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Foreign Venture Capitalists and Access to Foreign Research: The Case of US Initial Public Offerings

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1. INTRODUCTION

An extensive literature suggests that venture capital (VC) firms make a difference in their investee firms. They provide not only early-stage financing to new ventures, which would otherwise find it difficult to access outside financing, but also management and strategic advice as well as monitoring.[1] In turn, this multi-faceted input into their investee firms that VC firms provide creates value as reflected by better performance at the initial public offering (IPO) (Suchard, 2009). VC firms may also benefit their investee firms by providing access to networks and resources such as knowledge. More specifically, VC firms may facilitate and improve their investee firms' innovation (see e.g. Kortum and Lerner, 2000; Lerner, 2012; Luukkonen et al., 2013; Chemmanur et al., 2014; Corsi and Prencipe, 2019).

A limitation of the above literature is its focus on domestic VC firms. Nevertheless, an emerging literature on the role of foreign VC firms in the VC syndicates of IPO firms (see e.g. Nahata et al., 2014; Chemmanur et al., 2016; Chahine et al., 2019b; and Khurshed et al., 2020) suggests that foreign VC firms create value above and beyond the value created by domestic VC firms. We advance this literature by studying the role of foreign VC firms in enabling and improving innovation, proxied by greater research and development (R&D) expenditures. While VC firms provide financing as well as advice, thereby enhancing and improving innovation (e.g. Luukkonen et al., 2013), we argue that foreign VC firms, via their access to local research, improve their investee firms' innovative activity in ways that could not be achieved by domestic VC firms, which do not have access to this foreign research.

[1] See e.g. Hellmann and Puri (2002), Sorensen (2007), Hochberg, Ljungqvist and Lu (2007), Nahata (2008), Gorman and Sahlman (1989), Sahlman (1990), Bygrave and Timmons (1992), Gompers and Lerner (1999), and Schertler and Tykvová (2011).

Why would foreign VC firms have an incremental effect on innovative activity compared to their domestic counterparts? Isobe et al. (2000) argue that foreign investors in general are more committed to allocate resources to technology transfer. Further, Corsi and Prencipe (2017) hypothesize that foreign investors attempt to overcome their liability of foreignness by providing more innovation input into their investee firms. Dachs et al. (2008) and Frenz and Ietto-Gillies (2007) find evidence that foreign companies are more likely to innovate, including innovation in products and processes. Specifically, we expect that foreign VC firms from countries with high innovation output, as proxied by high patent activity, are likely to enhance and improve the innovation of their investee firms as reflected by greater R&D expenditures. We find empirical support for this argument. We analyze a sample of US IPO firms that went public between 2000 and 2016. The list of foreign VC firms invested in our sample firms includes well-known VC firms such as Novartis Bioventures Ltd. Novartis Bioventures Ltd is funded by Novartis AG, a Swiss pharmaceutical company, which in 2018 ranked among the top 25 companies that spend the most on R&D expenditures.[2] In turn, Switzerland ranks at number 9 in terms of the annual average number of patents lodged (see Figure 1). Another foreign VC firm invested in our sample firms is part of Sony Corporation, which ranked at place 41 globally in terms of its 2018 R&D spend and with Japan having the highest annual average number of patents lodged. We find that R&D expenditures in the last fiscal year prior to the fiscal year of the IPO[3] (standardized by total assets for the same year) increase with both domestic and foreign VC ownership. In addition, foreign VC ownership has a significantly more positive effect on R&D expenditures than domestic VC

[2]See https://www.ideatovalue.com/inno/nickskillicorn/2019/08/top-1000-companies-that-spend-the-most-on-research-development-charts-and-analysis/, accessed on 8 October 2020.

[3] We measure R&D expenditures in the last fiscal year prior to the fiscal year of the IPO as later in the paper we explain IPO underpricing by R&D expenditures. By using lagged rather than contemporaneous R&D expenditures, the latter is at least weakly endogenous.

ownership. Furthermore, the positive effect of foreign VC ownership stems from VC firms located in countries with high patent activity. This gives further credence to our argument that foreign VC firms enable their US investee firms to tap into local research, which would otherwise not be accessible to them. Finally, the positive effect on innovation input (i.e., R&D expenditures) of foreign VC firms from countries with high innovation output (i.e., high patent activity) stems mainly from corporate VC firms. This provides further credence to our argument: As corporate VC firms are part of a larger corporation, they have direct access to a corporate research department. Such access could also result in the expatriation of technical staff from the corporate VC firm's parent company to the corporate VC firm's investee firm (see e.g. Isobe et al., 2000). In other words, if our main argument is valid, the positive association between innovation and foreign VC ownership should mainly stem from this type of VC firm given the direct access to research. Again, this is exactly what we find.

While the impact of increased R&D expenditures on IPO underpricing is uncertain (see e.g. Zhou and Sadeghi, 2019), we find that greater R&D expenditures are associated with more underpricing, which in turn appears to be mitigated by the presence of foreign VC firms.

Again, the main contribution of this paper is to provide further evidence of value added by foreign VC firms, which is above and beyond the value added by domestic VC firms. The novelty of this paper is to focus on the role of foreign VC firms in enhancing and improving the innovation by their investee firms. We argue that foreign *corporate* VC firms, given their link to a corporate research department, are best at assuming this role. This paper adds to a growing literature, which suggests that foreign VC firms provide their investee firms with access to resources, such as local research, which would otherwise not be available to the investee firms. We also contribute to the literature, which provides evidence that the type of (foreign) VC firm matters. Our paper has

important implications for management: New ventures whose success relies on being innovative should ensure that their VC syndicate contains foreign VC firms, especially corporate VC firms from countries with high patent activity.

This paper proceeds as follows. Section 2 reviews the relevant literature and develops the hypotheses. Section 3 describes the sample selection and the methodology. The next section contains the empirical analysis, followed by further tests in Section 5. Finally, Section 6 contains the discussion and conclusion.

2. LITERATURE REVIEW AND HYPOTHESES

A growing literature suggests that foreign VC firms create additional value for their investee firms as compared to the value created by their domestic counterparts. For example, Cumming et al. (2016) provide evidence on the value added by foreign VC firms using a sample of portfolio companies from 81 countries over 1995-2010. They find that involvement by foreign VC firms translates into a higher probability of IPO exit and higher proceeds for their investees. Nahata et al. (2014) suggest that the foreign VC firm bridges cultural differences between its country of origin and the investee firm's country of origin. Hence, foreign VC firms enable their portfolio companies to overcome the so called "liability of foreignness" (Zaheer, 1995). The latter is created by the unfamiliarity of investors with the foreign country, including its culture and language. Chahine et al. (2019b) find that foreign VC firms mitigate this liability: New ventures with a VC syndicate with the right balance between domestic and foreign VC firms perform better at their IPO than other new ventures. Chahine et al. also report that foreign VC firms enhance the value added by foreign business activities if the VC firms originate from the countries where the IPO firm has foreign business activities. Again, this suggests that foreign VC firms reduce the liability of foreignness their investee firms face.

