Commercialization Strategy and IPO Underpricing

SERENA MORRICONE
University of Lausanne
Faculty of Business and Economics (HEC Lausanne)
Email: Serena.Morricone@unil.ch

FEDERICO MUNARI*
University of Bologna, Department of Management
Via Terracini 28, Bologna, Italy
Tel: 0039 051 2090208
Fax: 0039-051-2090222
Email: federico.munari@unibo.it

RAFFAELE ORIANI
Luiss Guido Carli
Department of Business and Management
E-mail: roriani@luiss.it

GAETAN DE RASSENFOSSE
Ecole polytechnique fédérale de Lausanne
College of Management of Technology
E-mail: gaetan.derassenfosse@epfl.ch

* Corresponding author

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Abstract

This paper studies the interplay between two defining features of technology-based firms: licensing as a commercialization strategy and the reliance on equity financing. Within the context of an IPO, we argue that the technology commercialization strategy of a firm going public affects information asymmetries and, therefore, IPO underpricing. In particular, we theorize that underpricing will be higher when a firm's technology commercialization strategy is more based on licenses. We also posit that the size of the patent portfolio will mitigate this effect. Our results from a sample of 130 IPOs in the U.S. semiconductor industry confirm these predictions.

Keywords: Initial public offering (IPO), Underpricing, License, Patent, Semiconductor, Endogeneity.

JEL classification: G32, L24, L63, M13, O32, O34

1. Introduction

This paper studies a question at the confluence of two defining features of technology-based firms: the rising importance of licensing as a commercialization strategy on the one hand (Arora and Gambardella, 2010; Laursen et al., 2010) and the well-documented relevance of equity financing on the other hand (Carpenter and Petersen, 2002; Aghion et al., 2004). While these two features have been extensively studied in isolation, we have limited knowledge on their interplay.

Since the seminal work of Teece (1986), research has extensively investigated commercialization strategies for new technologies and their impact on a firm's performance (e.g., Gans and Stern, 2003; Kasch and Dowling, 2008). Firms can generate revenues by directly bringing new technologies onto the markets for products (i.e., *product-based commercialization strategies*), by licensing the technology to third parties (i.e., *licensing-based commercialization strategies*), or by adopting a combination of the two strategies.[1] Several authors have shown that technology commercialization strategies vary not only across industries but also within industries (e.g., Hall and Ziedonis, 2001; Linden and Somaya, 2003; Pisano, 2006). Previous literature has devoted much attention to the determinants of technology commercialization strategy (e.g., Fosfuri, 2006; Gambardella and McGahan, 2010). However, we know little about the effect of commercialization strategy on equity financing.

We focus on one observable effect of licensing on equity financing, namely IPO underpricing. An IPO represents a pivotal event in the life of technology firms allowing them to raise new funds through the issue of new shares acquired by external investors. Notwithstanding the benefits of going public, the substantial information asymmetry between

[1] A firm can profit from innovation also through strategic alliances and equity-based cooperation such as joint ventures. However, in this work we do not consider such forms since they cannot be regarded as transactions in the market for technologies (Arora and Gambardella, 2010), and they might not generate a specific stream of revenues.

firms' insiders (owners and managers) and external investors, together with the ex-ante uncertainty about the firm's value, may generate IPO underpricing (Beatty and Ritter, 1986; Rock, 1986; Carter and Manaster, 1990), as measured by the first-day return of the listing stock. As Certo et al. (2001) put it, underpricing represents "money left on the table" by the firm, reducing the financial benefits of the IPO.

In this paper, we argue that higher revenues generated through licensing-based technology commercialization strategies increase the ex-ante uncertainty on firm value and, therefore, IPO underpricing. Recognizing the role of patents as signals for external investors, we also argue that the size of the patent portfolio mitigates the effect of a licensing-based commercialization strategy on IPO underpricing. Previous works have shown that patents may serve as signals within the context of an IPO under specific contingencies (e.g., Heeley et al., 2007; Hsu and Ziedonis, 2013; Useche, 2014), but they have not analyzed their impact when conditioned by the adoption of specific commercialization strategies.

We base our empirical analysis on the semiconductor industry, using a sample of 130 firms that went public in the United States between 1996 and 2007. The semiconductor industry represents an ideal setting to test our hypotheses given the presence of firms with distinctive commercialization strategies and the surge in the number of patents (Hall and Ziedonis, 2001).

Our empirical analysis provides two novel results. First, we show that higher revenues from licensing-based technology commercialization strategies lead to more pronounced IPO underpricing. Second, a firm's stock of patents lowers the effect of a licensing-based commercialization strategy on IPO underpricing. We offer three contributions to the literature. First, by combining research on technology commercialization strategies and IPO underpricing, we highlight that licensing-based strategies may reduce the ability of the firm to raise new financial resources. Second, we contribute to the literature on the strategic management of intellectual property (IP). We show that firm's activities related to the generation, protection, and utilization of IP are relevant for value creation and appropriation, in particular for firms pursuing commercialization strategies based on licensing. Finally, we contribute to the research on IPO underpricing and quality signals (Certo et al., 2001, 2009; Daily et al., 2003) by showing that innovation activities and strategic choices significantly affect the performance of IPOs in terms of underpricing.

2. Theory and hypotheses

2.1 Technology commercialization strategy and IPO underpricing

According to Rock (1986), the IPO process is subject to adverse selection, and underpricing compensates uninformed investors for the extra cost incurred by collecting information required to screen firms going public. Investors collect information in order to decrease the ex-ante uncertainty on the firm value (Ritter, 1984; Beatty and Ritter, 1986; Daily et al., 2005).

Technology companies provide an ideal set-up to study IPO underpricing. Research has shown that information asymmetry, and the potential adverse selection that it creates, is acute in technology companies, for two reasons. First, the innovation process is particularly opaque for outside investors (Aboody and Lev, 2000; Heeley et al., 2007). Second, most technology companies go public on the basis of future rather than actual profitability, further increasing the uncertainty of the investment (Jain et al., 2008; Ritter and Welch, 2002).

Since future profitability is not directly observable, investors rely on different proxy measures such as revenues (Mouri et al., 2012; Ritter, 1984). Indeed, current revenues are an indicator of the firm's commercial and technological strengths and a predictor of its future revenues and earnings (Henderson, 1999; Steffens, 1993). Some sources of revenues, however, are more uncertain than others and this may induce variations in the extent of IPO underpricing.

