Somaya, 2003, Ahuja and Lahiri 2006): a) licensing-based strategies adopted by firms focusing on the development of patented technologies which are then licensed to external partners (so called fabless companies); b) integrated strategies, adopted by firms which engage in the development, manufacturing and commercialization of new technologies.

We analyze the relation between commercialization strategies and underpricing in a sample of 131 firms that went public in the United States in the semiconductor industry in the period 1996-2007. In order to classify the business models, we analyzed information reported in the "Prospectus summary" and "Business description" sections of companies' IPO prospects.[2]

In the empirical analysis, we present both descriptive evidence and multivariate analyses to test the relationship between commercialization strategy and IPO underpricing. The main result we obtain both in the descriptive and multivariate analyses is that firms that adopt a licensing-based strategy are characterized by a higher underpricing at the IPO, as a consequence of higher information asymmetries.

The rest of the paper is organized as follows. In the next section we present our theoretical background, explaining why we expect that patent commercialization strategy affects information asymmetries and IPO underpricing. In Section 3 we introduced our empirical setting – the semiconductor industry, whereas in Section 4 we describe the sample and the calculation of variables. Section 5 reports the results of the descriptive and multivariate analyses. In the final section we draw our conclusions from the theoretical and empirical analysis.

2. THEORY BACKGROUND

2.1 Information asymmetry and the role of patents

Since they are highly idiosyncratic and have very uncertain results, R&D investments generate information asymmetries between insiders and external financers. Aboody and Lev

[2] It should be noted that IPO prospectuses have a standard structure. In particular, Regulation S-K describes the structure of these documents and provides a format that companies are required to follow when creating a prospectus.

(2000) have found that in more R&D-intensive firms insider trading is more likely, signaling that R&D investments increase information asymmetries.

These information asymmetries can hinder the financing of innovation (Hall, 2002). In fact, as external financers have not the same knowledge of the innovation projects as the insiders, a problem of adverse selection arises. In response, external investors are not available to fund firm's R&D projects, or they fund them only if the expected rate of return (i.e., the cost of capital for the firm) is high enough. In smaller and younger R&D-intensive firms with no track record on previous activities, information asymmetries are even more important and they can create strong financing constraints due the absence of potential investors or to a too high cost of capital imposed on external sources of financing (e.g., Himmelberg and Petersen, 1994; Carpenter and Petersen, 2002).

Patents can be important to reduce information asymmetries for R&D-intensive firms for several reasons. First, by their nature, they disclose information about the technologies developed and available to the firm. Second, as patents are granted after a thorough examination process by a national patent office, they are a signal of the quality of the invention. Third, they make the firm more attractive to those external investors, above all venture capitalists, that have a specific knowledge of the industry technological background.

Empirical studies support this view for both younger entrepreneurial and more mature traded firms. The analysis of Mann and Sager (2007) on the software industry documents a positive and significant correlation between patenting and the firm's progress through the venture capital cycle. Similarly, Hsu and Ziedonis (2008), analyzing 370 semiconductor startups that received more than 800 rounds of VC funding from 1980 through 2005, found a statistically significant and economically large effect of patent filings on investor estimates of start-up value. In the semiconductor industry, the field interviews conducted by Hall and Ziedonis (2001: 110) on the use and importance of patents show that patents are "… an imperfect, but quantifiable measure of technology that enabled technology-based trades to be made in external markets, both in financial markets (venture capital) and with suppliers and owners of complementary technologies". The empirical analysis of Hall, Jaffe and Trajtenberg (2005) on a broad sample of US traded firms shows that in a firm market value model patent data add information to the R&D investments, as demonstrated by the positive and significant coefficients. This implies that stock market investors recognize the value of patents. In the same vein, Deng, Lev and Narin (1999) find a significant relationship between patents and stock returns.

2.2. IPO Underpricing and Patents

A well known pattern associated with the process of going public is the frequent incidence of 'underpricing', as measured by the high initial returns of an IPO which occur when the IPO price is below the closing price at the end of the first day of trading (Ritter 1998). The empirical regularity of IPO underpricing has motivated a large theoretical literature trying to explain its reasons. The best established explanation for the underpricing phenomenon resides in the asymmetric information based model (Rock 1989) which assumes that firms and underwriters will discount the initial offer price in order to induce investors to buy stock in absence of full information on firm's value. Consequently, the initial underpricing is conceived as measure of information asymmetry and it increases in the ex ante uncertainty about the value of the IPO firm (Ritter 1984, Beatty and Ritter 1986).

As explained in the previous section, for high technology-based firms, the economic attributes of innovation efforts naturally lead to substantial information asymmetries between corporate insiders and external investors. Consequently, ex ante uncertainty about the value of the firm is more severe high technology-based firms compared to tangible-based companies.

In order to control for ex ante uncertainty, empirical studies of IPO underpricing used various proxies related to company characteristics, offering characteristics, prospectus disclosure, and aftermarket variables (see Ljungqvist 2005 for a review).

Some recent studies have focused on different innovation measures as proxies of ex ante uncertainty about the value of the IPO firm. In particular, some scholars (Guo et al., 2004; Guo et al., 2006) documented a positive relation between R&D intensity and initial IPO underpricing, thus singling out R&D as a major contributor to information asymmetries.

Other studies examined patent-related measures as a signal of firm's value. Chin, Lee, Kleinman and Chen (2006) found that official monthly reports of newly developed patents released to the public and the frequency of patent citations significantly increase IPO underpricing in Taiwan. Bessler and Bittelmeyer (2008) investigated the impact of innovation on the performance of German firms that went public at the "Neuer Markt" during the period from 1997 to 2002. The authors found that mean underpricing for IPOs with patents is lower relative to the group of IPOs without patents in hot issue periods, but in contrast it is higher in cold issue markets. Finally, Heeley, Matusik and Jain (2007) proved that patents reduce information asymmetries in industries where the link between patents and inventive returns is transparent, thereby reducing underpricing. Conversely, in industries where the link is not

transparent patents reflect increased information asymmetries and underpricing.

