

# Patent Commercialization Strategy and IPO Underpricing: Evidence from the US Semiconductor Industry

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## Abstract

R&D and innovation are critical factors to succeed. Nevertheless, they generate information asymmetries between corporate insiders and external investors. Within the context of an IPO, information asymmetries increase the risk of underpricing. In this paper, we claim that the patent commercialization strategy of the firm going public affects information asymmetries and IPO underpricing. In particular, underpricing will be higher when a firm's patent commercialization strategy is more based on licenses. A firm's stock of patent attenuates this effect. Our results on a sample of 130 IPOs in the US semiconductor industry confirm these predictions.

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# **Patent Commercialization Strategy and IPO Underpricing: Evidence from the US Semiconductor Industry**

## **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 & Lev, 2000). Therefore, on one hand innovation contributes to firm value by boosting expected economic performance, while on the other hand it can reduce firm valuation by external investors due to potential adverse selection arising from information asymmetries. Although several studies have shown a positive valuation of patents and R&D investments by the stock markets (e.g., Hall, Jaffe, & Trajtenberg, 2005; Hall & Oriani, 2006), other authors have advanced that more R&D intensive firms are systematically undervalued (e.g., Chan, Lakonishok, & Sougiannis, 2001; Eberhart, Maxwell, & Siddique, 2004).

Information asymmetries represent a problem especially for the funding of younger and R&D-intensive firms operating in high tech industries, for which external investors have less information available, often creating serious financing constraints (e.g., Guiso, 1998; Carpenter & Petersen, 2002). A critical step in the financing of these firms is the Initial Public Offer (IPO), which potentially allows them raise new funds through the issue of new shares acquired by external investors. The proceedings from the share issue can be allocated to finance innovation and growth. However, within the context of an IPO, the presence of information asymmetries may result in a higher risk of underpricing for the firm going public (e.g., Guo, Lev, & Shi, 2006). Underpricing is usually defined as the difference (if positive) between the closing price of the stock at the end of the first day of trading and the initial offer price divided by the offer price (i.e., the stock return of the first trading day). It represents money left on table by the firm and pre-IPO shareholders, involving a transfer of

wealth from pre-IPO shareholders to first-day investors (Certo, Covin, Daily, & Dalton, 2001).

In order to reduce information asymmetries and mitigate underpricing, firms going public may disclose information to signal their quality (Certo, 2003). Existing studies have demonstrated, for example, that IPO performance is affected, among others, by underwriter prestige (e.g., Carter, Dark, & Singh, 1998), venture capital backing (e.g., Megginson & Weiss, 1991), the presence of one or more founders (Nelson, 2003), board composition (Filatotchev and Bishop, 2004), top management team legitimacy (Cohen & Dean, 2005) and the level of CEO equity (Certo, Daily, Cannella, & Dalton, 2003).

For more R&D-intensive firms, however, the effect of signaling is more controversial, as they are characterized by higher information asymmetries. In this respect, patents have been considered a valid signal of the quality of a firm's innovation activities (Long, 2002; Hsu & Ziedonis, 2008). Some recent studies have focused on the relationship between patent-based measures and the pricing of IPOs. Specifically, Chin, Lee, Kleinman, and Chen (2006) have found a positive association between number of patents and IPO performance. Heeley, Matusik and Jain (2007) have documented how the number of patents significantly reduces IPO underpricing, but only in the industries characterized by stronger appropriability regimes. The previous papers, however, have not considered the importance of firm-specific innovation strategies within the IPO context. As Certo and colleagues (2009: 1359) have pointed out in a recent review on IPO research, "... scholars should direct their attention to uncovering how and why some firms are able to convert such investments into gains at IPO, whereas others are not". Indeed, although in high-tech industries patents represent fundamental assets, firms generally adopt different strategies to exploit and commercialize them. In the specific case of the semiconductor industry, for example, Hall and Ziedonis (2001) showed that patents play a multifaceted role: large-scale manufacturers use patents as legal rights to exclude other

producers, whereas specialized design firms use them as a signal to attract the interest of downstream manufacturers and financial investors.