Concerning the effects of VC firms on innovation by their investee firms, there are two competing hypotheses (e.g. Hirukawa and Ueda, 2011; Bertoni and Tykvová, 2015). On the one side, there is the "innovation-first" hypothesis, according to which innovation precedes VC financing as VC firms are attracted by innovative firms. On the other side, there is the "VC-first" hypothesis, which states that VC financing comes first as it enhances and improves innovation by the recipients of such financing. Both hypotheses have empirical support. The "innovation-first" hypothesis is supported by e.g. Baum and Silverman (2004), Engel and Keilbach (2007), and Hirukawa and Ueda (2011). In turn, the "VC-first" hypothesis is validated by Kortum and Lerner (2000; and 2001) who find that VC investment increases the number of patent applications by the investee firm (see also Arqué-Castells, 2012; Bertoni et al., 2010; and Popov and Roosenboom, 2012). As there is support for both hypotheses, it is safe to argue that the direction of causality between VC financing and innovation flows both ways. Given our focus on firms about to go public as well as on VC financing pre-dating the IPO date, we argue that firms with VC ownership, whether domestic or foreign VC ownership, are more likely to engage in R&D. This discussion leads to our first hypothesis.

H1: R&D expenditures are positively related to both foreign and domestic VC ownership.

In turn, foreign VC firms from countries with high innovation output (i.e., high patent activity) are more likely to have a positive effect on the R&D conducted by their investee firms than foreign VC firms from countries with low patent activity. Indeed, foreign VC firms located in countries with high patent activity likely have access to local research. Such access may be via their networks, which may include contacts at public universities. Foreign corporate VC firms have more direct links to research. They are part of an industrial corporation, which likely has its own research department. Such VC firms would then be well placed to create synergies between the

R&D conducted by their investee firms and the R&D conducted by their parent company. Hence, our second hypothesis is as follows.

H2: The positive association between R&D expenditures and foreign VC ownership is higher for VC firms from countries with greater patent activity.

A priori, greater R&D expenditures should signal better future performance and hence lower IPO underpricing. However, there are at least two reasons why there might be no negative link between R&D expenditures and IPO underpricing. First, firms tend to reach the peak of their innovation at the time of their IPO (Bernstein, 2015). Importantly, the quality of their internal innovation declines following their IPO. Second, the output from R&D is highly uncertain. Hence, greater R&D expenditures may exacerbate information asymmetry around the IPO. In turn, this would increase IPO underpricing. Both Guo et al. (2006) and Zhou and Sadeghi (2019) find support for this argument as they observe a significant and positive relation between IPO underpricing and R&D expenditures. Hence, we expect a positive link between IPO underpricing and R&D expenditures. This leads us to our third hypothesis.

H3: Greater R&D expenditures are associated with greater underpricing.

While the input of innovation, i.e., R&D expenditures, can be easily measured at the time of the IPO, the future output of innovation, i.e., patents, is difficult to predict (Guo et al., 2006). While Zhou and Sadeghi (2019) confirm the existence of a positive link between IPO underpricing and R&D expenditures, i.e., innovation input, they also find a *negative* link between IPO underpricing and patent activity, i.e., innovation output. This suggests that investors are uncertain about whether IPO firms are successful in turning innovation input into innovation output, and ultimately are successful in creating shareholder value.

While an extensive body of literature (e.g. Megginson and Weiss, 1991; Stuart et al. 1999) supports that VC firms certify the quality of IPO firms, we argue that foreign VC firms, via their presence, signal the quality of innovation input. Foreign VC firms from countries with high patent activity are particularly well placed to play this role. This argument is consistent with prior evidence on the positive role played by VC syndicates in nurturing innovation (Tian, 2012). This argument is further supported by Haeussler et al. (2012) who show that firms' patenting activities have a strong effect on the timing of VC financing. The authors further investigate the quality of ventures' patents and find that, compared with ventures with lower patent quality, those with higher patent quality receive VC investment faster. Hence, we expect that foreign VC firms, particularly those from countries with high patent activity, moderate the positive link between IPO underpricing and R&D expenditures. This discussion leads to our fourth hypothesis.

H4: Underpricing associated with R&D expenditures is mitigated by ownership of foreign VC firms coming from countries with greater patent activity.

Finally, the effects of VC ownership on the performance of IPO firms are unlikely the same across types of foreign VC firms. From a resource-based perspective, different types of foreign investors likely have a differential effect on the outcomes of their portfolio companies given differences in their pool of resources. Importantly, corporate research departments generate about two thirds of all research conducted in the USA (Lerner, 2012). Within the VC industry, corporate VC firms are known to create value added (Gompers and Lerner, 2000; Dushintsky and Lenox, 2006) and boost equity growth (De Clercq et al., 2006). They also facilitate the development of innovative firms (Chemmanur et al., 2014), by providing their investees with valuable industry-specific expertise and access to a distribution channel (Hege et al., 2003; Dushnitsky and Lenox, 2006), which enhances the latter's probability of success (Nahata, 2008). Lerner (2012) goes one

step further by arguing that the best way to encourage innovation is via corporate VC firms given the link of such VC firms to corporate research departments.

Other types of VC firms such as financial or bank-affiliated, independent or private VC firms[4] are likely to lack the resources or long-term commitment of corporate VC firms. For example, independent VC firms have a shorter time to exit, as their future funding depends on successful exits. Their access to funding is also relatively limited and they are more likely to exit through an IPO (Wright et al., 1996; Guo et al., 2015). As such, they likely focus on the short-term outlook of their investees and might therefore forego longer-term, risky investments that could benefit the firm's future growth. Finally, financial and other VC firms may be constrained by the objectives of their fund providers, which may prevent them from exclusively pursuing financial profit maximization or the development of their investees. For example, financial VC firms may focus on forging relationships with future banking clients to leverage the complementarities between their VC business and their traditional loan business (Ginsberg et al., 2011). They also have limited skills in mentoring and supporting the performance of their portfolio firms (Cumming and MacIntosh, 2007; Johan, 2010). Hence, we argue that corporate VC firms are more likely to encourage their investee firms to invest in innovation, as reflected by greater R&D expenditures.

H5: The positive association between foreign corporate VC ownership and R&D expenditures is greater than the equivalent association between foreign non-corporate VC ownership and R&D expenditures.

[4] Additional types of VC firms include pension funds, endowments, foundations, consultancies, university affiliated programs, incubators, and government affiliated programs.