We argue that revenues generated from licenses are associated with a greater degree of uncertainty than revenues generated from product sales. To understand why this is the case, consider first the total revenues generated by firm *F* with a product-based commercialization strategy ($r^{!}$). They can be expressed as follows:

$$r^{!}_{!} = market\ size * (market\ share)_{!}$$

That is, revenues depend on the total product *market size* and the *market share* of the focal firm in that product market. Whereas *market size* is contingent on exogenous factors affecting the overall level of product market demand, market share depends upon the firm's idiosyncratic ability to combine technology with complementary assets (Teece, 1986; Sirmon et al., 2007; Certo et al., 2009). Thus, from the perspective of an external investor, the uncertainty associated with a product-based commercialization strategy arises from uncertainty related to the market (market uncertainty, U_M) and to the focal firm (firm uncertainty, U_F).

Next, consider the total revenues generated by firm *F* with a licensing-based commercialization strategy ($r_{!}$).[2] They can be expressed as follows:

$$r_{!} = royalty\ rate * [market\ size * (market\ share)_{!}] * (1 - contractual\ loss)$$
$$= royalty\ rate * r^{!}_{!} * (1 - contractual\ loss)$$

where *royalty rate* is the rate contractually agreed with the licensee firm *L* and applies to revenues generated by firm *L* in the product market ($r^{!}_{!}$), and *contractual loss* is a parameter ranging from zero to one, reflecting the expected losses generated by the potential licensee's opportunism in the execution of the licensing contract (e.g., Arora and Merges, 2004). The

[2] License agreements provide monetary compensation for the licensor in the form of fixed fees (lump sum payment) and/or variable fees (royalties). Lump sum payments typically cover the investment cost sustained by the licensor. The most relevant stream of revenues usually stems from royalty payments (Bousquet et al., 1998; Smith and Parr, 2004).

contractual loss may arise because not all the relevant activities can be fully specified in the contract, as well as because the prescribed activities cannot be adequately monitored or enforced (Oaxley, 1997; Somaya et al., 2011). The importance of contractual hazards in licensing-based strategies is well illustrated with the IPO prospectus of Virage Logic, a U.S. company operating in the semiconductor industry: "… many factors beyond our control, such as fluctuating sales volumes of products that incorporate our intellectual property, commercial acceptance of these products, accuracy of revenue reports and difficulties in the royalty collection process, limit our ability to forecast our royalty revenues."

Comparing revenues arising from a product-based commercialization strategy with revenues arising from a licensing-based strategy, it becomes clear that the latter is more uncertain, for two reasons. First, a licensing-based strategy is affected by an additional source of uncertainty (contractual uncertainty, U_C) compared to a product-based strategy. Second, external investors are exposed to the licensee's firm uncertainty (U_L) instead of, or in addition to, the listing firm uncertainty (U_F). Compared to the listing firm, the licensee bears higher firm uncertainty in the effective integration of an external technology into products and services due to problems with the coordination of the design across firm boundaries (Linden and Somaya, 2003). In an extreme case, the licensee could even decide not to develop and market the licensed technology or could lack the ability to do so (Dechenaux et al., 2008). In addition, a licensee's characteristics are often not observable by external investors, which limit the ability of the latter to evaluate the licensee's risks properly.

Overall, we expect that the larger the revenues from licensing, the higher the uncertainty for external investors and, therefore, the more pronounced the IPO underpricing. That is, we hypothesize:

Hypothesis 1: IPO underpricing increases with the amount of revenues generated from licensing-based commercialization strategies, ceteris paribus.

2.2 IPO underpricing and patents

In the particular context of an IPO, the stock of granted patents can convey relevant information to external investors about firms pursuing a licensing-based strategy. Empirical evidence suggests that patents have a signaling role under specific circumstances (Arthurs et al., 2009; Heeley et al., 2007; Hsu and Ziedonis, 2013; Munari and Toschi, 2011; de Rassenfosse and Fischer, 2016). However, the literature has paid scant attention to firm-specific contingencies such as the commercialization strategy. There are two reasons why we expect the patent stock of firms adopting a licensing-based commercialization strategy to matter to external investors.

First, the possession of patents provides the firm with bargaining power against users of the technology through the threat of patent litigation (Agarwal et al., 2009). As summarized by Somaya (2012), the willingness of third parties to make concessions in licensing negotiations depends on their expectations about risks in patent litigation. The possession of a large stock of patents can, therefore, allow companies to pursue licensing-based commercialization strategies more effectively, by affecting their negotiation power vis-à-vis competitors (Ceccagnoli, 2009). This is particularly important in contexts characterized by highly fragmented property rights, such as semiconductors, where expanding the portfolio of patents becomes an important deterrence mechanism and a bargaining chip to negotiate more attractive licensing terms (Hall and Ziedonis, 2001; Ziedonis, 2004).

Second, a large patent portfolio limits potential licensee opportunism and the related contractual hazards (Arora and Ceccagnoli, 2006; de Rassenfosse et al., 2016; Gans and Stern, 2003). The possession of a larger stock of patents allows firms to protect themselves against leakage of knowledge and unauthorized use of the technology by the licensee (Arora and Merges, 2004), thus reducing the uncertainty about the licensee' opportunistic behavior and related contractual losses.

By contrast, patents represent a weaker quality signal for external investors in the case of a product-based strategy for two reasons. First, a firm's ability to generate future revenues from product sale depends on complex combinations of the patent portfolio with other resources and complementary assets (Teece, 1986; Certo et al., 2009). Second, a firm pursuing a product-based strategy can send different quality signals to investors, based on the size, quality and innovation of the product portfolio (Chaney et al., 1991; Deeds et al., 1997; Certo et al., 2009). The existence of alternative means for conveying quality makes patents a less relevant signaling device (Hsu and Ziedonis, 2013).

Based on the above discussion, we hypothesize the following:

Hypothesis 2: The stock of patents mitigates the effect of revenues generated from a licensing-based commercialization strategy on IPO underpricing.

3. Data and methods

3.1 Empirical setting

The empirical setting is the U.S. semiconductor industry. It represents an ideal context for our study for three reasons. First, a rapid pace of technological change and high level of R&D investment have characterized this industry since its inception. Second, semiconductor firms rely heavily on patents (Hall and Ziedonis, 2001). Third, and most importantly, this industry experienced the emergence of two distinct technology commercialization strategies: integrated (product-based) and licensing-based (Linden and Somaya, 2003). It is characterized by a significant vertical specialization of design and manufacturing activities, resulting in the formation of specialized design firms and specialized manufacturing firms. While integrated commercialization strategies involve the control of all the resources for the manufacturing and commercialization of semiconductors, firms adopting licensing-based strategies tend to be specialized design firms, earning revenues solely from licensing, or from a combination of licenses and product sales.