Thus, IPO underpricing might not be influenced only by the possession of patents, but also by the strategic use which is made of them to create and capture value, i.e. *patent commercialization strategy*. We refer in particular to two different patent commercialization strategies (Hall & Ziedonis, 2001; Linden & Somaya, 2003; Ahuja & Lahiri, 2006; Fosfuri, 2006): a) licensing-based strategies adopted by firms focusing on the development of patented technologies which are then licensed to external partners; b) integrated strategies, adopted by firms which exploit patents within the development, manufacturing and commercialization of new products.

While previous research has addressed the determinants of the choice of a commercialization strategy based on licensing (e.g., Gans & Stern, 2003; Arora & Merges, 2004; Fosfuri, 2006; Kasch & Dowling, 2008), to our knowledge no previous work has studied the relationship between the choice of a particular patent commercialization strategy and the access to external financing. With specific reference to IPOs, 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.

In order to complement previous literature, we intend, therefore, to analyze the two following research questions: *i) How does the choice of a given patent commercialization strategy affect IPO underpricing?; ii) Does a firm's patent stock moderate the effect of the patent commercialization strategy on IPO underpricing?*. We will analyze these research questions in the semiconductor industry, on a sample of 130 firms that went public in the United States in the period 1996-2007. The semiconductor industry represents an ideal setting to test our hypotheses given the surge in the number of patents and the presence of firms with different

commercialization strategies (Hall and Ziedonis, 2001). In order to analyze the patent commercialization strategies, we relied on the information about the revenues generated by patent licensing activities reported in the IPO prospectus.<sup>2</sup> Our empirical analysis provides two main results. First, we show that when firms rely more on licensing-based patent commercialization strategies, the underpricing at their IPO is higher. Moreover, a firm's stock of patents can reduce underpricing when the patent commercialization strategy is more based on licenses.

The rest of the paper is organized as follows. In the next section we present our theoretical background and our research hypotheses. In Section 3 we introduce 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 analyses.

## **2. THEORY AND HYPOTHESES**

### **2.1 Innovation and information asymmetries**

R&D investments generate information asymmetries between insiders and external investors, since they are highly idiosyncratic and have very uncertain results. These information asymmetries can hinder the financing of innovation (Hall, 2002). In fact, as external investors 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

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<sup>2</sup> 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.

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 & Petersen, 1994; Guiso, 1998; Carpenter & 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.

In the specific case of firms going-public, therefore, patents could be important for reducing the level of information asymmetries involved in the IPO. However, in this paper we advance that their role depends on the patent commercialization strategy adopted by the firm going public.

## **2.2 Patent commercialization strategy and IPO underpricing**

A well known pattern associated with the process of going public is the ‘underpricing’, as measured by the high initial returns of an IPO which occur when the share offer price is below the closing price at the end of the first day of trading. The empirical regularity of IPO underpricing has motivated a large theoretical literature trying to explain its causes (see Ritter and Welch, 2002, for a review of the empirical evidence). The most established explanation for underpricing resides in the model based on information asymmetries, which assumes that firms and underwriters will discount the initial offer price in order to induce external investors to buy stock in absence of full information on firm’s value (Rock 1986). In particular, the initial underpricing should increase with the ex ante uncertainty about the value of the IPO firm (Ritter, 1984, Beatty & Ritter, 1986).

As explained in the previous section, the economic attributes of innovation lead to higher information asymmetries between corporate insiders and external investors, increasing therefore the risk of potential underpricing at the IPO. For instance, in a study of 1431 IPOs in the United States, Heeley and colleagues (2007) found that firms investing more in R&D experienced higher underpricing. In a similar vein, Guo and colleagues (2006) showed that, on a sample of 2,696 US IPOs issued during 1980–1995, the R&D activities of issuers significantly affected both the initial underpricing of IPOs and their long-term performance.

Previous research has shown that patents can play a role in this context (Heeley et al., 2007), but we claim that information asymmetries are affected as well by the specific patent commercialization strategy a firm will decide to adopt. In a seminal article, Teece (1986) has discussed how firms can choose different governance modes in order to translate innovation 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. Cooperation can take various forms, ranging from equity-based cooperation or joint ventures, strategic alliances or patent licensing agreements.