2.2 Patent commercialization strategy and IPO underpricing

In a seminal article, Teece (1986) explained that firms may choose different governance modes in order to translate promising technology into economic returns. They can either directly invest to develop and control the complementary assets required to bring the innovation into the market, cooperate with other companies to access their complementary assets, or sell the technology. Under a cooperative commercialization strategy, therefore, the firms try to earn returns on the innovation by operating on the market for ideas rather than on the product market (Gans and Stern, 2003).

Cooperation can take various forms, ranging from equity-based cooperation or joint ventures, strategic alliances or licensing agreements. We explicitly focus on a firm's decision to license patents to one ore more buyers. In this case, the licensee acquires the right to exploit the company's innovation by paying a corresponding financial amount. The revenue model of a company adopting a licensing-based commercialization strategy is therefore mainly based on up-front payments, milestone payments and royalties paid on sales or profits.

The increasing interest for this type of commercialization strategy in a wide variety of industries is a consequence of the rapid diffusion of markets for technologies, defined by Arora et al. (2001) as "markets for intellectual property that is licensed and its close substitutes, i.e. the technologies or goods that are close enough substitutes significantly to constrain the exercise of market power with respect to the intellectual property that is licensed". They include transactions involving full technology packages (patents and other intellectual-property and know-how) and patent and know-how licensing.

Although markets for technologies are not a new phenomenon (Lamoreaux and Sokoloff, 1998), they have grown rapidly over the last two decades as a consequence of the increasing complexity of technology and the amount of resources required to come out with innovations. A new division of innovative labor is therefore taking place in several industries, such chemical engineering, semiconductors and electronics, software, biotechnology and pharmaceutical (Arora et al., 2001), whereby specialist firms focus on the development of new scientific and technological knowledge, protect it with patents and other IPRs and then

sell in the downstream market[3]. In all such cases, patents are increasingly used a mechanism for defining the boundaries of the property rights on the technologies under exchange.

Previous research has largely addressed the determinants affecting the choice of a commercialization strategy based on licensing, either focusing on environmental conditions external to the company - such as the strength of appropriability regimes (Gans and Stern, 2003; Arora and Merges, 2004), the importance of complementary assets (Gans and Stern, 2003; Teece, 2000), or the intensity of competition on the market (Fosfuri, 2006) - or on internal resources - such as the experience in prior alliances or the availability of financial resources (Kasch and Dowling, 2008).

However, to our knowledge no previous work has explicitly studied the relationship between the choice of a particular commercialization strategy (integrated vs. licensing-based) and access to external financing. With specific reference to the case of firms going public, moreover, no previous attempt has been made to analyze whether the choice of a given commercialization strategy impacts on the degree of information asymmetries between the issuer and the investors, and by that on the level of IPO underpricing.

We directly address this research question claiming that firms adopting licensing-based commercialization strategies experience higher levels of underpricing at IPO as compared to fully integrated companies, as a consequence of the presence of significant information asymmetries between the company and investors. The high degree of asymmetric information characterizing these firms may derive from at least three different and interrelated reasons: the difficult valuation of intangible-intensive companies (Lev, 2008); the significant hazards characterizing the markets for technologies, in which such companies operate (Teece, 1988; Arora et al., 2001); the high risks of patent infringements and litigation underlying this type of commercialization strategy (Hall and Ziedonis, 2008).

For what concerns the first explanation, firms adopting licensing-based commercialization strategy share the main characteristics of so-called "conceptual companies" (Lev, 2008): they are more intangibles-intensive than other firms - their main resources being characterized by

[3] Several biotechnology entrants over the period going from the mid 80s to the late 90s rather than aspiring to become fully integrated pharmaceutical companies, chose to focus their effort on research and to collaborate with established pharmaceutical companies on development and commercialization (Pisano, 2006). In the semiconductor industry, so-called fabless companies which chose to license their technology rather than engaging in capital-intensive downstream applications have grown rapidly over the years (Hall and Ziedonis, 2001;). In the chemical engineering sector, since the early '50s specialist producers of engineering and technology knowledge served downstream firms through licensing transactions (Arora, 1997). In the case of nanotechnology (Munari and Toschi, 2009), several new start-ups adopt business model based on licensing to exploit their patented inventions in a wide variety of application contexts, given the characteristics of general-purpose technology of this emerging field.

R&D and technology, IPRs, alliances, human and social capital - and they possess negligible physical assets. This is likely to pose significant valuation problems by financial analysts and external investors. Traditional financial and accounting indicators are of very limited help to correctly assess the presence and quality of internally-generated intangible assets (Hand and Lev, 2001). Several studies demonstrated that although for intangible intensive industries analyst coverage is significantly wider (Barth et al., 2001), however these industries are characterized by higher errors in analysts' forecast (Gu and Wang, 2005) and more variance in analysts' forecasts (Barron et al., 2002).

Moreover, traditional financial reports provide no indication of efficiency of use and future exploitation potential of IPRs and other intangible assets, nor they provide any disclosure of risks related to innovative technologies. For such reasons, high tech and science-based companies, whose primary assets are intangibles, are notoriously difficult to value from the perspective of an external investor (Guo et al. 2005).

A second explanation for a high level of underpricing for firms adopting licensing-based strategy derives from the limitations and problems which characterize markets for technologies (Arora et al., 2001). Firms operating in such markets face high contractual hazards that undercut their ability to coordinate arm's-length transactions of inventions and other knowledge assets (Teece, 1988). First, it is difficult for them to adequately define ex-ante all the detailed specifications to subcontract the development of knowledge assets, leading therefore to incomplete contracts and higher hazards of opportunistic behavior by the counterpart. Moreover, if a buying company has to undertake tight interactions with a technology supplier, this might generate sunk costs, and by that high switching costs and lock-in problems. A third hazard deals with the disclosure problem (Arrow, 1962): if a technology seller releases too much information ex ante, the buying firm can appropriate the knowledge without any payment. Finally, unless the company is operating in a regime of tight appropriability, the technology seller may not be able to capture value from the innovation, with the risk that the manufacturer, through the integration into R&D and distribution, becomes a direct competitor.[4] Therefore, the presence of significant contractual hazards and transaction costs characterizing the markets for technology increases the level of uncertainty involved in the ex-ante valuation of a licensing-based company by an external investor.