3.2 Sample and data sources

The analysis is based on a sample of semiconductor companies that went public in the United States in the period 1996–2007.[3] We use secondary data from the Securities Data Corporation (SDC) database, New Issues. From an initial sample of 178 firms, we excluded firms that were not available in Worldscope and for which missing information prevented us from computing IPO underpricing. (The Worldscope database by Thomson Reuters offers financial data on some of the world's leading public and private companies.) The final sample includes 130 firms.

We used the IPO prospectus to get information on a firm's technology commercialization strategy. In particular, we manually collected the information on the firm's business segments and the sources of revenues as reported in the last financial statement of the IPO prospectus. Similarly, we retrieved from the preliminary IPO prospectuses the range of file prices used to account for the partial-adjustment phenomenon. Ritter's data set (Loughran and Ritter, 2004) provided company founding dates and underwriters' reputation rankings. From the Delphion database, we retrieved data on patents granted at the USPTO by each firm in the five years before the IPO. We then linked these patents to the PATSTAT database in order to collect citation data (de Rassenfosse et al., 2014).

3.3 Variable definition

[3] Our sample period begins in January 1996 because IPO prospectuses are only available on SEC Electronic Data Gathering, Analysis, and Retrieval (EDGAR) service from that date.

The dependent variable is *Underpricing*. It measures the percentage change in the stock price during the first day of trading. We compute it by dividing the difference between the initial stock offer price and the closing price at the end of the first day of trading by the initial stock offer price.

In order to measure the sources of revenues, we collected information from the IPO prospectuses in which U.S. firms have to clearly describe the source of their revenues (Regulation S-K). They have to indicate for each of the last three fiscal years the amount of total revenues contributed by any different source. Thus, IPO firms are obliged to disclose whether their revenues derive from licensing agreements and/or from product sales. The variable *Licensing-based revenues* is the log of a firm's revenues (in millions of USD) derived from technology licenses, as reported in the last financial statement before the IPO.[4] Similarly, the variable *Product-based revenues* is the log of revenues (in millions of USD) coming from the sale of products and services.

The variable *Patent stock* measures the depreciated amount of USPTO patents granted to the company in the five years before the IPO. In line with previous studies (Hall et al., 2005), we applied a depreciation rate of fifteen percent to the annual number of patents.

We also included a broad set of control variables that are known to be associated with underpricing (see for a review Daily et al., 2003). We include two measures of VC involvement in the IPO firm: a dummy variable (*VC-backed*) taking the value of one if a company received venture-capital backing before the IPO, and zero otherwise; and the numbers of VCs (*Nb VCs*) that have invested in the focal firm. Previous studies provided opposite conclusions on the relation between venture capital and IPO underpricing. Some of them (e.g., Megginson and Weiss, 1991) supported a monitoring and certification role of

[4] In order to ensure that licensing revenues effectively arise from technology-based agreements, we controlled the description of licensing agreements, and the contracts reported as exhibits of IPO prospectus.

venture capital that decreases IPO underpricing. Other studies (e.g., Brav and Gompers, 2003) showed that venture-backed companies experience more underpricing at the IPO.

We include the variable *Insider shareholder* to capture the proportion of total shares outstanding after the IPO retained by insider shareholders (Leland and Pyle, 1977). According to signaling theory, the retention of shares by insider shareholders makes investors more confident about the long-term prospects of the firm.

To address the effects of hiring a highly reputed lead underwriter on 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 than 8.00, and zero otherwise.[5] Previous studies investigating the relationship between underpricing and underwriter reputation have found that the role of underwriter is not consistent across time. The signaling role of hiring a prestigious underwriter found in 1980s (e.g., Beatty and Welch, 1996) reversed itself in the 1990s and in the Internet bubble period (Loughran and Ritter, 2004).

Concerning other IPO characteristics, we control for the size of the offer by including the log of *IPO proceeds.* Similarly, the revision in offer price during the book-building period is seen as function of information revealed by investors and predicts the amount of IPO underpricing (Hanley, 1993; Loughran and Ritter, 2002; Ritter, 2011). We control for this partial-adjustment phenomenon by including the dummy variables *Positive revision* if the final offer price is higher than the maximum of file price range and *Negative revision* if the final offer price is lower than the minimum of file price range.

We also control for firm characteristics. Because larger and more established firms tend to be associated with lower underpricing, we control for the firm *Size* and *Age* measured, respectively, as log total assets and the difference between the IPO year and the company's

[5] 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').

founding year (Carter et al., 1998). Similarly, we included a dummy variable (*Spin-off*) taking the value one if the company is a spin-off, and zero otherwise. Given the vertical specialization of design and manufacturing activities in the semiconductor industry, we collect information on firms' manufacturing activities from the business description of the IPO prospectuses. We introduce a dummy variable *Manufacturing* that takes the value of one if a company has in-house manufacturing capabilities, and zero if the company outsources its manufacturing.

To account for financial aspects of the firm, we include four variables calculated for the last financial statement year prior to the IPO. Because firms investing more in R&D generally experience higher underpricing (Guo et al., 2006; Heeley et al., 2007), we include the amount of R&D investment (*R&D*). Given that most of technology-based firms go public on the basis of predicted rather than actual profitability (Jain et al., 2008; Ritter and Welch, 2002), we also control for the firm's profitability by including the return on equity (*ROE*) and the amount of net income (*Net income*). We control for firms' level of *Debt* to account for the possibility that financial leverage may affect underpricing.

Finally, we account for market conditions at the time of IPO by including the number of firms in high technology industries going public in the three months before the IPO (*Hi-tech IPOs*) and we control for the pre-IPO market returns by including the average stock market return in the twenty days before the firms' IPO (*Market return*). We also add the full set of year dummies to account for time-specific trends.

3.4 Treatment of endogeneity

Given the limited research in the area, we cannot confidently exclude the possibility that unobserved firm factors affecting the decision to license proprietary technologies could also influence IPO underpricing. Factors such as management attitude towards risk and the structure of licensing contracts are unobservable to the econometrician and might affect investors' evaluation at the time of IPO. In this case, the ordinary least square (OLS) estimator would produce inconsistent estimations and would bias coefficients due to the fact that the error term is correlated with *Licensing-based revenues*.

To account for this possibility, we employ an instrumental variable method. Since the classical 2SLS estimator has weak finite sample properties (Bascle, 2008), we rely on the limited-information maximum likelihood (LIML) estimator, which represents "the most reliable estimator" in our context (Blomquist and Dahlberg, 1999:81).

The ideal instrument is strongly correlated with the licensing decision but does not affect IPO underpricing (other than through its effect on the licensing decision, that is). The downstream market for semiconductors offers the chance to find measures that are concurrently exogenous to underpricing and theoretically linked with the licensing decision.