We explicitly focus on a firm's decision to license patents to one or more buyers, referring to firms adopting licensing-based patent commercialization strategies. The increasing interest for this type of commercialization strategy in a wide variety of industries is a consequence of the rapid diffusion of the "markets for technologies" (Arora, Fosfuri, & Gambardella, 2001). Although markets for technologies are not a new phenomenon (Lamoreaux & 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 as chemical engineering, semiconductors and electronics, software, biotechnology and pharmaceutical (e.g., 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 license them in the downstream market<sup>3</sup>.

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<sup>3</sup> 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 & 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 & Toschi, 2009), several new start-ups adopt business model based on licensing to

We argue that firms relying more on a licensing-based patent commercialization strategy will be characterized by higher information asymmetries and, as a consequence, by a higher underpricing, for at least two different reasons. First, firms adopting a licensing-based commercialization are more intangibles-intensive than other firms (their main resources being R&D, patents, other IPRs, alliances, human and social capital) and they possess negligible physical assets (Lev, 2008). This is likely to pose significant valuation problems by financial analysts and create higher information asymmetries between corporate insiders and external investors. Several studies have demonstrated that for intangible-intensive firms analyst coverage is significantly wider (Barth, Kasznik, & McNichols, 2001), but analysts' forecasts present larger errors (Gu & Wang, 2005) and higher variance (Barron, Byard, Kile, & Riedl, 2002). Moreover, financial reports provide less useful information to external investors on intangible assets than on tangible assets (Guo, Lev, & Zhou, 2005), thus exacerbating the information asymmetries between corporate insiders and external investors when a firm is more based on intangible assets.

Second, a licensing-based commercialization strategy involves higher contractual hazards (Teece, 1986). In fact, the difficulty to define ex-ante all the detailed specifications for the licensing agreements may lead to incomplete contracts and higher risks of opportunistic behavior by the counterpart.<sup>4</sup> Being highly specific to the licensing contracts, these risks generate higher information asymmetries between corporate insiders, better informed about the contracts, and external investors.

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exploit their patented inventions in a wide variety of application contexts, given the characteristics of general-purpose technology of this emerging field.

<sup>4</sup> A typical risk is that the licensor, through the upstream integration into R&D, becomes a direct competitor. 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.

In summary, our two explanations, based on the difficult valuation of intangible assets and the imperfections of licensing contracts, support the expectation of higher information asymmetries at the moment of IPO between a corporate insiders and external investors when the firm adopts a licensing-based patent commercialization strategy. This should result in the following hypothesis:

*Hypothesis 1. IPO underpricing will be higher for those firms relying more on a licensing-based patent commercialization strategy*

### **2.3. IPO underpricing and patents**

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

Other studies have examined patent-related measures as a signal of firm's value. Chin and colleagues (2006) have analyzed a cross-sectional sample of 623 Taiwanese IPO firms and found that official monthly reports of newly developed patents released to the public and the frequency of patent citations significantly increased IPO underpricing. They concluded that, because of high uncertain value of patents, greater level of innovation capital lead to greater uncertainty in firm's value. Bessler and Bittelmeyer (2008) investigated the relation between innovation and performance for a sample 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 was lower relative to the group of IPOs without patents in hot issue periods, but in contrast it was higher in cold issue markets. However, these results are far to be conclusive as they are based on descriptive statistics and not tested with multivariate analyses.

Finally, Heeley and colleagues (2007) conducted a cross-sectional study on a sample of 1,413 US firms conducting initial public offerings in the period 1981–98. They showed that patents have the potential to convey interpretable information to investors about the value of innovation, but only when there is a stronger relationship between patents and firm performance. They proved that patents reduce information asymmetries (i.e., underpricing) in industries with a stronger appropriability regime, while they generate higher underpricing in industries with a weaker appropriability regime.