3. SAMPLE SELECTION AND METHODOLOGY

We started by obtaining the list of all IPOs from 2000 to 2016 from SDC Platinum.[5] This resulted in a total of 2,738 IPOs. We then excluded privatizations, spinoffs, real estate investment trusts (REITs), other special purpose vehicles, unit trusts, IPOs in the over-the-counter market, IPOs of financial firms, and those with an offer price of less than $5. The population of regular IPOs is 1,943 IPOs. We then matched these data with data from Compustat and Datastream on R&D expenditures[6] and total assets for the last fiscal year prior to IPO date. Due to 462 IPO firms with missing data on total assets and another 486 firms for which we were unable to obtain IPO prospectus, our final sample includes 995 IPOs.

Table 1 compares the sample to the population of US IPOs in terms of the distribution across time, based on the IPO year (Panel A), and across industries, using the one-digit Standard Industrial Classification (SIC) codes (Panel B). The percentages of firms in our sample across both time and industries are comparable to those of the population of IPO firms, thus confirming the sample's representativeness of the population.

Insert Table 1 Here

We retrieved the IPO prospectuses for our sample from SEC EDGAR. We used them to determine the ownership and location of the VC firms. We collected data on the founding years of the VC firms from their respective websites. Finally, we obtained the annual number of patents for the last year prior to IPO date for the countries of the foreign VC firms from the Organisation for Economic Co-operation and Development (OECD) database on patents.[7]

[5] Our data start in 2000 as the data on international patent activities are available only from 1999 onwards.
[6] Missing data on R&D expenditures were collected from the financial statements. If R&D expenditures were not disclosed in the financial statements, R&D expenditures were set to zero.
[7] The database is available at https://stats.oecd.org/Index.aspx?DataSetCode=PATS_IPC.

Our main dependent variables include R&D expenditures to total assets and IPO underpricing. *R&D to Total Assets* is the ratio of R&D expenditures over total assets during the last fiscal year prior to the fiscal year of the IPO. We also test the validity of our predictions by replacing *R&D to Total Assets* by the pre-IPO firm-level patent count, using the natural logarithm of one plus the number of patents at the end of the year prior to IPO date (*Ln Number of Patents*) obtained from the patent database of Bena et al. (2017), which uses patent data published by the US Patent and Trademark Office (USPTO). We assign a value of zero for the pre-IPO number of patents for IPO firms not included in this database.

We measure IPO performance by underpricing, obtained from SDC Platinum. *Underpricing* is the percentage change between the first day of trading's closing price and the offer price. Our empirical analysis uses a three-stage least squares (3SLS) cross-sectional regression model, which controls for the endogenous determination of VC ownership in the first regression and VC ownership or R&D expenditures in the second regression. There are two sets of hypotheses: The first set relates to the impact of foreign VC ownership and the level of innovation output in the foreign VC's country of origin, i.e., the level of patent activity, on the level of innovation input, i.e., R&D expenditures (i.e., Hypotheses (1) and (2)). The second set is about the effect of the joint impact of R&D expenditures, foreign VC ownership, and the level of patent activity on IPO underpricing (i.e., Hypotheses (3), (4), and (5)).

R&D 3SLS Regression Model

The validity of our first set of hypotheses is tested using the following 3SLS model:

$$\text{VC Ownership} = \text{Instrumental variables} + \text{Controls} + \xi \quad (1)$$

R&D to Total Assets = α_0 + α_1 Domestic VC Ownership + α_2 Foreign VC Ownership

+ Controls + ξ (2)

Where *VC Ownership*, *Domestic VC Ownership*, and *Foreign VC Ownership* are the total number of shares owned by all VC firms, domestic VC firms, and foreign VC firms, respectively, expressed as a proportion of the total number of shares outstanding prior to IPO. The control variables include *HH Index*, which controls for industry concentration. Lower industry concentration, i.e., higher competition, pushes firms to invest in R&D to better compete (Weiss and Wittkopp, 2005). We expect a negative association between *R&D to Total Assets* and *HH Index*, measured as the sum of the squared market shares of firm *i* in its industry, based on the two-digit SIC codes, at the end of the fiscal year prior to the IPO date. Both Equations (1) and (2) control for firm characteristics. Firm size, i.e., *LnAssets*, is the natural logarithm of total assets at the end of the fiscal year prior to the fiscal year of the IPO. *IPO Firm Age*, i.e., the age of the IPO firm since inception, controls for uncertainty. Finally, *Hi-tech* dummy equals one if the firm operates in a high-technology industry (as per Loughran and Ritter, 2004), and zero otherwise. All the regressions models are cross-sectional and they include industry and year dummies.

The instrumental variables are *Post-1980 Inception*, *VC Cluster*, and *CEO-VC Experience*. We argue that location, inception, and CEO experience affect the likelihood of the IPO firm receiving VC funding but not the extent to which has R&D expenditures. The likelihood of receiving VC funding has been shown to be higher if the IPO firm is located in California, New York, or Massachusetts, which are all areas with VC clusters (Powel et al., 2002; Chen et al., 2010). *VC Cluster* is a dummy variable equal to one if the IPO firm is located in such an area, and zero otherwise. Moreover, IPO firms, i.e., those established after 1980, and those with CEOs who

have prior work experience in the VC industry[8] are more likely VC-backed (Lungeanu and Zajac, 2016; Chahine and Zhang, 2020). *Post-1980 Inception* is a dummy variable equal to one if the IPO firm was founded after 1980, zero otherwise. Finally, *CEO-VC Experience* is a dummy variable equal to one if the CEO has worked for a VC firm, zero otherwise.

To test the validity of our second hypothesis on the differential effect of patent activity in the country of origin of the foreign VC firm, we split foreign VC ownership into two variables: *Foreign VC Ownership in Countries with High Patents*, and *Foreign VC Ownership in Countries with Low Patents*. We distinguish between high and low patent countries based on the median number of patents in the countries of origin of the VC firms invested in the sample.[9]

IPO Underpricing 3SLS Regression Model

The validity of our second set of hypotheses related to underpricing is tested by the following 3SLS regression model:

$$\text{VC Ownership} = \text{Instrumental variables} + \text{Controls} + \xi \quad (3)$$

$$\text{R\&D to Total Assets} = \alpha_0 + \alpha_1 \text{ Domestic VC Ownership} + \alpha_2 \text{ Foreign VC Ownership} + \text{Instrumental variable} + \text{Controls} + \xi \quad (4)$$

$$\text{Underpricing} = \alpha_0 + \alpha_1 \text{ R\&D to Total Assets} + \alpha_2 \text{ Domestic VC Ownership} + \alpha 3 \text{ Foreign VC Ownership} + \text{Controls} + \xi \quad (5)$$