Semiconductors are present in electronic devices and, in particular, represent a core component of solar panels through which photovoltaic power is generated. It is reasonable to argue that the sales volume of electronic devices and the photovoltaic energy production affect the size of the downstream market for semiconductors and, hence, are linked to *Licensing-based revenues*. At the same time, these variables are clearly exogenous to firm's characteristics. Consequently, we employ as instrumental variables the log of sales of electronics and appliance stores in the United States in the month of the firm's IPO in million of dollars (*Electronics sales*) and the log of solar energy in million kilowatt-hours (*Solar energy*) produced in the United States in the month of the firm's IPO.

Regarding the possible endogeneity of the patent stock, we feel confident that the model controls for the key factors that affect the decision to file for patents and could be linked to IPO underpricing. The entrepreneurial finance literature has shown that patents are endogenous to the outcome of the IPO process (Useche, 2004) and aspects of VC activity

(Haeussler et al., 2014; Hoenen et al., 2014). Regarding the IPO process, Useche (2004) observes that the size of the patent stock is significantly correlated with the firm valuation at the time of IPO. In a careful test for endogeneity, the author notes that potential endogeneity bias is “not particularly strong” (p. 1307). Besides, he notes that the quality of the patent stock is not taken into account by investors. As a robustness test, we will build a quality-adjusted patent stock measure to further mitigate potential endogeneity concerns.

Arguments related to VC activity deserve particular attention. If aspects of VC activity affect both the patenting decision *and* IPO underpricing, then not controlling for VC activity would lead to biased estimates. As explained in section 3.3, we have collected information on whether the company is backed by a VC firm as well as on the number of venture capitalists on board. Besides, we control for the size of the company (which is positively correlated with the amount of cash invested by VCs) and its age (which is positively correlated with VC rounds). In light of all these variables, we are confident that we have controlled for the most important confounding factors related to patenting and VC activity.

4. Results

Table 1 reports descriptive statistics and coefficients of correlation among variables.

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Average IPO underpricing in the full sample is 18 percent, which is a value in line with results from previous studies (Ritter and Welch, 2002). Considering the commercialization strategies, the amount of *Product-based revenues* represents the prevailing model of the revenue generation process. On average, firms in the sample owned a depreciated stock of 12 USPTO patents in the five years preceding the IPO. As far as the other firms’ characteristics are concerned, the average firms’ age is 14 years, and the majority of IPOs were carried with a prestigious underwriter (81%). A total of 63 percent of companies are backed by VCs and they have an average of five VCs investing in the company before the IPO date.

Most variables exhibit reasonably small correlation coefficients. However, some variables are highly correlated with each other, stemming from a common scale effect. In particular, the correlation coefficients between *Product-based strategy*, *Debt* and firm *Size* indicate that larger firms have more access to debt financing and obtain more revenues from the sale of products. Yet, the mean variance inflation factors of the regression models (2.91 in Model 1 and 3.09 in Model 2) exclude any problem of multicollinearity.

Table 2 reports results of Models 1 and 2, aimed at testing Hypotheses 1 and 2 respectively.

--- Include Table 2 around here ---

Results of the first-stage regression for Model 1 indicate that the instruments are statistically significant and satisfy the relevance condition. Indeed, the first-stage F-statistic of 10.43 exceeds the critical value of 8.68 for a LIML with 10 percent of relative bias (Stock et al., 2002). Concerning the exogeneity condition (assessed by testing the correlation between the instruments and the second stage disturbances), tests of over-identifying restrictions confirm that the instruments are exogenous. The Anderson-Rubin statistics (0.008, p-value 0.930) and the Basmann statistics (0.006 p-value 0.939) fail to reject the null hypothesis of exogeneity.[6]

In the second stage of Model 1, we investigate the relationship between revenues from licensing-based strategy and IPO underpricing. Consistent with Hypothesis 1, higher revenues from licensing-based strategy significantly increase IPO underpricing. The coefficient of *Licensing-based revenues* is positive and statistically significant at the one percent level.

[6] The difference-in-Sargan statistic or C-statistic allows to individually test the exogeneity of *Solar energy* and *Electronics sales*. However, to be performed, we need to include a third instrument found in the *Coal* consumption by residential sector in the month of the IPO. The C-statistics indicate that *Solar energy* and *Electronics sales* can be considered exogenous given that the null hypotheses are not rejected for both instruments (*Solar energy* 0.697, p-value 0.404; *Electronics sales* 0.021, p-value 0.884).

We assessed whether the results are robust to weak instruments using Moreira's conditional likelihood ratio (CLR) test (see Finlay and Magnusson (2009) for a discussion). We find that the null hypothesis of no relationship between *Licensing-based revenues* and *Underpricing* is rejected at the one percent level. Furthermore, the Wald test (chi-squared 9.68, significant at the one percent level) indicates that *Licensing-based revenues* generate significantly higher underpricing than *Product-based revenues.*

Additionally, since LIML might lose accurate inference properties in the presence of heteroscedasticity (Bekker and van der Ploeg, 2005; Hausman et al., 2012), we ran the Pagan and Hall heteroscedasticity test. Results of the test indicate the absence of heteroscedasticity (p-value of 0.980 for Model 1; and p-value of 0.977 for Model 2).

In line with the results provided by Hsu and Ziedonis (2013), we find that patent stock is negatively correlated with IPO underpricing, suggesting that patents reduce information asymmetry. However, this finding may not hold true across firm characteristics. Next model conditions the effect on the commercialization strategy (Hypothesis 2). In particular, Model 2 includes the interaction term *Licensing-based revenues***Patents stock.* The interaction between an endogenous and an exogenous variable is itself endogenous and requires interacting the two instruments (*Solar Energy* and *Electronics sales*) with the variable *Patent stock.* Tests of instruments relevance and exogeneity confirm previous results.

Consistently with Hypothesis 2, the coefficient of the interaction between *Licensing-based revenues* and *Patent stock* is negative and significant at the five percent level. The coefficient associated with the *Patent stock* variable is no longer significant. This result supports the hypothesis that patents act as a positive quality signal for investors only in the presence of revenues generated by a licensing-based strategy. Holding licensing-based revenues constant, a one standard-deviation increase in patent stock (+27 patents) decreases IPO underpricing by about 8 percentage points. This is an economically significant effect in light of the fact that the mean IPO underpricing reaches 18 percent (Table 1).

4.1 Robustness checks

We performed different robustness checks. First, we investigate the moderating role of patents for firms adopting a product-based commercialization strategy. Second, we employ a measure of patent stock quality. Table 3 reports only the second stage of the regression results for space reason.