However, none of these studies has considered that the effect of patents on underpricing may depend on the firm-specific patent commercialization strategy. In particular, a firm's stock of patents is more effective to mitigate information asymmetries when not only the industry-specific appropriability regime, but also the firm-specific patent commercialization strategy involves a clearer link between patents and expected performance. Within an integrated commercialization strategy, patents create value only indirectly, through the products that will be sold on the market. Firm's ability to effectively use patents depends on firm-specific, complex and idiosyncratic combinations of the patents with other resources and complementary assets (Teece, 1986; Miller, 1993; Certo et al., 2009). External investors will be less informed than corporate insiders about these combinations, so that patents will be less useful signal on firm quality.

Conversely, the adoption of a licensing-based patent commercialization strategy requires a direct exploitation of the patents owned, as firm's revenues mainly come from the licenses of these patents. Patents are the core assets for the firm and are used in isolation within licensing agreements to generate revenues. For firms adopting a licensing-based commercialization strategy, the possession of patents is then a critical condition to predict firm performance. Therefore, when the commercialization strategy is more based on licensing, patents become an extremely important quality signal for external investors (Hall & Ziedonis, 2001).

Accordingly, we advance the following:

*Hypothesis 2. A firm's patent stock negatively moderates the relationship between patent commercialization strategy and IPO underpricing.*

### **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, Klevorick, Nelson, & Winter, 1987; Cohen, Nelson, & Walsh, 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.<sup>5</sup>

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<sup>5</sup> 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 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 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 patent commercialization strategies: integrated and licensing-based ones (Linden & Somaya, 2003).<sup>6</sup> Firms adopting an integrated commercialization strategy own and control all the required resources for semiconductor manufacturing and commercialization: design, process technology, fabrication and assembly equipment, test equipment, distribution facilities. The firms adopting a licensing-based strategy 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. These firms typically outsource the fabrication of the devices to a specialized semiconductor manufacturer. Whereas IBM, Motorola and Samsung are well-known examples of companies adopting an integrated strategy, ARM, Qualcomm and

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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 & Teece, 2000).

<sup>6</sup> 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.

Broadcom can be taken as examples of firms adopting a licensing-based patent commercialization strategy.<sup>7</sup>

Given that the number of firms embracing the licensing-based commercialization strategy in the semiconductor industry has increased significantly over the course of the last thirty years (Macher, Mowery, & Simcoe, 2002; Hall & Ziedonis, 2001), this setting provides an ideal setting to study our research question.

## 4. DATA AND METHODS

### 4.1 Sample and data sources

Our analyses are based on a final sample of 130 companies that went public in the United States in the semiconductor industry in the period 1996-2007. Table 1 shows the distribution over time of the firms going public included in our sample.

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The initial sample of semiconductor 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 from that date. The initial sample consisted of 178 semiconductor firms that have an IPO prospectus. We first excluded 20 firms without price and accounting data available from Worldscope and Datastream. We lost additional 28 firms due to missing information on the final IPO offer price required for the calculation of underpricing, reducing the final sample size to 130 firms.

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<sup>7</sup> 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.

We collected the IPO prospectuses for all these firms from the SEC database. Since the IPO prospectus is the primary source of information on newly issued stocks, we used such source in order to define a firm's patent commercialization strategy (integrated vs. licensing-based), analyzing the information reported in the document. From the Securities Data Corporation (SDC) database we obtained financial information on the IPO. Financial statement information (assets, debt, revenues, earnings, shareholder's equity, R&D expenses) were obtained from Worldscope and Datastream. In particular, from the last financial statement reported in the IPO prospectus we manually collected the information on the amount of revenues arising from licensing. Ritter's data set (Loughran & Ritter, 2004) provided company founding dates and underwriters' reputation rankings. From Delphion database we retrieved data on patents filed at the USPTO by each firm in the 5 years before the IPO, as done in the paper by Heeley et al. (2007). Finally, measures of disclosure on licensing activities were derived from content analysis of the IPO prospectus.

## 4.2 Variable Definition

*Dependent variable.* In our regression analyses, we used *Underpricing (UP)* as dependent variable. It measures the percent change in the 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 the IPO and  $P_0$  is the offer price of the IPO.