4 Teece (2000) reports the historical example of the RCA colour television to illustrate the risks involved in a pure licensing strategy. When RCA developed colour television, it decided to license its proprietary technology aggressively and outsource the manufacturing of the key components of the television itself. Its licensees, in particular those from Japan, subsequently integrated downstream and upstream, becoming producers of whole TV sets, ultimately leading RCA out of the market.

The abovementioned arguments highlight that the effectiveness of a commercialization strategy based on licensing is strongly dependent on the strength of IPR protection (Arora and Merges, 2004). On the one hand, when strong patent protection is available, the seller of technology is less exposed to risk of misappropriation through imitation by the potential buyer. On the other hand, the buyer might require clear and explicit boundaries of the property rights of the underlying technology in order to enter into the transaction.

However, intellectual property protection is highly imperfect, and might be extremely hard to enforce. Lemley and Shapiro (2005) introduced the concept of probabilistic patents to illustrate all the cases in which patents are very unlikely to hold up if litigated and thus cannot be asserted effectively. The uncertainty surrounding the legal protection conferred by patents is particularly critical in the ICT and electronics industries (Cockburn and Macgarvie, 2006), either for the presence of dense patent thickets which make infringements highly probable, or for the existence of so-called "patent trolls", those individuals or patent holding companies that obtain patents of dubious merit and then use lawsuits to extract settlements (Reitzig and Henkel, 2008)[5].

The legal uncertainty surrounding patent protection thus represents the third reason of the difficult valuation at the IPO of licensing-based firms. It is clear that the potential downsides of incurring in a patent litigation are significantly higher for these firms as compared to fully integrated ones, given that intangible knowledge assets are more central to their value-creation strategies. Empirical evidence from the semiconductor industry provides support to this claim. In a study of patent lawsuits involving 136 U.S. semiconductor firms between 1973 and 2001, Hall and Ziedonis (2007) estimate the probability that firms will be involved in patent lawsuits, either as enforcers of exclusionary rights or as targets of litigation filed by other patent owners. Results of their probit estimation show that design specialist firms are more likely to be involved in patent litigation as compared to integrated companies, with the increase in probability equally split between being a target and being a litigant.

In summary, our previous explanations - based on the difficult valuation of intangible-assets, the imperfections of the markets of technologies and the uncertainty surrounding patent protection –support the expectation of higher uncertainty and information asymmetries at the moment of IPO between a company and the investors, when the former adopts a licensing-based strategy as compared to an integrated-strategy. This should result in a higher level of

[5] The legal dispute between Research-in-Motion (RIM), the maker of Blackberry hand-held devices, and NTP Inc, a patent holding company, which ended with the decision of RIM to pay $600 million to settle its claims of patent infringement, provides a well-known example of the economic damages stemming from uncertain IPRs.

IPO underpricing for firms adopting a licensing-based commercialization strategy, as compared to those favoring an integrated one.

3. EMPIRICAL SETTING: THE SEMICONDUCTOR INDUSTRY

The empirical setting we analyze is represented by the semiconductor industry in the United States. It represents an ideal context to study the effects of patent commercialization strategies on IPO underpricing for several reasons. First, since its inception, this industry has been characterized by a rapid pace of technological change and high levels of R&D investments.
Second, there is a widespread recourse to patenting by semiconductor firms. Hall and Ziedonis (2001) show that the number of semiconductor-related patents in the United States has risen sharply since the early 1980, well above the overall increase in patenting. They refer to a "patent paradox", stemming from the gap between the observed increase in patenting and the relative ineffectiveness of patents as a mechanism to appropriate the returns from innovation, as reported in innovation surveys. Indeed, the Yale and Carnegie-Mellon surveys on appropriability conditions (Levin et al., 1989; Cohen et al., 2000), administered to R&D managers of US manufacturing firms respectively in 1983 and 1994, showed that patents were rated as a weak instrument to protect innovative results in the semiconductor industry. Hall and Ziedonis (2001) explain this paradox in large part in terms of the strategic use of patents which has consolidated in the industry, based on the accumulation of vast patent portfolios to be used by firms as "bargaining chips" in order to obtain the required freedom to operate[6].
The third and more compelling reason to choose the semiconductor industry as our research setting resides in the significant vertical specialization of design and manufacturing activities which characterizes the industry, resulting in the formation of specialized design firms and specialized manufacturing firms over the last thirty years. Whereas until the '80s large firms operating in the semiconductor industry, such as IBM, DEC, AT&T and Motorola, were highly integrated, that decade showed the emergence of specialized design firms, also known as "fabless" companies. Such companies typically do not have in-house fabrication plants or

[6] In cumulative technology fields as semiconductors and electronics, indeed, it is likely that a firm, in order to compete with advanced product and processes, has to use also the technology of other companies. Overlapping developments are therefore very frequent, as well as the risks to achieve positions of mutually blocking patents. The need to achieve freedom to operate in design and manufacturing thus naturally resulted in patent cross-licensing agreements, which generally involve the mutual exchange of portfolios of all current and future patents in a given field-of-use (Grindley et al., 2000).

manufacturing setups, but solely concentrate on research, design and development of semiconductor chips. The benefits associated with the fabless model mainly reside in the elimination of the huge capital investment associated with building and operating a new fab, and on the possibility to focus on core competencies in research and design activities, thus accelerating the development process.