--- Include Table 3 around here ---

In order to test whether patents also play a role for a product-based commercialization strategy, Model A includes the interaction term *Product-based revenues* Patents stock*. In Model B, we also include the interaction term *Licensing-based revenue*Patents stock* (full specification). The lack of statistical significance of the interaction term *Product-based revenues* Patents stock* in Models A and B indicates that patents are not always a quality signal for external investors.

Previous results rely on an aggregate patent stock measure that does not control for the quality of the patent portfolio. We rerun our base models (Models 1 and 2 of Table 2) using a depreciated patent stock portfolio weighted by the number of forward citations received by each firm's patent up to five years after the grant date (e.g., Hall et al., 2005). Results of Models C and D of Table 3 confirm our primary results. The magnitude of the coefficients is smaller by an order of magnitude than reported in our main analysis. However, the standard deviation of the citation-weighted variable is also an order or magnitude larger than the non-weighted variable (220.66 vs 26.72), suggesting that the economic impact of the variable is in a similar range.

5. Discussion and conclusions

This paper analyzes whether the technology commercialization strategy affects IPO underpricing and the role of patents in this relationship. Focusing on the semiconductor industry, we have shown that underpricing increases with the amount of revenues a firm generates from a licensing-based technology commercialization strategy. We attribute this result to idiosyncratic contractual hazards that affect revenues from licensing-based strategies (and not revenues from product-based strategies). We further show that a firm's stock of patents mitigates the effect of a licensing strategy on underpricing.

Our results shed new light on the effects of technology commercialization strategies on firm financing. We offer several contributions to the literature. First, we add novel insights and evidence to studies investigating technology commercialization strategies (Gans and Stern, 2003; Arora and Merges, 2004; Fosfuri, 2006; Kasch and Dowling, 2008). This body of research has mainly focused on the determinants of such a strategic choice, but it has largely neglected to assess its impact on external financing decisions and value creation. We have highlighted that licensing-based strategies tend to be associated with a high level of uncertainty and hazards for external investors, which might significantly impact on the long-term sustainability of this strategy.

Second, we contribute to the literature on the strategic management of IP (Reitzig and Puranam, 2009; Somaya, 2012). 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 IP are even more important for firms pursuing commercialization strategies based on licensing (Gans and Stern, 2003). It follows that firms should devote significant (both human and financial) resources to such activities, in order to mature distinctive capabilities.

Finally, we contribute to the research on IPO underpricing and quality signals (Certo et al., 2001, 2009; Daily et al., 2003), showing that innovation activities and strategic choices significantly affect the performance of IPOs in terms of underpricing. Thus, we have improved our understanding on how and why some firms are able to convert innovation efforts into gains at IPO, whereas others are not (Certo et al., 2009).

The results presented in the paper also have potentially important managerial implications. As far as access to public equity markets through an IPO is concerned, our results suggest that firms adopting a commercialization strategy based on licensing may encounter greater difficulties in raising new financial resources. This finding has several consequences for the pricing of shares and the timing of the IPO. In order to avoid strong discounting, these firms should disclose more information to potential investors concerning their intangible assets and the use they intend to make of them.

Finally, the paper uncovered some interesting and additional issues that deserve further development. First, we have not assessed how the particular characteristics of licensing contracts impact underpricing. With respect to the structure of licensing contracts, for instance, it could be interesting to assess whether some specific terms (i.e., exclusivity, restrictions) or economic conditions (down-payment, royalty rate) may affect the valuation of the company in the context of IPO or in other funding events. Structuring and shaping licensing alliances to address the challenges arising in the markets for technologies can play an important role in highly uncertain environments (Somaya et al., 2011). Second, a compelling analysis of disclosure behavior in financial statements and IPO prospects could shed more light on the relationship between licensing, patents and underpricing. A detailed analysis of how the relevant information about patents and patent exploitation strategies flows from firms going public to investors could enhance our understanding of the value relevance of such intangible assets in the funding process. Third, we focused on the short-term returns of initial public offers, and leave future research to investigate the long-term effects of technology commercialization strategies. Such research might be of interest to assess the potential existence of risk miss-measurement associated with different commercialization strategies. Finally, it would be worth assessing the validity of our conclusions in different industries. In particular, the signaling role of patents for firms carrying a product-based commercialization strategy might be tested in discrete technology industries, such as pharmaceuticals.

Notwithstanding these limitations, we believe that this study provides important implications for the long-term sustainability of licensing-based strategies and their impact on the ability of more innovative firms to raise new financial resources on equity markets.

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References

Aboody, D. Lev, B., 2000. Information asymmetry, R&D, and insider gains. Journal of Finance 55(6), 2747–2766.

Agarwal, R., Ganco, M., Ziedonis, R.M. 2009. Reputations for toughness in patent enforcement: implications for knowledge spillovers via inventor mobility. Strategic Management Journal 30(13), 1349–1374.

Aghion, P., Bond, S., Klemm, A., Marinescu, I., 2004. Technology and financial structure: are innovative firms different? Journal of the European Economic Association 2(2–3), 277–288.

Arora, A., Ceccagnoli, M., 2006. Patent protection, complementary assets, and firms' incentives for technology licensing. Management Science 52(2), 293–308.

Arora, A., Gambardella, A., 2010. Ideas for rent: An overview of markets for technology. Industrial and Corporate Change 19(3), 775–803.

Arora, A., Merges, R.P., 2004. Specialized supply firms, property rights and firm boundaries. Industrial and Corporate Change 13(3), 451–475.

Arthurs, J.D., Busenitz, L.W., Hoskisson, R.E., Johnson, R.A., 2009. Signaling and initial public offerings: The use and impact of the lockup period. Journal of Business Venturing 24, 360–372.

Bascle, G., 2008. Controlling for endogeneity with instrumental variables in strategic management. Strategic Organization 6, 285–330.

Beatty, R.P., Ritter, J.R., 1986. Investment banking, reputation, and the underpricing of initial public offerings. Journal of Financial Economics 15(1-2), 213–232.

Beatty, R.P. Welch, I., 1996. Issuer expenses and legal liability in initial public offerings. Journal of Law and Economics 39, 545–602.

Bekker, P.A., van der Ploeg, J., 2005. Instrumental variable estimation based on grouped data. Statistica Neerlandica 59(3), 239–67.

Blomquist, S., Dahlberg, M., 1999. Small sample properties of LIML and jackknife IV estimators: Experiments with weak instruments. Journal of Applied Econometrics 14(1), 69–88.

Bousquet, A., Cremer, H., Ivaldi, M., Wolkowicz, M., 1998. Risk sharing in licensing. International Journal of Industrial Organization 16(5), 535–554.

Brav, A,. Gompers, P.A., 2003. The role of lockups in initial public offerings. Review of Financial Studies 16(1), 1–29.