*Independent variables.* In order to define a measure for the patent commercialization strategy, for each firm we created a variable *Licensing-based strategy* calculated as the ratio between a firm's revenues from licenses and total revenues, as reported in the last financial statement

before the IPO. This is a continuous variable ranging from 0 and 1 and measuring to which degree a firm relies on licensing-based patent commercialization strategy to capture the value of its innovation.<sup>8</sup>

In order to test Hypothesis 2, we followed Heeley and colleagues (2007) and created a variable *Patent stock*, measuring the total number of USPTO patents filed by the company in the 5 years before the IPO. There are two main reasons to adopt a five-year window before the IPO to construct such measure (Heeley et al., 2007). First, recent patents provide the most updated information about firm inventive capabilities at the time of IPO. Second, although in theory patent protection lasts for 20 years from the date of filing, previous research has shown that patents tend to be exploited in a relatively short protection period, after which they lose most of their economic value.

*Control variables.* In our regression analyses, we included a set of control variables that have been associated with underpricing by previous studies (see Ljungqvist, 2005, for a review). We include a measure of underwriter reputation to account for the effects of hiring a highly reputed lead underwriter on underpricing. Previous studies (e.g., Loughran & Ritter, 2004) have shown that since the 1990s prestigious underwriters have been associated with higher underpricing. We include a dummy variable (*Prestigious underwriter*) taking the value one if the underwriter reputation ranking proposed by Loughran and Ritter (2004) is equal to or greater to 8.00, and zero otherwise. In Loughran and Ritter's scale, a reputation ranking of 8.00 or higher indicates a top-tier underwriter, whereas a value less than 8.00 is associated with regional underwriters or small IPOs ("penny stocks"). We control for the retention of shares by insider shareholders (*Insider shareholder*) that measures the proportion of total shares

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<sup>8</sup> In order to validate such measure, we then created an additional variable – Licensing words - computed by counting the total number of words related to licensing disclosed in the IPO prospectus. We considered the following words to create such variable: "license-s/d", "licensing", "licensor", "royalty", "royalties", "sublicense-s/d", "sublicensing", "sublicensor". Our analyses show a significant correlations between the two variables Licensing-based Licensing Words (0.5024 significant at 1% level), thus confirming the robustness of our measure.

outstanding after the IPO retained by insiders shareholders. According to signalling theory (see Daily, Certo, Dalton & Roengpitya, 2003, for a review), the retention of shares by insider shareholders makes investors more confident about the long-term prospects of the firm. We include a dummy variable (*VCbacked*) taking the value of one if a company received venture-capital backing before the IPO, and zero otherwise. Previous studies provided opposite conclusions on the relation between venture capital and IPO underpricing. Some of them (e.g. Megginson & Weiss, 1991) supported a monitoring and certification role of venture capital that decreases IPO underpricing. Other studies (e.g. Brav & Gompers 2003) proved that venture-backed companies experience more underpricing at the IPO. We control for the firm's age at the IPO including the variable (*logAge*) calculated on the basis of the IPO year and the company's founding year (Ritter 2004). In the empirical model we use the log-transformation of this variable to account for its high skewness. According to IPO literature (e.g. Ritter, 1984, 1998), the age affects the information availability on the firm and reduces the level of uncertainty in case of older and more established firms. This reduction of information asymmetry implies that there is a negative relation between firm age and IPO underpricing. We include a measure of firms' R&D investments (*R&D intensity*) that we calculated as R&D expenditures scaled by sales as reported in the last financial statement year just prior to the IPO. Firms investing more in R&D generally experience higher underpricing (Guo et al., 2006; Heeley et al. 2007). To account for the effect of other firms' characteristics, we include different financial variables calculated for the last financial statement year just prior to the IPO. Firms' leverage (*Leverage*) measures the company's total debt scaled by total assets. Previous studies (e.g. Kim, Pukthuanthong-Le & Walker, 2008) claimed that debt serves as a signal of better firm quality, since managers of highly leveraged firms face tougher budget constraints and have less control over the firm's cash flows. This increases transparency and reduces the severity of agency conflicts between managers and outside

investors. In the absence of a history of profits, Bartov, Mohanram and Seethamraju (2002) have suggested that investors rely on revenue as an important financial value driver of IPO firms. We control for the firm's profitability including a measure of firm's total revenues earned just prior to the IPO (*Revenues*) and a dummy variable (*Loss*) taking the value of one if a firm reports negative net income in the last financial statement prior to the IPO year, and the value of zero otherwise. Finally, we added a full set of year dummies to check for time-specific trends in the stock market.