The industry thus experienced the emergence of two different commercialization strategies: firms pursuing integrated models and firms pursuing licensing-based models (Linden and Somaya, 2003)[7]. The former own and control all the required resources for semiconductor manufacturing and commercialization: design, process technology, fabrication and assembly equipment, test equipment, distribution facilities. The latter are specialized design firms, possessing innovative technologies and exclusive intellectual property, and earning revenues solely from licensing, or from products, or a combination of the two. Such firms typically outsource the fabrication of the devices to a specialized semiconductor manufacturer, called a semiconductor foundry. Whereas IBM, Motorola and Samsung are well-known examples of companies adopting an integrated business model, ARM, Qualcomm and Broadcom can be taken as examples of companies adopting a licensing-based patent commercialization strategy.[8]

Given that the number of firms embracing the licensing-based commercialization strategy in the semiconductor industry has increased tremendously over the course of the last thirty years (Macher et al., 2002; Hall and Ziedonis, 2001), this setting provides optimal opportunities to study our research question.

4. DATA AND METHODS

4.1 Sample

Our analyses are based on a sample of 131 companies that went public in the United States in the semiconductor industry in the period 1996-2007. The initial sample of semiconductor

[7] Linden and Somaya (2003) introduce a further distinction with reference to component-modes, adopted by those independent component manufacturers specialized in the production of components to be sold to integrated companies for assembly.

[8] For example, ARM (Advanced RISC Machines) is a very effective example of licensing-based firm (Davis, 2008). Founded by twelve Cambridge engineers in 1990, it invented the RISC chip. It calls itself a purely intellectual property licensing company: instead of bearing the costs associated with manufacturing, it licenses its proprietary technology to semiconductor manufacturers and OEMs. By the end of 2008, more than 200 leading semiconductor companies had licensed more than 580 ARM technology designs.

firms (SIC code 3674) was obtained from Securities Data Corporation (SDC) database, New Issues. Our sample period begins in January 1996 because IPO prospectuses are available on SEC Electronic Data Gathering, Analysis, and Retrieval (EDGAR) service only after that time. The initial sample consisted of 178 semiconductor firms that have an IPO prospectus.
The first sample selection criterion excluded 20 firms without price and accounting data available from Worldscope and Datastream. We lost an additional 27 firms due to missing information on final IPO offer price required for the calculation of underpricing, reducing the final sample size to 131 firms.

--- Insert Table 1 about here ---

Since the IPO prospectus is the primary sources of information on newly issued stocks, we define a firm's patent commercialization strategy (integrated vs. licensing-based) analyzing the information reported in the "Prospectus Summary" and "Business description" sections of IPO prospectus.

4.2 Data sources and variables definition

The data used in this study are derived from different sources. From Securities Data Corporation (SDC) database we obtained financial information on the IPO. For each firm of our sample we collected IPO prospectus and integrated data on firm's characteristics and fill missing data from SDC. Financial statement information (assets, debt, revenue, earnings, shareholder's equity, R&D expense) is obtained from Worldscope and Datastream. Ritter's data set (Loughran & Ritter, 2004) provided company founding dates and underwriters' reputation rankings. From Delphion database we retrieved data on patents granted by the USPTO to each firm in the 5 years before the IPO, as done in the paper by Heeley et al. (2007). Finally, measures of disclosure were derived from content analysis of the IPO prospectus. Our analyses involve four sets of variables related to IPO and firms' characteristics, disclosure and patents.
Among IPO characteristics, underpricing (*UP*) is our dependent variable and measures the percent change in stock price during the first day of trading. It is calculated as follows:

$$\frac{P_1 - P_0}{P_0}$$

where P_1 is the closing price at the end of first day of trading of IPO, P_0 is the offer price of IPO. Prestigious underwriter (*prest_underwriter*) is a dummy variable taking the value of one if underwriter reputation measure (Loughran and Ritter, 2004) is equal to or greater than 8.00, zero otherwise. Insider shareholders (*insider*) measures the proportion of total shares outstanding after the IPO retained by insiders shareholders. Internet bubble period (*bubble*) is a dummy variable taking value one if IPO occurs in years 1999 and 2000, zero otherwise.

As concerns firms' characteristics, *Licensing-based* strategy is a dummy variable that classifies company's commercialization strategy. It takes the value of one if a company adopts a licensing-based strategy and the value of zero if company has an integrated-strategy. In order to identify the specific patent commercialization strategy, we analyzed the sections "Prospectus Summary" and "Business description" of IPO prospectuses. In particular, a company is coded as licensing-based if it describes itself as specialized design firms earning revenues solely from licensing or from a combination of licensing and products, zero otherwise.

We further validate the measure of firms' commercialization strategy computing the correlations between *Licensing-based* and, respectively, the total number of words on licenses reported in the IPO prospectus (*Licenses words*) and a dummy variable that takes value 1 if company earns revenues from licenses (*Revenues from licenses*).[9]

--- Insert Table 2 about here ---

Table 2 confirms high significant correlations between licensing-based strategy and, respectively, companies earning revenues from licenses (0.46 significant at 1% level) and word counting of licenses (0.24 significant at 1% level).

Our final sample is constituted by 36 (27%) companies adopting licensing-based commercialization strategies and 95 (73%) integrated firms, for a total of 131 firms. Table 3 shows the distribution of IPO by year and commercialization strategy of the firm going public. In the whole sample period, the percentage of integrated firms on the total of firms

[9] We include among the variable *Licenses words* the following words: "license-s/d", "licensing", "licensor", "royalty", "royalties", "sublicense-s/d", "sublicensing", "sublicensor".

going public remains always above the 60%.

--- Insert Table 3 about here ---

Venture capital backed (*VCbacked*) is a dummy variable taking the value of one if a company has venture capital backing and the value of zero otherwise. *Firm age* is the difference between company's founding year (Ritter 2004) and IPO year. In the empirical model we use the log-transformation of firm age to account for skewness in the data. High R&D intensity (*High R&D)* is dummy variable taking value of one if the R&D intensity is above the median. In particular R&D intensity is calculated as R&D expenditures of year before IPO scaled by sales. *Debt* is company's total debt scaled by total assets. Both accounting variable are calculated for the year just prior to the IPO. Loss firms (*loss*) is a dummy variable taking the value of one if a firm reports negative net income for the year just prior to the IPO and the value of zero otherwise. Primary SIC 3674 (*SIC 3674*) is dummy variable taking value of one if a company has semiconductor (3764) as main SIC code and the value of zero otherwise. In particular, the main SIC code represents the business segment providing the most revenue to the company.