Carpenter, R. E., Petersen, B. C., 2002. Capital market imperfections, high-tech investment, and new equity financing. The Economic Journal 112(477), F54–F72.

Carter, R.B., Dark, F.H., Singh, A.K., 1998.Underwriter reputation, initial returns, and the long-run performance of IPO stocks. Journal of Finance 53, 285–311.

Carter, R., Manaster, S., 1990. Initial public offerings and underwriter reputation. Journal of Finance 45(4), 1045–1067.

Ceccagnoli, M., 2009. Appropriability, preemption, and firm performance. Strategic Management Journal 30(1), 81–98.

Certo, S.T., Covin, J.G., Daily, C.M., Dalton, D.R., 2001.Wealth and the effects of founder management among IPO-stage new ventures. Strategic Management Journal 22(6-7), 641–658.

Certo, S.T., Holcomb, T.R., Holmes, R.M., 2009. IPO research in management and entrepreneurship: Moving the agenda forward. Journal of Management 35(6), 1340–1378.

Chaney, P.K., Devinney, T.M., Winer, R.S. 1991. The impact of new product introductions on the market value of firms. Journal of Business 64, 573–610.

Daily, M.C., Certo, S.T., Dalton, D.R., Roengpitya, R., 2003. IPO underpricing: A meta-analysis and research synthesis. Entrepreneurship Theory and Practice 2(3), 271–295.
Daily, M.C., Certo, S.T., Dalton, D.R., 2005. Investment bankers and IPO pricing: Does prospectus information matter?. Journal of Business Venturing 20(2005), 93–111.
de Rassenfosse, G., Dernis, H., Boedt, G., 2014. An introduction to the Patstat database with example queries. Australian Economic Review 47(3), 395–408.
de Rassenfosse, G., Fischer, T., 2016. Venture debt financing: Determinants of the lending decision. Strategic Entrepreneurship Journal 10(3), 235–256.
de Rassenfosse, G., Palangkaraya, A., Webster, E., 2016. Why do patents facilitate trade in technology? Testing the disclosure and appropriation effects. Research Policy 45(7), 1326–1336.
Dechenaux, E., Goldfarb, B., Shane, S., Thursby, M., 2008. Appropriability and commercialization: evidence from MIT inventions. Management Science 54(5), 893–906.
Deeds, D.L., Decarolis, D., Coombs, J.E. 1997. The impact of firm specific capabilities on the amount of capital raised in an initial public offering: Evidence from the biotechnology industry. Journal of Business Venturing 12(1), 31–46.
Finlay, K., Magnusson, L.M., 2009. Implementing weak-instrument robust tests for a general class of instrumental-variables models. Stata Journal 9(3), 398–421.
Fosfuri A. 2006. The licensing dilemma: Understanding the determinants of the rate of technology licensing. Strategic Management Journal 27(12), 1141–58.
Gambardella, A., McGahan, A., 2010. Business-model innovation, general purpose technologies, specialization and industry change. Long Range Planning 43(2-3), 262–271.
Gans, J.S., Stern, S., 2003. The product market and the market for 'ideas': Commercialization strategies for technology entrepreneurs. Research Policy 32(2), 333–350.
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(3–4), 550–579.
Haeussler, C., Harhoff, D., & Mueller, E. (2014). How patenting informs VC investors–The case of biotechnology. Research Policy 43(8), 1286–1298.
Hall, B., Jaffe, A.B., Trajtenberg, M., 2005. Market value and patent citations. The RAND Journal of Economics 36(1), 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.
Hanley, K.W., 1993. The underpricing of initial public offerings and the partial adjustment phenomenon. Journal of Financial Economics 34, 231–250.
Hausman, J.A., Newey, W.K., Woutersen, T., Chao, J.C., Swanson, N.R., 2012. Instrumental variable estimation with heteroskedasticity and many instruments. Quantitative Economics 3(2), 211–255.
Heeley, M.B., Matusik, S.F., Jain, N., 2007. Innovation, appropriability, and the underpricing of initial public offerings. Academy of Management Journal 50(1), 209–225.
Henderson, A.D., 1999. Firm strategy and age dependence: a contingency view of the liabilities of newness, adolescence, and obsolescence. Administrative Science Quarterly 44, 281–314.
Hoenen, S., Kolympiris, C., Schoenmakers, W., Kalaitzandonakes, N., 2014. The diminishing signaling value of patents between early rounds of venture capital financing. Research Policy 43, 956–989.
Hsu, D.H., Ziedonis, R.H., 2013. Resources as dual sources of advantage: implications for valuing entrepreneurial firm patents. Strategic Management Journal 34, 761–781.
Jain, B.A., Jayaraman, N. Kini, O., 2008. The path-to-profitability of Internet IPO firms. Journal of Business Venturing 23(2), 165–194.

Kasch, S., Dowling, M., 2008.Commercialization strategies of young biotechnology firms. An empirical analysis of the U.S. industry. Research Policy 37(10), 1765–1777.
Laursen, K., Leone, M.I., Torrisi, S. 2010. Technological exploration through licensing: New insights from the licensee's point of view. Industrial and Corporate Change 19(3), 871–897.
Leland, H.E., Pyle, D.H., 1977. Informational asymmetries, financial structure, and financial intermediation. Journal of Finance 32(2), 371–387.
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.
Loughran, T., Ritter, J.R., 2002. Why don't issuers get upset about leaving money on the table in IPOs? Review of Financial Studies 15, 413–443.
Loughran, T., Ritter, J.R., 2004. Why has IPO underpricing changed over time?. Financial Management 33, 5–37.
Megginson, W., Weiss, K., 1991. Venture capitalist certification in initial public offerings. Journal of Finance 46(3), 879–903.
Mouri, N., Sarkar, M.B., Frye, M., 2012. Alliance portfolios and shareholder value in post-IPO firms: The moderating roles of portfolio structure and firm-level uncertainty. Journal of Business Venturing 27(3), 355–371.
Munari, F., Toschi, L., 2011. Do venture capitalists have a bias against investment in academic spinoffs? Evidence from the micro and nanotechnology sector in the UK. Industrial and Corporate Change 20(2), 397–432.
Oaxley, J., 1997. Appropriability hazards and governance in strategic alliances: A transaction cost approach. Journal of Law, Economics and Organization 13(2), 387–409.
Pisano, G., 2006. Profiting from innovation and the intellectual property revolution. Research Policy 35(8), 1122–1130.
Reitzig, M., Puranam P. 2009. Value appropriation as an organizational capability: The case of IP protection through patents. Strategic Management Journal 30, 765–789.
Ritter, J.R., 1984. The "hot issue" market of 1980. Journal of Business, 215–240.
Ritter, J.R., 2011. Equilibrium in the initial public offerings market. Annual Review of Financial Economics 3, 347–374.
Ritter, J.R., Welch, I., 2002. A review of IPO activity, pricing, and allocations. Journal of Finance 57, 1795–828.
Rock, K., 1986. Why new issues are underpriced. Journal of Financial Economics 15(1-2), 187–212.
Sirmon, D.G., Hitt, M.A., Ireland, R.D., 2007. Managing firm resources in dynamic environments to create value: Looking inside the black box. Academy of Management Review 32, 273–292.
Smith, G.V., Parr, R.L., 2004. Intellectual property: Licensing and joint venture profit strategies. John Wiley & Sons, New Jersey.
Somaya, D., 2012. Patent strategy and management: An integrative review and research agenda. Journal of Management 38(4), 1084–1114.
Somaya, D., Kim, Y., Vonortas, N.S., 2011. Exclusivity in licensing alliances: Using hostages to support technology commercialization. Strategic Management Journal 32(2), 159–186.
Steffens, J. 1993. Newgames: Strategic competition in the PC revolution, Elsevier Science, New York.
Stock, J.H., Wright, J.H., Yogo, M., 2002. A survey of weak instruments and weak identification in generalized method of moments. Journal of Business & Economic Statistics 20(4), 518–529.