### 4.3 Methods

In order to analyze whether the choice of a given patent commercialization strategy impacts on the degree of information asymmetries between the issuer and the investors, our empirical analyses estimate the impact of the licensing-based commercialization strategy on IPO underpricing.

In particular, to test Hypothesis 1, we first estimated the following OLS regression model:

$$UP_i = a_0 + a_1 \text{licensing-based strategy}_i + a_2 \text{patents stock}_i + a_3 \text{control variables} + e_i \quad (1)$$

where  $UP_i$  is the underpricing at the IPO, *Licensing-based Strategy* indicates the firm's patent commercialization strategy and measures the share of firm's total revenues arising from licenses. *Patents stock* is total number of USPTO patents filed in the 5 years before the IPO. The control variables included in Eq. (1) are those described in the previous section. The hypothesis that a patent commercialization strategy based on licensing increases the information asymmetries at the moment of IPO between corporate insiders and external investors, and thereby underpricing, suggests that the coefficient of *Licensing-based strategy* is greater than zero ( $a_1 > 0$ ).

In order to understand whether a firm's patent stock moderates the effect of the patent commercialization strategy on IPO underpricing (Hypothesis 2), we then estimated a second model in which we introduced an interaction term between *Patent Stock* and *Licensing-based Strategy*. More precisely, we estimated the following OLS equation:

$$UP_i = b_0 + b_1 \text{licensing-based strategy}_i + b_2 \text{patents stock}_i + b_3 \text{patents stock}_i * \text{licensing-based strategy}_i + b_4 \text{control variables} + e_i \quad (2)$$

The hypothesis that patents represent a positive signal for investors when firm's commercialization strategy is more based on licensing, thus reducing underpricing, implies that the coefficient on the interaction between *Patent Stock* and *Licensing-based Strategy* is lower than zero ( $b_3 < 0$ ).

## 5. ANALYSES AND RESULTS

### 5.1 Descriptive statistics

Table 2 presents the descriptive statistics for the sample of IPO firms.

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Insert Table 2 about here  
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Average IPO underpricing in the full sample is 18%, a value in line with results provided by previous studies. For example, 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 (2002) report an average underpricing of 18.8%.<sup>9</sup> Considering patent commercialization strategies, 20% of

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<sup>9</sup> The study of Heeley et al. (2007) reports slightly lower average levels of first-day stock returns (11.65%). However, it is 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.

the companies (26 companies out of 130) included in our sample report positive revenues from licenses. The average value of *Licensing-based Strategy* is therefore quite limited, around 5%. For some companies included in our sample, such variable takes the value 1, as they adopt pure-licensing commercialization strategies, generating revenues only through licensing transactions. On average, the firms in the sample filed 31 USPTO patents in the five years preceding the IPO. Moreover, Table 2 shows that the majority of our sample is composed by venture-backed companies (66%) and by firms with a prestigious underwriter (80%). Considering accounting data, 50% of the sample reports negative income in the last financial statement prior the IPO and the average revenues are equal to 137 million of dollars. The average R&D intensity is 4.26 and the average leverage ratio is 0.28.

In Table 3 we report the correlation matrix. None of the correlation coefficients raise serious problems of multicollinearity. Standard test demonstrate that correlations among independent variables are not worrisome since individual (average) variance inflation factors are below the conventional level of 10 (6) and condition numbers are close to 1.

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 Insert Table 3 about here  
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## 5.2 Regression Results

Table 4 shows the results of our regression analyses. We started by estimating Equation (1) through standard OLS, in order to test Hypothesis 1 and investigate the relation of IPO underpricing and licensing-based commercialization strategy.