The model uses the same instruments as in Equation (1) but also uses *HH Index* as an instrument in Equation (4). Equation (5) includes commonly used control variables in the IPO

[8] We collect this information from the CEO biographies published in the IPO prospectuses.
[9] The country data on the number of patents are pooled for each year and the country median is then calculated for this year.

underpricing literature (e.g. Chahine et al., 2007; Bruton et al., 2010). Specifically, *Price Revision* is the difference between the offer price and the mid-file price range expressed as a proportion of the latter. We also include *LnMarket Capitalization*, *LnAssets*, *IPO Age* and *Hi-tech* as defined above. We add a loss dummy and the leverage of the IPO firm. *Loss* is equal to one if the firm has a net loss, zero otherwise, and *Leverage* is equal to the ratio of total liabilities to total assets. Both variables are calculated at the end of the fiscal year prior to the fiscal year of the IPO. Finally, we include *Underwriter Reputation* using Loughran and Ritter (2004),[10] and *Market Return*, i.e., the return on the equally-weighted CRSP index over the three-month period prior to the IPO date to control for market momentum (Helwege and Liang, 2004).[11] All regression models control for industry effects (using the two-digit SIC codes) and for year effects. All variables are defined in Appendix 1.

4. EMPIRICAL ANALYSIS

In this section, we first present descriptive statistics. We then analyze the associations between R&D expenditures, VC ownership, and underpricing in line with our hypotheses.

4.1. Descriptive Statistics

Table 2 reports summary statistics, including the mean, standard deviation, and the correlation matrix for our main variables. The average firm in our sample has R&D expenditures amounting to 28.1% of total assets. The average IPO firm has 1.18 patents at the end of the fiscal year prior to IPO date. VC ownership is on average 33.3% and is mainly in the hands of domestic

[10] We use the updated underwriter reputation ranking by Jay Ritter using the methodology in Loughran and Ritter (2004) and covering 1980-2015. Since our sample period ends in 2016, we assign the rank 9 (highest rank) to underwriters who consistently ranked 9 during 2000-2015. For the remaining underwriters, we use their ranking of 2015 for 2016.

[11] Similar to Helwege and Liang (2004), we use the equally-weighted market return. As IPO firms are usually smaller than the average listed firm, using a value-weighted market return may lead to biased results on the impact of market momentum on IPO firms.

VC firms who own 29.5 percentage points on average compared to only 3.8 percentage points owned by foreign VC firms. The annual average number of patents in the countries of origin of the sample's foreign VC firms is 1,050. Figure 1 reports the average annual number of patents across 1999-2015. The average ranges from 18,051 patents per year for Japan to 10 for Argentina.[12]

Focusing on the control variables, Table 2 also shows that the average IPO firm has a market capitalization of $569.7m, and total assets of $475.6m. Moreover, the firms are approximately 16 years old at IPO, and 37.8% of them operate in high-technology industries. Finally, the average for the HH index is 0.045, and that 53.6% of the firms were founded after the year 1980, whereas 49% are located in VC clusters, and 15.1% have a CEO with prior VC work experience.

As to the pairwise correlations, Table 2 shows that *IPO Underpricing* is positively related to *R&D to Total Assets*, providing preliminary support for Hypothesis (3). Further, both *R&D to Total Assets* and the *Number of Patents* are positively correlated with VC ownership, including both domestic and foreign VC ownership, as well as foreign patents, thereby preliminarily supporting Hypothesis (2). Thus, the level of innovation input is positively associated with VC ownership and the level of innovation output of the country of origin of the foreign VC firm. As to the instrumental variables, *HH index* is negatively correlated with *R&D to Total Assets*, but not with *Underpricing* or *VC Ownership*, as expected. Moreover, *Post-1980 Inception*, *VC Cluster*, and *CEO-VC Experience* are significantly and positively associated with VC ownership but not significantly correlated with *R&D to Total Assets* or *Underpricing*, thus confirming the validity of our instruments.

[12] The annual number of patents for Japan exceeds the equivalent number for the USA in every year, except in 1999.

Insert Table 2 Here

Focusing on the composition of foreign VC firms involved in our study (not tabulated), we find that there are 349 foreign VC firms involved with 228 IPO firms in which foreign VC firms hold an average 11.3% pre-IPO ownership. Further, they are on average approximately 20 years old at the time of IPO.

Panel A in Appendix 2 shows that the majority of the 349 investments made by the foreign VC firms are made by independent foreign VC firms, followed by corporate foreign VC firms, which made slightly more than a quarter of the 349 investments. Panel B reports the distribution of the 228 foreign VC firms by type and origin. The 228 foreign VC firms originate from 24 different countries, mostly the United Kingdom (53), Canada (26), Japan (25), France (19), and Switzerland (17). The list of foreign VC firms includes well-known VC firms such as Novo Holdings A/S (10 IPO firms), TVM Life Science Ventures GmbH (10 firms), Novartis Bioventures Ltd (7 firms), Abingworth Bioventures (7 firms), Nomura International PLC (6 firms), and Apax Partners Worldwide (6 firms). Novo Holdings A/S is wholly owned by the Novo Nordisk Foundation, the largest financial endowment in Denmark and one of the largest endowments in the world with a net worth of $59.89bn in 2019; TVM Life Science is one of the oldest transatlantic VC funds with teams in Munich and Montreal; and Apax is a major private-equity company that has raised more than $50bn since 1981. Finally, Panel C suggests that the total and average age of domestic VC firms is significantly higher in mixed VC syndicates than in purely domestic VC syndicates. Hence, there is no evidence that VC syndicates with both domestic and foreign VC firms are of lower quality. Finally, Panel C suggests that the average age of foreign VC firms in purely foreign VC syndicates is around 17 years which is higher than the average age of 10 years of domestic VC firms in purely domestic VC syndicates.

4.2. Foreign VC Ownership and R&D Expenditures

Table 3 reports the results of the 3SLS estimation of Equations (1) and (2) controlling for the endogenous determination of *VC Ownership*. Specification (1), which is based on Equation (1), shows that *VC Ownership* is positively and significantly associated with *VC Cluster* and *CEO-VC Experience* (p=1%), confirming the validity of these two instruments. It is also greater in hi-tech firms (p=1%), whereas it decreases with firm size (p=1%). The Sargan $\chi 2$ test of over-identifying restrictions (not tabulated) has a p-value of 0.181 and 0.172 in Specification (2a) and (2b), respectively, suggesting that our instrumental variables are not associated with the error term in the *R&D to Total Assets* regression.

Further, Specification (2a), which is based on Equation (2), suggests that *R&D to Total Assets* increases with domestic (p=1%) and foreign VC ownership (p=1%), providing strong support for Hypothesis (1). A Wald test for the difference in coefficients suggests that the positive effect of VC ownership on *R&D to Total Assets* is stronger for foreign VC ownership than domestic VC ownership (p=10%). *R&D to Total Assets* also decreases with the HH index, firm size, and for hi-tech firms (p=1%).