Teece, D.J., 1986. Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. Research Policy 15(6), 285–305.
Useche, D., 2014. Are patents signals for the IPO market? An EU–US comparison for the software industry. Research Policy 43(8), 1299–1311.
Ziedonis, R.H. 2004. Don’t Fence Me In: Fragmented Markets for Technology and the Patent Acquisition Strategies of Firms. Management Science 50, 804–820.

TABLES AND FIGURES

TABLE 1 Descriptive statistics (N= 130)

		Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Underpricing	0.18	0.30	1.00																			
2	Licensing-based revenues	0.26	0.68	**0.25**	1.00																		
3	Product-based revenues	3.16	1.74	0.05	**-0.23**	1.00																	
4	Patents stock	12.05	26.72	0.10	**0.37**	0.12	1.00																
5	Manufacturing	0.55	0.50	-0.14	-0.13	**0.30**	-0.02	1.00															
6	VC-backed	0.63	0.48	0.11	0.04	-0.19	0.09	**-0.27**	1.00														
7	Nb VCs	5.32	5.20	**0.18**	0.02	**-0.24**	0.10	**-0.31**	**0.79**	1.00													
8	Insider shareholder	0.74	0.22	-0.15	**-0.18**	0.11	0.10	-0.10	0.04	0.04	1.00												
9	Prestigious underwriter	0.81	0.40	**0.33**	0.08	**0.32**	**0.18**	**-0.24**	0.15	**0.20**	0.07	1.00											
10	Size	3.98	1.61	0.09	-0.06	**0.79**	0.16	**0.32**	-0.14	**-0.20**	0.02	**0.32**	1.00										
11	Age	14.65	15.22	-0.04	0.03	**0.36**	0.08	**0.31**	-0.15	**-0.21**	-0.07	0.01	**0.30**	1.00									
12	Spin-off	0.08	0.28	0.12	-0.05	**0.29**	0.08	0.16	**-0.34**	**-0.30**	0.05	0.08	**0.29**	**0.32**	1.00								
13	R&D	0.19	1.30	-0.02	-0.05	**0.27**	0.11	0.13	-0.02	-0.06	0.02	0.03	**0.20**	0.02	-0.04	1.00							
14	ROE	0.35	5.68	-0.15	-0.15	-0.08	-0.04	-0.09	0.02	0.11	-0.07	-0.07	-0.12	-0.07	-0.02	0.02	1.00						
15	Net income	0.00	0.04	0.03	-0.06	0.16	0.03	0.03	-0.05	-0.05	0.13	-0.01	0.09	**0.21**	**0.31**	-0.07	0.00	1.00					
16	Debt	0.07	0.24	-0.08	-0.11	**0.52**	0.09	**0.26**	**-0.18**	**-0.21**	0.03	0.13	**0.62**	0.17	**0.34**	**0.48**	-0.02	0.11	1.00				
17	IPO proceeds	3.96	1.25	0.12	-0.01	**0.43**	0.10	0.11	0.02	0.01	-0.03	**0.41**	**0.66**	0.12	-0.01	**0.19**	0.00	**-0.27**	**0.49**	1.00			
18	Positive revision	0.34	0.48	**0.28**	0.12	0.03	0.15	-0.11	0.08	0.16	-0.01	**0.31**	0.12	-0.02	0.02	0.02	-0.05	0.03	-0.02	**0.20**	1.00		
19	Negative revision	0.19	0.40	**-0.23**	-0.07	0.15	-0.07	0.01	-0.11	-0.13	0.04	-0.16	0.13	0.13	0.06	-0.06	-0.04	-0.07	0.06	-0.06	**-0.35**	1.00	
20	Hi-tech IPOs	18.63	14.67	**0.21**	0.00	-0.13	-0.06	0.03	**-0.21**	-0.11	-0.04	0.09	-0.10	0.00	0.02	0.04	-0.06	0.01	-0.05	-0.05	0.12	-0.02	1.00
21	Market return	0.10	0.22	0.13	**0.23**	-0.01	0.04	-0.03	0.04	0.07	-0.02	0.09	0.01	0.08	-0.12	**-0.24**	-0.09	0.07	-0.15	-0.01	**0.49**	-0.15	0.10

Correlation coefficients significant at the 5% probability threshold in bold.