In order to compute disclosure measures, we performed a content analysis of IPO prospectuses. In addition to *licenses words* used to validate a firm's commercialization strategy, we computed the following two variables: *secrecy* defined as total number of words on secret disclosed in the IPO prospectus[10], while *IPR words* measures the total number of words related to Intellectual Proprietary rights.[11]

Finally, as patents-related measures we calculated *patents stock* that measures the total number of patents granted at the USPTO in the 5 years before the IPO. *Citations* is the number of forward citations per patents received by firm's patents stock. It is normalized in order to account for patent truncation.[12]

[10] We include among the variable *secrecy* the following words: "secret", "secrets" and "secrecy".

[11] The variable *IPR words* comprises the variable *Licenses words* (above defined) and the following words: "patent-s/ed/ing/able", "patentability", "unpatentable", "assignee-s", "copyright-s/-ed/-able", "trademark-s", "intellectual".

[12] We calculated a normalized citation intensity indicator to control for the truncation in time of citations, given that - *ceteris paribus* - older patents are likely to receive more citations. We first computed the difference between the average number of citations received per firm's patent and the industry citation intensity. This last one is defined as the average number of citations per patent received by the firms included in our sample in a given year. We than computed the normalized indicator as the ratio of the difference described above and the industry citation intensity.

4.3 Methods

In order to analyze whether the choice of a given commercialization strategy impacts on the degree of information asymmetries between the issuer and the investors, the empirical analysis intends to estimate the impact of the licensing-based strategy on IPO underpricing.
To this purpose, we first present descriptive analyses in order to understand whether companies adopting licensing-based or integrated-strategy significantly differ in terms of firms' and IPO characteristics, disclosure and patents measures.
Then, multivariate analyses are employed to investigate whether and to what extent the degree of IPO underpricing is affected by licensing-based strategy. In particular, to test the hypothesized relationships, we started by estimating the following OLS equation:

$$UP_i = a_0 + a_1 licensing\_based_i + a_2\ patents\_stock_i + a_3 citations_i + a_4 secrecy_i + a_5 control\ variables\ + e_i \quad (1)$$

where UP_i is the IPO underpricing, *licensing_based* is dummy variable for companies adopting a licensing-based strategy, *patents stock* is total number of patents granted at the USPTO in the 5 years before the IPO, *citations* is the number of forward citations received by firm's patents stock normalized in order to account for patent truncation, *secrecy* is the total number of words on secret disclosed in the IPO prospectus. The independent control variables included in Eq. (1) are: dummy prestigious underwriter (*prest_underwriter)*, insider shareholders (*insider*), dummy for internet bubble period (*bubble*), company's total debt scaled by total assets (*debt*), dummy for loss firms (*loss*), dummy for semiconductor as main SIC code (*SIC 3674*).

4.3.1 Endogeneity issue

In the analysis of the relationship between the choice of a given commercialization strategy and the degree of IPO underpricing, a firm's decision to adopt licensing-based strategy cannot be treated as an exogenous variable. The estimation of equation (1) through standard OLS does not account for the endogeneity and self-selection of licensing-based strategy leading to inconsistent coefficients estimates.
Managers make decision on the type of commercialization strategy to adopt not randomly (Hamilton & Nickerson, 2003). Then, it is likely that a set of unobserved factors influence the firm's choice for a licensing-based strategy (or integrated one) and they are also likely to

influence the IPO underpricing. Consequently, we apply a treatment effect approach and estimate the following set of equations:

$$Licensing\_based_i = c_0 + c_1\ highR\&D_i + \ c_2\ VCbacked_i + c_3\ log(age)_i + + u_i$$

$$UP_i = \ b_0 + b_1 licensing\_based_i + b_2\ patents\_stock_i + b_3 citations_i + b_4 secrecy_i + b_5 control\ variables\ + e_i \quad (2)$$

Eq. (2) models the choice of adopting a licensing-based strategy as compared to an integrated strategy, while Eq. (1) estimates the impact of commercialization strategy adopted on underpricing. In order to explain the decision for licensing-based strategy, we use the following independent variables used by prior studies (Hall and Ziedonis 2001, Ahuja and Lahiri 2006): dummy for high R&D intensity (*High R&D*), dummy for venture capital backed (*VCbacked*), firm age (*log age*).

5. ANALYSES AND RESULTS

5.1 Descriptive statistics

Table 4 presents descriptive statistics for the sample of IPO firms, and a comparison of mean values between the sub-samples of firms adopting different commercialization strategies (licensing-based strategy vs. integrated-strategy).

--- Insert Table 4 about here ---

Average IPO underpricing in the full sample is 19%, a value in line with results provided by previous studies[13]. It is noteworthy that average IPO underpricing is higher in the group of firms adopting a licensing-based commercialization strategy (26%) as compared to integrated companies (16%). The difference is statistically significant at the 10% level if we perform a one-tailed t-test.

[13] In a survey of IPO activity in the U.S. over the period 1980-2001, based on a sample of 6249 IPOs from various samples, Ritter and Welch report average underpricing levels of 18.8% over the whole period. The study of Helley et al. (2007) reports slightly lower average levels of first-day stock returns (11.65%). However, it is a based on a sample of IPOs from the period 1981-1998, thus excluding the "hot market" period 1999-2000, characterized by very high values of underpricing, due to the Internet bubble.