Specification (2b), which is based on an extended Equation (2), replaces *Foreign VC Ownership* by *Foreign VC Ownership from High Patent Countries* and *Foreign VC Ownership from Low Patent Countries*. This enables us to test the validity of Hypothesis (2). While *R&D to Total Assets* still increases with *Domestic VC Ownership* (p=1%), it also increases with both foreign VC ownership from high (p=1%) and low patent countries (p=10%). Importantly, the Wald test for the difference in coefficients shows that the positive effect of high patent countries is significantly higher (p=10%) than the one of low patent countries. The Wald test for the difference between the coefficient on domestic VC ownership and that on foreign VC ownership from high

patent countries suggests that the positive effect of VC ownership on *R&D to Total Assets* is significantly stronger (p=10%) for foreign VC ownership from high patent countries than for domestic VC ownership.

Hence, while controlling for potential VC ownership selection bias, we find that both domestic and foreign VC ownership are a catalyst for IPO firms' R&D expenditures, and this effect is stronger for foreign VC ownership. Finally, the effect stemming from foreign VC ownership is mainly due to ownership by foreign VC firms from high patent countries. [13] To conclude, there is strong support for Hypothesis (2).

The main story of our paper is that foreign VC firms enhance and improve the innovation by their investee firms. This is reflected in greater innovation input as measured by R&D expenditures in IPO firms with foreign VC ownership. We also argue that foreign VC firms signal the quality of the innovation input of their investee firms. This would result in lower underpricing. The assumption here is that greater innovation *input* in IPO firms with foreign VC ownership eventually results in greater innovation *output*. Specification (3a) suggests that the pre-IPO number of patents is positively associated with foreign VC ownership (p=1%), thus providing strong support for our implicit assumption. Further, Specification (3b) shows that the pre-IPO number of patents also increases with both foreign VC ownership from high (p=1%) and low patent countries (p=5%). In what follows, we focus on R&D expenditures.

Insert Table 3 Here

[13] We repeat our tests allowing for alternative explanations for the differential effect of foreign VC firms on innovation output as proxied by the pre-IPO number of patents for each IPO firm. Such alternative explanations include the level of GDP per capita in the country of origin of the foreign VC firm. We also split foreign VC ownership into two variables: *Foreign VC Ownership in High GDP Countries*, and *Foreign VC Ownership in Low GDP Countries*. We still find that the positive association between innovation output and foreign VC ownership is higher for VC firms coming from high GDP countries. This confirms Hypothesis (2).

We further include *Leverage* and *Loss* as additional control variables in the *R&D to Total Assets* regression specifications. Although, the sample size drops to 793 observations, the results (not tabulated) hold. Given this drop, we report the results in Table 3 excluding these two variables. However, we include both variables in the 3SLS regression explaining underpricing in Table 4 as they are key control variables for underpricing as per prior IPO literature (e.g. Leone et al., 2007; and Filatotchev et al., 2016).

4.3. IPO Underpricing, R&D Expenditures, and Foreign VC Ownership

Table 4 tests the validity of Hypotheses (3) and (4), using the 3SLS model consisting of Equations (3), (4), and (5). The second-stage regression in Specifications (6a) to (6c) explains *Underpricing*, whereas the first-stage regression in Specifications (4) and (5) explains *VC Ownership* and *R&D to Total Assets*, respectively. Specification (4) reveals that, consistent with Specification (1) in Table 3, VC ownership increases with *VC Cluster* (p=1%), *CEO-VC Experience* (p=1%), and *Hi-tech* firms (p=1%), whereas it decreases with *LnAssets* (p=1%).

Furthermore, Specification (5) reveals that *R&D to Total Assets* increases with both domestic (p=1%) and foreign (p=1%) VC ownership, thus providing further support for Hypothesis (1). Yet the effect is economically stronger for the latter as confirmed by the Wald test (p=5%). *R&D to Total Assets* is negatively related to *HH Index* (p=1%), an instrumental variable. *R&D to Total Assets* increases in IPO firms making a loss in the year prior to the year of the IPO (p=1%), as well as increasing with leverage (p=5%). Conversely, *R&D to Total Assets* decreases with firm size (p=1%) and in hi-tech firms (p=5%). The Sargan $\chi 2$ test of over-identifying restrictions (not tabulated) has a p-value of 0.125, which confirms the validity of our instrumental variables.

Further, Specifications (6a), (6b), and (6c) suggest a negative association between underpricing on the one hand, and domestic VC ownership (p=10% or worse) and foreign VC ownership (p=5% or worse)[14] on the other hand. The presence of both domestic and foreign VC firms seems to signal the quality of the IPO firm, thus reducing IPO underpricing. These results extend prior literature on the role played by VC firms in reducing IPO underpricing (e.g. Barry et al., 1990; and Megginson and Weiss, 1991; Lerner, 1995; Brav and Gompers, 2003). Additionally, for Specification (6a), the Wald test for the difference in coefficients suggests that, in line with our previous results, the effect of VC ownership in reducing IPO underpricing is stronger (p=1%) for foreign VC firms than for domestic VC firms. The effect is also economically more significant: A one percentage point increase in foreign VC ownership is associated with a decrease in IPO underpricing by 0.52 percentage points compared to only 0.11 percentage points for domestic VC ownership.

Specifications (6a) to (6c) also reveal that, in line with Hypothesis (3), IPO underpricing is positively associated with *R&D to Total Assets* (p=5% or better), yet Specification (6c) indicates that this association is mitigated by the ownership of foreign VC firms coming from countries with high innovation output (p=10%), which validates Hypothesis (4). Hence, foreign VC firms from countries with high patent activity seem to signal the quality of the innovation input.

In addition, Specification (6b) shows a negative association between underpricing and *Foreign VC Ownership from High Patent Countries* (p=5%). This effect is stronger than that of domestic VC firms on IPO underpricing as confirmed by the Wald test for the difference in coefficients (p=1%). Again, there is economic significance: A one percentage point increase in

[14] The loss of significance in Specification (6c) might be due to the high correlation between *Foreign VC Ownership* and the interaction between *R&D to Total Assets* and *Foreign VC ownership in Low Patent Countries*.

foreign VC ownership is associated with a reduction in underpricing by 0.52 percentage points compared to only 0.11 percentage points for domestic VC ownership.

As for the control variables, the results from the underpricing regressions, i.e., Specifications (6a), (6b), and (6c) are consistent with prior literature on IPO underpricing (e.g. Chahine et al., 2012). Underpricing increases with the offer price revision (p=1%), firm size (p=1%), and for IPOs completed following a period of positive market returns (p=1%), whereas underpricing decreases with leverage (p=5% or better).