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 Insert Table 4 about here  
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We find that the adoption of a patent commercialization strategy more focused on licensing significantly increases IPO underpricing. Indeed, the coefficient of the variable *Licensing-*

*based Strategy* is positive and statistically significant at the 1% level. This result confirms Hypothesis 1 and suggests that the degree of information asymmetry with external investors is positively related to the adoption of a commercialization strategy mainly based on licensing. Looking at the relation between IPO underpricing and the stock of patents held by the firm, we find that the coefficient of *Patent Stock* is positive, but not statistically significant at conventional levels in Model 1. This finding is in line with the expectations that patent stock represents an important signal for investors only when it is accounted for the firm's commercialization strategy that is the strategic use that is made of them to create and capture value.

As regards control variables, we find a positive and statistically significant (at 1% level) effect of *Prestigious Underwriter* on IPO underpricing. This result is in line with Loughran and Ritter's (2004) findings demonstrating that prestigious underwriters underprice more firms going public. Conversely, the variables *Loss firms* and *Insider shareholders* are negative and statistically significantly (respectively, at 5% and 10% level), thus reducing the level of IPO underpricing. Thus, firm's profitability and the retention of shares by insider shareholders represent positive signals of firm's quality thereby reducing the ex-ante uncertainty on firm's value and information asymmetries. Although the effects of other control variables are not significant, their signs are aligned with the expectations.

In order to test Hypothesis 2 and understand whether patent stock moderates the effect of patent commercialization strategy on IPO underpricing, in Column 2 we provide estimates from Equation 2, including an interaction term between *Licensing-based Strategy* and *Patent Stock*. We still find that a licensing-based strategy significantly (at 5% level) increases IPO underpricing and the degree of information asymmetry. On the other hand, the main effect of *Patent Stock* is now positive and statistically significant, at the 5% level. In line with the results provided by Heeley et al. (2007), this suggests that, within a context characterized by a

weaker appropriability regime, such as the semiconductor industry, patents increase the level of underpricing.

However, consistently with Hypothesis 2, the coefficient of the interaction between *Patent Stock* and *Licensing-based Strategy* is positive and significant at 5% level. This result supports the hypothesis that patents represent positive quality signals for investors when a firm's commercialization strategy is more based on licensing. The effects of the other control variables on underpricing are similar to those described for Model 1.

## 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 relation between patents and underpricing (Chin et al., 2006; Heeley et al., 2007), it has not considered that the firm-specific strategy adopted to exploit patents may also be an important determinant of information and by that of underpricing at IPO.

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 increases 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. In fact, firms adopting this strategy have more intangible assets, whose value is more difficult to assess for external investors, and their performance is more affected by contractual hazards, on which insiders have better information than external investors.

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 are 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 IPO underpricing. 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 important implications. First, not only patents, but also patent commercialization strategies matter in the financing of innovation of firms in high tech industries. This result is in line with the findings of O' Brien (2003), which show that a firm's innovation strategy may affect its financing decisions. As concerns specifically the access to public equity markets through an IPO, our results suggest that firms adopting a commercialization strategy more based on licensing may encounter greater difficulties in raising new financial resources.

Moreover, the fact that licensing-based firms suffer from a higher underpricing could have several consequences for the share pricing strategies and the timing of the IPO. To avoid strong discount, these firms could delay the moment of the IPO and should disclose more information to potential investors concerning their intangible assets and the use they intend to make of them. In addition, managers should be aware that patents are important signal on the quality of the firm to external investors when a firm's revenues mainly come from licenses. In this way, the information asymmetries could be mitigated and the pricing could be more efficient, so that the money left of the table at the IPO could be reduced.

Finally, we contribute to the literature on the strategic management of IPR. Reitzig and Puranam (2009) have argued that firm's activities related to the generation, protection and utilization of IP are relevant for value creation and appropriation. Our results confirm that the protection and exploitation of IPRs are even more important for firms pursuing commercialization strategies based on licensing. For this kind of firms, it is therefore necessary to devote significant (both human and financial) resources to such activities, in order to mature distinctive capabilities in the strategic management of IPRs.

Finally, we have to acknowledge that at the present status the paper still presents several limitations. First, we did not assess how the specific characteristics of patent portfolios (i.e. quality, breadth, scientific strength) impact on underpricing. This is an interesting issue that deserves further development. Second, we did 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.