From the table, we can observe other important differences between licensing-based firms as compared to fully integrated ones. The former group tends to be younger and smaller at the time of IPO. Firms in this group tend to go public on average after 11 years from their founding, as opposed to 16 years in the case of integrated companies, whereas their revenues are on average $33.43 as compared to $174.81 million in the other group. Moreover, licensing-based companies are significantly more R&D intensive than their counterparts. Finally, they are more likely to reach the IPO with negative profitability levels, the dummy Loss being significantly higher in their case (0.72 vs. 0.42). All such findings signal the higher risk profile of such companies from the perspective of an external investor, and support our expectations of higher information asymmetries characterizing them.

Other interesting findings emerge in Table 4, with respect to the level of disclosure on IPRs characterizing the two groups of companies. In many respects, licensing-based companies tend to provide more information regarding IPRs in the IPO prospects. The frequency of word counts related to licensing and in more general terms to IPRs in such documents is significantly higher for design specialist firms as compared to integrated companies, the difference being statistically significant at the 5% level. On the one hand, this evidence confirms that the protection and exploitation of IPRs represent critical factors for commercialization strategies based on licensing. On the other hand, it suggest that licensing-based companies going public have to provide more detailed information on IPRs and other intangible assets in their financial statements in order to lower general information asymmetries towards the financial markets.

In Table 5 we report the correlation coefficients. No serious problems of multicollinearity seem to emerge.

--- Insert Table 5 about here ---

5.2 Regression Results

Table 6 shows the results of our regression analysis. We started by estimating equation (1) through standard OLS in order to investigate the relation of IPO underpricing and licensing-based strategy.

--- Insert Table 6 about here ---

We find that the probability the choice to adopt a licensing-based strategy significantly (at the 5% level) increases IPO underpricing, suggesting that the degree of information asymmetry is positively related to the type of commercialization strategy adopted. Looking at the relation between IPO underpricing and patent-related measures, we find that patents stock and citations normalized are not statistically significant at conventional levels. Further interesting finding concerns the level of disclosure on secrecy words. We find that information asymmetry between company and investors decrease as firm disclose more that rely on secrets in order to protect intellectual proprietary rights. As regards control variables, we find positive and significant (at 1% level) effects of prestigious underwriter and Internet bubble period on IPO underpricing. Conversely, firm's debt significantly (at 10% level) reduces IPO underpricing.

Despite the relevance of these findings, estimations through standard OLS could lead to inconsistent coefficient estimates due to the potential endogeneity of the licensing-based strategy. The right column of Table 6 shows the results of treatment effect approach in which we firstly model the choice of adopting a specific commercialization strategy (licensing-based versus integrated-based) and, secondly, estimate the impact of commercialization strategy on IPO underpricing.

The decision of adopting a licensing-based strategy as compared to an integrated approach is significantly related to high level of R&D intensity and affected by venture capital funding. Conversely, firm's age does not influence the choice of commercialization strategy. Examining the effect licensing-based strategy on IPO underpricing, treatment effect model confirms previous result. After controlling for the self-selection of commercialization strategy, we still find that a licensing-based strategy significantly (at 5% level) increases IPO underpricing and the degree of information asymmetry. Similarly, findings of treatment effect approach confirm that disclosure on secrecy is negatively related to IPO underpricing. Patent-related measures exhibit no significant effects, indicating that stock market valuation of semiconductor companies might not be influenced by the simple possession of patents, but it is affected by the strategic use which is made of them to create and capture value (Hall and Ziedonies, 2001). As regards control variables, we find that prestigious underwriter and Internet bubble period significantly (at 1% level) increase IPO underpricing. Conversely, we find significant and negative effects of debt (at 5% level), insider shareholder (at 10% level) and loss firms (at 10% level) on IPO underpricing. Finally, the control variable for semiconductor as main SIC code has not significant effects in both OLS and treatment effect model.

6. CONCLUSIONS

In this paper we have analyzed whether patent commercialization strategy affects IPO underpricing. Whereas the existing literature has provided interesting results on the role of patents in reducing information asymmetries and limiting underpricing, it has not considered that the strategy to exploit patents may also be important. Focusing on the semiconductor industry, where it is possible to identify two distinct types of patent commercialization strategy (licensing based vs. integrated), we have shown that the decision to adopt a licensing-based strategy increase underpricing at the moment of the IPO. This is due to the greater uncertainty on the value of the firms adopting this strategy, which increases information asymmetries and therefore the underpricing.

Our result shed new light on a relevant topic, which is the effect of patent commercialization strategies on firm value. We advance that not only patents are important, but also the way they used and combined within a firm's strategy. This poses a new attention on the heterogeneity of firms' patent strategies and their relevance in explaining performance. New evidence using measures at the firm-level could be important to investigate more in depth this issue.

The results presented in the paper have also potential importance implications for managers. The fact that licensing-based firms suffer from a higher underpricing could have several consequences for the pricing strategies and the timing of the IPO. To avoid strong discount, these firms could delay the moment of the IPO and disclose more information to potential investors. In this way, the information asymmetries could be mitigated and the pricing could be more efficient.

We have to acknowledge that at the present status the paper still presents several limitations. First, although our effort of validation, our measure of the patent commercialization strategy is imperfect and could be improved by using alternative variables. Second, the theoretical background and the empirical analysis do not account completely for potential interactions between patents and strategies. Some patents could be more valuable when firms adopt a given commercialization strategy and viceversa. This is an interesting issue that deserves further development. Third, we do not analyze how the relevant information about patents and patent strategies flows from firms going public to investors. A more compelling analysis of disclosure behavior would be needed to shed more light on the relationship between patents and underpricing.

Notwithstanding these limitations, we believe that our analysis is dealing with an innovative topic, namely the relationship between patent commercialization strategies, information asymmetries and underpricing, which may have important implications for both academics and practitioners.

References

Aboody, D., Lev, B., (2000). "Information asymmetry, R&D, and insider gains", *Journal of Finance* 55 (2000), 2747-2766.

Ahuja, G., Lahiri, N., (2006). "Integration and search", working paper.

Arora, A., Fosfuri, A., Gambardella, A., (2001). "Markets for Technology: The Economics of Innovation and Corporate Strategy" MIT Press, 2001.