Insert Table 4 Here

4.4. Foreign Corporate VC Ownership and the Association between R&D and Foreign Patent Activity

Table 5 tests the validity of Hypothesis (5) by replicating Table 3, while making a distinction between foreign corporate VC firms and non-corporate VC firms. While not tabulated, average foreign corporate VC ownership equals 1.22%, whereas average ownership of all other foreign VC firms amounts to 3.83%.

Specification (8a) suggests that *R&D to Total Assets* is positively associated with *Domestic VC Ownership* (p=1%), as well as both *Foreign Corporate VC Ownership* and *Foreign Non-Corporate VC Ownership* (p=5%), lending further support for Hypothesis (1).

Specification (8b) distinguishes between foreign VC firms from high patent countries and those from countries with low patent countries. Similar to Specification (8a), it also distinguishes between corporate foreign and non-corporate foreign VC firms. In support of Hypothesis (2), *Foreign Corporate VC Ownership from High Patent Countries* and *Foreign Non-Corporate VC Ownership from High Patent Countries* are positively associated with *R&D to Total Assets*

(p=10% or better). Importantly, the Wald test for the difference in the two coefficients indicates that for foreign VC ownership from high patent countries, the positive effect on *R&D to Total Assets* is significantly higher (p=10%) than for foreign non-corporate VC ownership. There is also an economic difference as the coefficient on foreign corporate VC ownership (from high patent countries) is more than three times the size of the coefficient foreign non-corporate VC ownership. This confirms Hypothesis (5). Finally, the effects of the control variables are consistent with those found in Table 3.

Insert Table 5 Here

5. FURTHER TESTS

This section contains three further tests. The first test investigates whether foreign VC experience matters. While the main analysis focused on foreign VC ownership, foreign VC experience might matter more, as it tends to be a better reflection of the resources, such as access to research, that a foreign VC firm may be able to offer. Hence, we replace foreign VC ownership by foreign VC experience, as proxied by VC age, and rerun our main regressions.

The second test verifies the robustness of our main findings. It uses regressions explaining domestic and foreign VC ownership as the first stage in the 3SLS model to control for potential domestic and foreign VC selection bias. Conversely, the preceding 3SLS models did not make a distinction between domestic and foreign VC ownership as we aggregated both.

Finally, we conduct two further robustness tests by i) distinguishing between lead foreign VC firms and non-lead foreign VC firms and ii) by excluding observations relating to foreign VC firms from non-OECD countries.

5.1. Foreign VC Experience and the Association between R&D and Foreign Patent Activity

The experience of the VC firm has been identified as influential in supporting portfolio companies (e.g. Chahine and Saade, 2011). Indeed, VC experience is an important driver for the VC firm's ability to actively monitor its portfolio companies (Bottazzi et al., 2008). VC experience is also associated with increased innovation (Kortum and Lerner, 2000), greater power in affecting the behavior and the decisions made by the VC syndicate, which in turn affect the decisions made by the portfolio companies (Chahine and Goergen, 2011), and ultimately improve IPO performance (Bottazzi et al., 2008; Gompers et al., 2008). In line with Chahine et al. (2019a), we use VC firm age as a proxy for VC experience, i.e., the difference in years between the IPO date and the VC firm founding date. We argue that older, i.e., more experienced, foreign VC firms have a positive impact on the innovation levels of their US investee firms whereas there is no such effect for less experienced VC firms. When distinguishing between foreign VC firms coming from countries with high and low patent activity, we expect the positive effect on R&D expenditures to be limited to the former.

Table 6 presents the results of the 3SLS estimation, which controls for the endogenous determination of VC experience. The first-stage regression in Specification (9) shows that VC experience as proxied by the natural logarithm of VC firm age (*LnVC Age*) is positively and significantly associated with *VC Cluster* and *CEO-VC Experience* (p=5%), confirming the results from Table 3. It is also greater in hi-tech firms (p=1%), while decreasing with firm size (p=1%).

The question arises whether foreign VC ownership still has explanatory power once we account for foreign VC experience. As Table 2 suggests, foreign (domestic) VC ownership and foreign (domestic) VC age are highly correlated: The Pearson correlation coefficient for the two variables equals 0.619 (0.757). Hence, we first regress foreign (domestic) VC ownership on

foreign (domestic) VC age. We then include the residuals from this regression (not tabulated) in the second-stage regression in Specifications (10a) and (10b) of Table 6. Specification (9a) shows that *R&D to Total Assets* is positively associated with both domestic and foreign VC firm age (p=1%). Additionally, Specification (10b) suggests that the positive association between *R&D to Total Assets* and foreign VC firm age is greater for VC firms coming from high patent countries (p=1%).[15] Both Specifications (10a) and (10b) show that the residuals of foreign VC ownership and domestic VC ownership do not significantly affect *R&D to Total Assets*. This suggests that what matters is VC experience rather than just VC presence, i.e., VC ownership.

Insert Table 6 Here

5.2. Foreign versus Domestic VC Ownership and the Association between R&D and Foreign Patent Activity

The first-stage regression in our analysis so far explains VC ownership (both domestic and foreign VC ownership), based on Equation (1). However, domestic and foreign VC ownership may be driven by different factors. For example, the investments of domestic VC firms are more likely to be driven by their location within VC clusters, whereas foreign VC firms are more likely to be attracted by potential investee firms led by foreign CEOs. Indeed, foreign investors are likely to trust foreign CEOs with whom they share a similar ethnic and/or socio-cultural background (Marsden, 1988).

These arguments have empirical support. First, Powell et al. (2002) confirm the importance of geographic proximity: The locations of research-intensive biotechnology ventures and their VC firms are highly clustered in a handful of key US regions. Second, foreign VC firms are more

[15] The results hold when using foreign and domestic VC age in two separate first-stage regressions and when including *Leverage* and *Loss* in the *R&D to Total Assets* regression.

likely to be attracted by firms with a foreign CEO as confirmed by Bloningen and Wooster (2003). Although not shown in Table 2, the correlation coefficients between domestic (foreign) VC ownership on the one side and the VC cluster dummy or the foreign CEO dummy on the other side are 0.246 and 0.064 (0.138 and 0.298), respectively.

Table 7 presents the 3SLS model explaining *R&D to Total Assets* via the second-stage regression and explaining domestic VC ownership and foreign VC ownership via the two first-stage regressions. Specification (13a) suggests that *R&D to Total Assets* is still positively and significantly associated with *Domestic VC Ownership* (p=1%) and *Foreign VC Ownership* (p=1%), providing further support for Hypothesis (1). Additionally, Specification (13b) reveals that the positive association between *Foreign VC Ownership* and *R&D to Total Assets* is again higher for VC firms coming from high patent countries. This provides further support for Hypothesis (2).