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## TABLES AND FIGURES

**TABLE 1**  
**The Distribution of Companies by IPO Year**

<b>IPO years</b>	<b>No. Firms</b>	<b>% of total sample</b>
1996	8	6
1997	14	11
1998	6	5
1999	19	15
2000	31	24
2001	5	4
2003	5	4
2004	14	11
2005	9	7
2006	9	7
2007	10	8
Total	130	100

**TABLE 2**  
**Descriptive Statistics**

<b>Variables</b>	<b>Obs</b>	<b>Mean</b>	<b>Standard Deviation</b>	<b>Min</b>	<b>Max</b>
Underpricing	130	0.18	0.30	-0.63	1.24
Licensing-based strategy	130	0.05	0.15	0	1.00
Licenses words	130	103.42	173.30	2	788
Patents stock	130	30.90	57.94	0	308
log(Age)	130	2.30	0.85	1	92
VCbacked <sup>a</sup>	130	0.66	0.48	0	1
R&D intensity	130	4.26	25.01	0	257.16
Leverage	130	0.28	0.36	0	3.13
Loss firms <sup>a</sup>	130	0.50	0.50	0	1
Revenues	130	136.93	545.56	0	5660
Prestigious underwriter <sup>a</sup>	130	0.81	0.40	0	1
Insider shareholder	130	0.74	0.22	-0.99	0.99

<sup>a</sup>) Dummy variable.

**TABLE 3**  
**Correlations Between Main Variables of Interest**

	Variable	1	2	3	4	5	6	7	8	9	10
1	Underpricing	1									
2	Licensing based strategy	0.29***	1								
3	Patents stock	0.08	0.14	1							
4	log(Age)	-0.07	-0.11	0.18**	1						
5	VCbacked	0.15*	0.06	-0.09	-0.17**	1					
6	R&D intensity	-0.24***	-0.05	-0.07	-0.04	-0.12	1				
7	Leverage	-0.22**	-0.07	-0.10	-0.02	-0.07	0.23***	1			
8	Loss firms	-0.12	0.09	-0.02	-0.30***	0.07	0.13	0.08	1		
9	Revenues	-0.06	-0.07	0.37***	0.23***	-0.23***	-0.03	0.06	-0.04	1	
10	Prestigious underwriter	0.33***	0.02	0.19**	-0.04	0.15*	-0.30***	-0.18**	0.06	0.08	1
11	Insider shareholder	-0.15*	-0.11	0.10	-0.04	0.08	-0.09	-0.01	-0.04	-0.02	0.07

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

**TABLE 4**  
**Regression Results<sup>a</sup>**

<b>Variables</b>	<b>Model 1</b>	<b>Model 2</b>
Intercept	0.291 <i>0.146**</i>	0.284 <i>0.144**</i>
Licensing based strategy	0.624 <i>0.218***</i>	0.757 <i>0.239***</i>
Patent stock	0.000 <i>0.000</i>	0.001 <i>0.000**</i>
Patent stock * Licensing based strategy		-0.003 <i>0.001**</i>
log(Age)	-0.020 <i>0.036</i>	-0.019 <i>0.036</i>
VCbacked <sup>b</sup>	0.077 <i>0.057</i>	0.084 <i>0.054</i>
R&D intensity	-0.001 <i>0.001</i>	-0.001 <i>0.001</i>
Leverage	-0.104 <i>0.076</i>	-0.098 <i>0.074</i>
Loss firms <sup>b</sup>	-0.121 <i>0.051**</i>	-0.127 <i>0.051**</i>
Revenues	0.000 <i>0.000</i>	0.000 <i>0.000</i>
Prestigious underwriter <sup>b</sup>	0.172 <i>0.054***</i>	0.168 <i>0.056***</i>
Insider shareholder	-0.231 <i>0.121*</i>	-0.231 <i>0.116**</i>
Year dummies	<i>yes</i>	<i>yes</i>
N	130	130
F-value	4.23***	13.50***
R <sup>2</sup>	0.3748	0.3876

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