Barron, O., Byard, D., Kile, C., Riedl, E., (2002). "High-technology intangibles and analysts' forecasts", *Journal of Accounting Research* 40 (2), 289-312.

Barth, M., Kasznik, R., McNichols, M., (2001). "Analyst coverage and intangible assets", *Journal of Accounting Research* 39 (1), 1–34.

Beatty, R.P., Ritter, J.R. , (1986). "Investment banking, reputation, and the underpricing of initial public offerings", *Journal of Financial Economics* 15, 213-232.

Bessser, W., Bittelmeyer, C., (2008). "Patents and the performance of technology firms: Evidence from initial public offerings in Germany", *Financial Markets and Portfolio Management* (22), 323-356.

Carpenter, R. E., Petersen, B. C., (2002). "Capital market imperfections, high-tech investment, and new equity financing", *Economic Journal* 112, 54-72.

Chin, C., Lee, P., Kleinman G., Chen, P.Y., (2006). "IPO anomalies and innovation capital", *Review of Quantitative Financial Accounting* (27), 67-91.

Cockburn, I. & MacGarvie, M., (2006). "Entry, exit and patenting in the software industry", NBER Working paper no. 12563, 2006.

Cohen, W.M., Nelson, R.R., Walsh, J.P., (2000). "Protecting their intellectual assets: Appropriability conditions and why U.S. manufacturing firms patent (or not)", NBER Working Paper no. 7552, 2000.

Davis, L., (2008). “Licensing strategies of the new “Intellectual Property Vendors””, *California Managament Review* 50(2), 6-31.

Deng, Z., Lev, B., Narin, F., (1999). “Science and technology as predictors of stock performance”, *Financial Analysts Journal* (May/June), 20-32.

Fosfuri, A., 2006. “The licensing dilemma: Understanding the determinants of the rate of technology licensing”, *Strategic Management Journal* 27(12), 1141-58.

Gans, J.S., Stern, S., (2003). “The product market and the market for “ideas”: Commercialization strategies for technology entrepreneurs”, Research Policy 32, 333–350.

Grindley, P., Teece, D., (1997). “Managing intellectual capital: licensing and cross-licensing in semiconductors and electronics”, *California Management Review* 39(2), 8-41.

Gu, F., Wang, W., (2005). “Intangible assets, information complexity, and analysts’ earnings forecasts”, *Journal of Business Finance & Accounting* 32 (9-10), 1673-1702.

Guo, R., Lev, B., Zhou, N., (2004). “Competitive costs of disclosure by biotech IPOs”, *Journal of Accounting Research* 42, 319–55.

Guo, R., Lev, B., Shi, C., (2006). “Explaining the short and long-term IPO anomalies in the US by R&D”, *Journal of Business Finance & Accounting* (33), 550–579.

Hall, B., Jaffe, A. B., Trajtenberg, M., (2005). “Market value and patent citations”, *Rand Journal of Economics* 36, 16-38

Hall, B, Ziedonis, R., (2001). “The patent paradox revisited: An empirical study of patenting in the U.S. semiconductor industry, 1979-1995”, *The RAND Journal of Economics* 32(1), 101-128.

Hall, B., Ziedonis, R., (2007). “An empirical analysis of patent litigation in the semiconductor industry”, paper presented at the 2007 American Economic Association annual meeting, Chicago, IL, 4-7 January

Hamilton, B. H., Nickerson, J. A., (2003). “Correcting for endogeneity in strategic management research”, *Strategic Organization* 1, 51-78.

Hand, J., Lev, B., (2003). “Intangible assets: Values, measures, and risks”, New York: Oxford University Press.

Heeley, M. B., Matusik, S. F., Jain, N., (2007). “Innovation, appropriability, and the underpricing of initial public offerings”, *Academy of Management Journal* (50), 209–225.

Himmelberg, C. P., Peterson, B. C., (1994). “R&D and internal finance: A panel study of small firms in high-tech industries”, *Review of Economics and Statistics* 76, 38-51.

Hsu, D. H., Ziedonis, R. H., (2008). “Patents as quality signals for entrepreneurial ventures”, Academy of Management Best Paper Proceedings.

Kasch, S., Dowling, M., (2008). "Commercialization strategies of young biotechnology firms. An empirical analysis of the U.S. industry", *Research Policy* 37 (2008), 1765–1777.

Lamoreaux, N., Sokoloff, K.L., (1999). "The Geography of the Market for Technology in the Late-Nineteenth and Early-Twentieth Century United States" in Gary D. Libecap, ed., Advances in the Study of Entrepreneurship, Innovation, and Economic Growth, Stamford, CT: JAI Press.

Lev, B., (2008). "The conceptual company risks, rewards and research ideas", Key-note address, IC4 Conference, The World Bank, Paris, May 2008.

Lev, B., Sougiannis, T., (1996). "The capitalization, amortization, and value-relevance of R&D", *Journal of Accounting and Economics* 21 (1996), 107–138.

Lev, B., Sougiannis, T, (1999). "Penetrating the book-to-market black box: the R&D effect." *Journal of Business Finance and Accounting* 23 (1999), 419-449.

Linden, G., Somaya, D., (2003). "System-on-a-chip integration in the semiconductor industry: Industry structure and firm strategies", *Industrial and Corporate Change* 12(3), 545-576.

Ljungqvist, A., (2005). "IPO underpricing" in B. Espen Eckbo (ed.), Handbook of Corporate Finance: Empirical Corporate Finance. Handbooks in Finance Series, Elsevier/North-Holland, 2005.

Macher, J. T., Mowery, D.C., Simcoe, T. S., (2002). "eBusiness and the semiconductor industry value chain: Implications for vertically specialized and integrated semiconductor manufacturers", *Industry and Innovation* 9(3).

Mann, R. J., Sager, T. W., (2007). "Patents, venture capital, and software startups", *Research Policy* 36, 193-208.