Insert Table 7 Here

5.3. Further Robustness Tests

We run two further untabulated robustness tests. The first test distinguishes between lead and non-lead foreign VC firms within the VC syndicate. A foreign VC firm is the lead VC firm if it invested in the first financing round and holds the largest pre-IPO ownership in case of more than one VC firm involved with the first round. We find that both lead and non-lead foreign VC ownership are positively associated with *R&D to Total Assets*, but only the former reduces IPO underpricing. The positive association between lead foreign VC ownership and *R&D to Total Assets* is also observed for foreign VC firms originating from both high and low patent countries. However, non-lead foreign VC ownership positively affects *R&D to Total Assets* only if the VC

firms originate from high patent countries. Finally, IPO underpricing decreases with the lead foreign VC ownership when the foreign VC firm originates from a high patent country.

The second untabulated test checks whether our results are robust to excluding the 26 IPO firms with involvement from the 39 VC firms coming from non-OECD countries. We confirm our main findings: Both domestic and foreign VC ownership positively affect *R&D to Total Assets*, and this positive association is greater for firms coming from high patent countries.

6. CONCLUSION AND DISCUSSION

While there is an extensive literature documenting that VC firms create value in their investee firms by providing advice and support as well as access to networks and resources, this literature has tended to focus on domestic VC firms. Nevertheless, the emerging literature on foreign VC firms suggests that such VC firms create value above and beyond the value created by their domestic peers. In this paper, we explore a new channel whereby foreign VC firms generate value in their investees. We hypothesize that foreign VC firms – in particular, foreign VC firms from countries with high patent activity – have access to research generated in their home country, which in turn benefits the innovation levels of their investee firms.

While innovation is a necessary condition for generating future value and maintaining or strengthening the firm's competitive advantage, the literature also suggests that investors struggle with valuing innovation input, i.e., R&D expenditures. Indeed, studies on the impact of R&D expenditures on IPO underpricing have found a positive effect, suggesting that greater R&D expenditures worsen rather than mitigate information asymmetry in firms that are going public, as reflected by greater IPO underpricing. We hypothesize that foreign VC firms, especially foreign VC firms from countries with high patent activity, mitigate the effects of this information asymmetry on IPO underpricing.

Studying US firms that conducted their IPO during 2000-2016, we find evidence supporting the above hypotheses. We find that ownership by foreign VC firms increases R&D expenditures of their investee firms. While confirming the previously documented positive effect of R&D expenditures on IPO underpricing, we also observe that this positive effect is reduced by foreign VC ownership. Further, this moderating effect stems from foreign VC firms located in countries with high patent activity. We also find that the beneficial effects of foreign VC firms stem mainly from foreign corporate VC firms. This makes perfect sense as such VC firms are part of a larger corporation and can therefore easily tap into the research generated by the research department of their organization.

Our paper has important implications for managers of new ventures, especially those relying on innovation. Managers of such firms should include foreign VC firms, especially those from countries with high patent activity, in their VC syndicate. This would not only ensure access to research, but it would also reduce the uncertainty about the valuation of the firm at the time of going public.

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Appendix 1 - Variables Definition

CEO-VC Experience	A dummy variable equal to one if the CEO has worked for VC firm, zero otherwise (Source: *IPO Prospectus*).
Domestic VC Ownership	Pre-IPO domestic VC ownership as a fraction of shares outstanding before the IPO (Source: *IPO Prospectus*).
Foreign Corporate VC Ownership	Pre-IPO foreign corporate VC ownership as a fraction of the shares outstanding before the IPO (Source: *IPO Prospectus*).
Foreign Non-Corporate VC Ownership	Pre-IPO foreign non-corporate VC ownership as a fraction of shares outstanding before the IPO (Source: *IPO Prospectus*).
Foreign Patents	The total number of patents in the country of origin of the VC firm during the last fiscal year prior to the IPO date. For IPOs with more than one foreign VC firm coming from different countries, we consider the sum of patents originated from all countries (Source: *OECD*).
Foreign VC Ownership	Pre-IPO foreign VC ownership as a fraction of the shares outstanding before the IPO (Source: *IPO Prospectus*).
Foreign VC Ownership from High (Low) Patent Countries	Equal to foreign VC ownership from countries with a high (low) number of patents. A country with a high (low) number of patents is defined as a country with an above (below) median number of patents. This number is calculated for every year.
HH Index	The sum of the squared market shares of firm *i* in its industry, measured using the 2-digit SIC, at the end of the fiscal year prior to the fiscal year of the IPO (Source: *Compustat*).
Hi-tech	A dummy variable equal to one if the IPO firm is in a High-technology industry sector, and zero otherwise. High-technology industry sectors are defined as per Loughran and Ritter (2004). They are those with SIC codes 3571, 3572, 3575, 3577, 3578 (computer hardware); 3661, 3663, 3669 (communications equipment); 3671, 3672, 3674, 3675, 3677, 3678, 3679 (electronics), 3812 (navigation equipment); 3823, 3825, 3826, 3827, 3829 (measuring and controlling devices); 3841, 3845 (medical instruments); 4812, 4813 (telephone equipment), 4899 (communications services); and 7371, 7372, 7373, 7374, 7375, 7378, and 7379 (software) (Source: *SDC Platinum*).
IPO Firm Age	The difference in years between the IPO date and the company's incorporation date (Source: *Jay Ritter Database*).
Leverage	The ratio of total liabilities to total assets in the fiscal year prior to the IPO (Source: *Compustat*).

Ln Number of Patents	The natural logarithm of one plus the pre-IPO firm-level patent count at the end of the year prior to IPO date. (Source: *Bena et al., 2017*).
LnAssets	The natural logarithm of Total Assets.
LnAverage VC Age	The natural logarithm of the average age of the VC firms in the IPO firm's VC syndicate (Source: *VC websites*).
Loss	A dummy variable equal to one if the IPO company has a negative ROA in the fiscal year prior to the IPO, and zero otherwise (Source: *Compustat*).
Market Capitalization	The offer price multiplied by the number of shares outstanding prior to IPO. Empirical investigations use the natural logarithm of market capitalization (Source: *SDC Platinum*).
Market return	The buy-and-hold market return of the equally weighted CRSP index over the three-month period prior to the IPO date (Source: *CRSP database*).
Post-1980 Inception	A dummy variable equal to one if the founding date of the IPO firm is after 1980, and zero otherwise (Source: *SDC Platinum*).
Price Revision	The difference between the offer price and the mid-file price range divided by the latter stipulated in the IPO prospectus (Source: *IPO Prospectus*).
R&D to Total Assets	R&D expenditures over total assets in the last fiscal year prior to the fiscal year of the IPO (Source: *IPO Prospectus and Compustat*).
Total Assets	Total assets in the last fiscal year prior to the fiscal year of the IPO. Empirical investigations use the natural logarithm of Total Assets (Source: *IPO Prospectus and Compustat*).
Underpricing	The difference between the closing price of the first day of trading and the offer price divided by the latter (Source: *SDC Platinum*).
Underwriter reputation	This is an index ranging from 1 to 9 (least to most reputable underwriters, as in Loughran and Ritter, 2004).
VC Cluster	A dummy variable equal to one if the IPO firm is located in California, New York, or Massachusetts, and zero otherwise (Source: *SDC Platinum*).
VC Ownership	Pre-IPO VC ownership as a fraction of shares outstanding before the IPO (Source: *IPO Prospectus*).