TABLE 2 Regression Results

	Model 1		Model 2		
	1st stage	*2nd stage*	*1st stage*		*2nd stage*
	Lic.rev	*Underpricing*	*Lic.rev*	*Lic.rev*Pat*	*Underpricing*
Licensing-based revenues	---	0.359***	---	---	0.450***
		0.105			*0.126*
Licensing-based revenues*Patent stock	---	---	---	---	-0.003**
					0.001
Product-based revenues	-0.207***	0.093***	-0.194***	-3.628	0.099***
	0.053	*0.035*	*0.049*	*2.245*	*0.035*
Patent stock	0.009***	-0.003**	-0.677***	-72.562***	0.001
	0.002	*0.001*	*0.176*	*8.060*	*0.002*
Manufacturing	-0.198	-0.052	-0.178	-8.657	-0.075
	0.127	*0.061*	*0.117*	*5.357*	*0.062*
VC-backed	-0.027	0.012	0.044	-14.554*	-0.038
	0.174	*0.083*	*0.164*	*7.501*	*0.088*
Nb VCs	-0.016	0.017**	-0.019	0.672	0.020**
	0.017	*0.008*	*0.016*	*0.719*	*0.008*
Insider shareholder	-0.514**	-0.085	-0.491**	3.076	-0.037
	0.236	*0.129*	*0.217*	*9.915*	*0.137*
Prestigious underwriter	0.235	-0.060	0.201	-0.553	-0.080
	0.172	*0.088*	*0.158*	*7.238*	*0.091*
Size	0.062	-0.014	0.051	-0.809	-0.022
	0.073	*0.036*	*0.067*	*3.069*	*0.038*
Age	0.003	-0.003	0.003	0.193	-0.003
	0.004	*0.002*	*0.004*	*0.166*	*0.002*
Spin-off	0.194	0.282**	0.267	-24.017**	0.187
	0.234	*0.111*	*0.217*	*9.944*	*0.123*
R&D	0.105**	-0.011	0.131***	0.591	-0.029
	0.050	*0.025*	*0.046*	*2.108*	*0.028*
ROE	-0.006	-0.004	-0.003	0.192	-0.003
	0.009	*0.005*	*0.009*	*0.394*	*0.005*
Net income	1.824	0.212	2.045	79.294	0.228
	1.406	*0.655*	*1.291*	*59.050*	*0.670*
Debt	-0.380	-0.237	-0.447	11.079	-0.160
	0.346	*0.169*	*0.321*	*14.691*	*0.180*
IPO proceeds	0.055	0.041	0.077	-1.286	0.024
	0.078	*0.037*	*0.072*	*3.283*	*0.039*
Positive revision	-0.088	0.065	-0.076	5.656	0.087
	0.147	*0.072*	*0.135*	*6.175*	*0.075*
Negative revision	0.112	-0.135*	0.169	8.776	-0.139*
	0.149	*0.071*	*0.138*	*6.295*	*0.073*
Hi-tech IPOs	0.005	0.001	0.004	-0.062	0.001
	0.006	*0.003*	*0.006*	*0.266*	*0.003*
Market return	0.552*	-0.217	0.553**	-8.888	-0.305*
	0.300	*0.163*	*0.276*	*12.619*	*0.178*
Solar energy	-0.325***	---	-0.273***	3.901	---
	0.074		*0.078*	*3.581*	
Electronics sales	-9.908***	---	-9.945***	-121.133	---
	3.520		*3.272*	*149.606*	
Solar energy*Patents stock	---	---	-0.008**	-1.375***	---
			0.003	*0.156*	
Electronics sales*Patents stock	---	---	0.080***	8.842***	---
			0.020	*0.910*	
Intercept	87.301***	-0.012	87.414***	1059.616	0.038
	30.472	*0.179*	*28.296*	*1293.776*	*0.180*
Wald test		9.68***			
First-stage F-statistic	10.43***		5.66***		
Moreira's CLR	15.46***				
Anderson-Rubin chi-squared	0.008 *(p-value 0.930)*		0.865 *(p-value 0.649)*		
Basmann F-value	0.006 *(p-value 0.939)*		0.319 *(p-value 0.727)*		
Durbin-Wu-Hausman test	7.701***		9.839***		
R-squared	0.532	0.240	0.614	0.893	0.203

*** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level in a two-tailed test.
Standard errors are in italics.

TABLE 3 Robustness Checks (2nd stage)

	A	*B*	*C*	*D*
Licensing-based revenues	0.351*** *0.100*	0.502*** *0.143*	0.330*** *0.095*	0.382*** *0.106*
Product-based revenues	0.082*** *0.032*	0.126*** *0.043*	0.083*** *0.032*	0.090*** *0.033*
Patent stock	-0.006* *0.003*	0.012 *0.009*	---	---
Product-based revenues*Patent stock	0.001 *0.001*	-0.003 *0.002*	---	---
Licensing-based revenues*Patent stock	---	-0.005** *0.003*	---	---
Patent Citation stock	---	---	-3.5e-04** *0.000*	0.000 *0.000*
Licensing-based revenues*Patent Citation stock	---	---	---	-2.9e-04** *0.000*
Manufacturing	-0.063 *0.060*	-0.064 *0.063*	-0.060 *0.059*	-0.077 *0.060*
VC-backed	-0.001 *0.083*	-0.039 *0.089*	-0.002 *0.082*	-0.021 *0.083*
Nb VCs	0.018** *0.008*	0.019** *0.009*	0.018** *0.008*	0.018** *0.008*
Insider shareholder	-0.076 *0.130*	-0.046 *0.138*	-0.102 *0.125*	-0.088 *0.126*
Prestigious underwriter	-0.053 *0.086*	-0.102 *0.096*	-0.049 *0.085*	-0.068 *0.088*
Size	-0.011 *0.035*	-0.032 *0.040*	-0.009 *0.035*	-0.020 *0.036*
Age	-0.003 *0.002*	-0.002 *0.002*	-0.003 *0.002*	-0.003 *0.002*
Spin-off	0.244** *0.115*	0.223** *0.122*	0.263** *0.109*	0.215** *0.114*
R&D	-0.020 *0.027*	-0.015 *0.028*	-0.009 *0.024*	-0.024 *0.027*
ROE	-0.004 *0.005*	-0.003 *0.005*	-0.004 *0.005*	-0.004 *0.005*
Net income	0.162 *0.649*	0.383 *0.689*	0.205 *0.643*	0.211 *0.650*
Debt	-0.246 *0.166*	-0.092 *0.195*	-0.241 *0.166*	-0.172 *0.174*
IPO proceeds	0.032 *0.037*	0.035 *0.039*	0.036 *0.036*	0.028 *0.037*
Positive revision	0.075 *0.072*	0.072 *0.076*	0.059 *0.070*	0.079 *0.072*
Negative revision	-0.129** *0.070*	-0.156** *0.075*	-0.137** *0.070*	-0.131** *0.071*
Hi-tech IPOs	0.001 *0.003*	0.000 *0.003*	0.001 *0.003*	0.001 *0.003*
Market return	-0.220 *0.161*	-0.336 *0.186*	-0.190 *0.156*	-0.256 *0.166*
Intercept	0.034 *0.175*	-0.034 *0.189*	0.019 *0.173*	0.066 *0.172*
First-stage F-statistic	12.15***	4.96***	12.34***	6.67***
Anderson-Rubin chi-squared	0.002	0.329	0.020	0.123
Basmann F-value	0.001	0.120	0.015	0.045
Durbin-Wu-Hausman test	7.95***	10.66***	7.44***	9.33***
R-squared	0.260	0.176	0.269	0.253

*** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level in a two-tailed test.
Standard errors are in italics.