Pisano, G. P., (2006). "Science business: The profits, the reality and the future of biotech", Harvard Business School Press, Boston, MA (2006).

Reitzig, M., Henkel, J., (2008). "Patent sharks", *Harvard Business Review* 86(6), 129-133.

Ritter, J. R., (1984). "The hot issue market of 1980", *Journal of Business* 57, 215-240.

Ritter, J. R., (1998). "Initial pubblic offering", *Contemporary Finance Digest* 2(1), 5-30.

Rock, K., (1986). "Why new issues are underpriced", *Journal of Financial Economics* 15, 187-212.

Teece, D.J., (1989). "Profiting from technological innovation", Research Policy 15 (1986), 285-305.

TABLES AND FIGURES

Tab. 1 Sample selection criteria

	No. Companies
Initial Sample: companies with IPO prospectus available on-line	178
Less: companies without Worldscope-Datastream data	*20*
Less: companies without information on offer price	*27*
Final Sample	**131**

Tab. 2 Correlations of variables related to licensing behaviour of companies in the sample

	Licensing based companies	Licenses words	Dummy Revenues from Licenses
Licensing based companies	1		
Licenses words	0.24***	1	
Dummy Revenues from Licenses	0.46***	0.34***	1

*** significant at the 1% level

Tab. 3 The distribution of companies by IPO year

	Integrated	***Licensing based***	***Total***
1996	7 *88%*	1 *13%*	8 *100%*
1997	10 *71%*	4 *29%*	14 *100%*
1998	4 *67%*	2 *33%*	6 *100%*
1999	13 *68%*	6 *32%*	19 *100%*
2000	25 *78%*	7 *22%*	32 *100%*
2001	3 *60%*	2 *40%*	5 *100%*
2003	4 *80%*	1 *20%*	5 *100%*
2004	9 *64%*	5 *36%*	14 *100%*
2005	6 *67%*	3 *33%*	9 *100%*
2006	8 *89%*	1 *11%*	9 *100%*
2007	6 *60%*	4 *40%*	10 *100%*
Total	95 *73%*	36 *27%*	131 *100%*

Tab. 4 Descriptive statistics (mean values)

	Integrated	Licensing based	*t-value*[a]	Total
Underpricing	0.16	0.26	*-1.43*	0.19
Prestigious underwriter[b]	0.77	0.92	*-2.32***	0.80
Insider shareholder	0.75	0.74	*0.16*	0.75
Internet bubble[b]	0.40	0.36	*0.41*	0.39
VCbacked[b]	0.60	0.83	*-2.89****	0.66
Age	16	11	*1.63**	15
High R&D intensity[b]	0.41	0.78	*-4.23****	0.51
Debt	0.28	0.25	*0.40*	0.27
Loss firms[b]	0.42	0.72	*-3.30****	0.50
Primary SIC3674[b]	0.76	0.83	*-0.98*	0.78
Licenses words	77.3	169.9	*-2.39***	102.7
Secrecy	8.7	10.8	*-1.18*	9.3
IPR words	198	314	*-2.10***	230
Patents stock	31.46	29.42	*0.19*	30.90
Citations	11.62	12.00	*-0.14*	11.72
N	95	36		131

[a)] The differences in means are based on pairwise t-tests with unequal variance. t-value in italic.
[b)] Dummy variable.
*** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level in a two-tailed test

Tab. 5 Correlations between main variables of interest

	1	2	3	4	5	6	7	8	9	10
Underpricing (1)	*1*									
Licensing based (2)	*0.13*	*1*								
Patents stock (3)	*0.07*	*-0.02*	*1*							
Citations (4)	*0.11*	*0.01*	*0.07*	*1*						
Secrecy (5)	*-0.08*	*0.10*	*0.06*	*0.31****	*1*					
prest_underwriter (6)	*0.33****	*0.17***	*0.19***	*0.21***	*0.10*	*1*				
insider (7)	*-0.12*	*-0.02*	*0.10*	*0.15**	*0.10*	*0.07*	*1*			
bubble (8)	*0.25****	*-0.04*	*0.00*	*0.11*	*0.24****	*0.23****	*-0.01*	*1*		
debt (9)	*-0.23****	*-0.05*	*-0.10*	*-0.08*	*-0.14*	*-0.18***	*-0.02*	*-0.03*	*1*	
loss (10)	*-0.08*	*0.27****	*-0.02*	*0.13*	*0.23****	*0.06*	*-0.04*	*0.13*	*0.07*	*1*
SIC 3674 (11)	*0.02*	*0.08*	*-0.03*	*0.03*	*-0.03*	*0.12*	*0.05*	*-0.03*	*-0.02*	*0.17***

*** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level in a two-tailed test

Tab. 6 Regression results[a]

	OLS *(1)*	*Treatment effect model* *(2)*
Dep. Var.: ***Underpricing***		
Intecept	0.209	0.161
	*0.109***	*0.112*
Licensing based[b]	0.103	0.388
	*0.059**	*0.174***
Patents stock	0.000	0.000
	0.000	*0.000*
Citations	0.002	0.001
	0.002	*0.002*
Secrecy	-0.006	-0.006
	*0.003***	*0.003***
prest_underwriter[b]	0.186	0.191
	*0.047****	*0.067****
insider	-0.178	-0.184
	0.140	*0.108**
bubble[b]	0.165	0.152
	*0.063****	*0.053****
debt	-0.159	-0.160
	*0.087**	*0.068***
loss[b]	-0.082	-0.103
	0.059	*0.053**
SIC 3674[b]	0.008	-0.015
	0.047	*0.060*
Dep. Var.: ***Licensing based***		
Intecept		-1.133
		*0.492***
High R&D[b]		0.787
		*0.271****
VCbacked[b]		0.495
		*0.293**
log Age		-0.128
		0.163
N	131	131
F-value	5.13***	
R^2	0.240	
Wald chi2		44.64

a) Consistent standard errors are in italic.
b) Dummy variable.
*** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level in a two-tailed test