Appendix 2 - Summary Statistics on the Foreign VC Firms

Panel A – The 349 Investments by the 228 Foreign VC Firms by Type of VC Firm

	Financial	Corporate	Independent	Others	Total
Number	46	90	201	12	349
%	13.20	25.80	57.60	3.40	100

Panel B – The Type and Origin of the 228 Foreign VC Firms

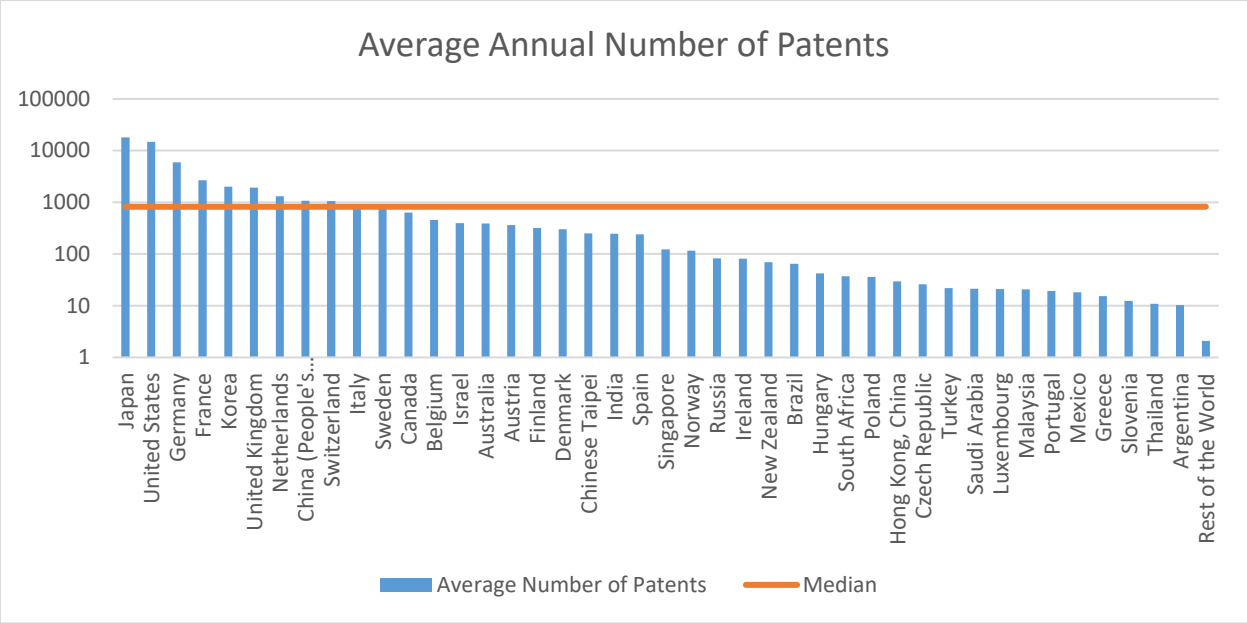
Country	Financial	Corporate	Independent	Others	Total
Number	33	60	125	10	228
%	14.5	26.3	54.8	4.4	100
Canada	7	6	12	1	26
United Kingdom	6	10	36	1	53
Japan	5	13	7	0	25
France	4	7	8	0	19
Switzerland	4	4	7	2	17
Germany	2	4	8	0	14
Sweden	2	2	1	0	5
Denmark	1	4	1	1	7
Netherlands	1	1	6	2	10
Taiwan	1	0	10	0	11
Ireland	0	2	1	0	3
Belgium	0	1	3	0	4
China	0	1	3	0	4
Luxembourg	0	1	1	0	2
Mexico	0	1	0	0	1
Norway	0	1	0	0	1
Russia	0	1	0	1	2
Singapore	0	1	1	2	4
Israel	0	0	7	0	7
Australia	0	0	5	0	5
Hong Kong	0	0	3	0	3
South Korea	0	0	2	0	2
Norway	0	0	1	0	1
Panama	0	0	1	0	1
Vietnam	0	0	1	0	1

Panel C – Total VC Age in Mixed VC Syndicates, Purely Domestic and Purely Foreign VC Syndicates

	Sum VC Age		Average VC Age	
	Domestic	Foreign	Domestic	Foreign
Mixed Syndicate	75.307	29.894	19.566	20.874
Foreign VC Only		16.643		17.036
Domestic VC Only	37.839		10.104	
Prob.(T-test for Diff.)	0.000	0.136	0.000	0.195

There is a total of 349 investments made by 228 foreign VC firms in 227 IPO firms. Foreign VC firms hold an average 11.3% pre-IPO ownership, and they are 19.6 years old at the time of IPO. Panel A of the table reports the type of foreign VC firm for each of the 349 investments. Panel B shows the type and origin of the 228 foreign VC Firms. Panel C reports the sum of VC age, a proxy for VC experience as well as VC reputation, for domestic and foreign VC firms for mixed VC syndicates, syndicates of foreign VC firms only, and syndicates of domestic VC firms only.

Figure 1: Average Number of Patents Per Country During 1999-2015



The figure reports the average annual number of patents per country for the period of 1999-2015. The scale for the y-axis is in logarithmic form with the base being 10. The rest of the world includes a total of 58 countries with average annual number of patents ranging from zero for Puerto Rico to just below 10 for Liechtenstein. In the figure, the median is based on the data pooled across countries and years, whereas in the regression analysis we recalculate the median for each year (i.e., we pool the data across countries only).

Table 1 – Data Representativeness of Sample

Panel A: Distribution across Time

Year	IPO Sample		IPO Population	
	Number of Firms	% of Firms	Number of Firms	% of Firms
2000	215	21.6	366	18.8
2001	19	1.9	59	3.0
2002	36	3.6	51	2.6
2003	34	3.4	51	2.6
2004	100	10.1	157	8.1
2005	83	8.3	140	7.2
2006	93	9.3	140	7.2
2007	90	9.0	165	8.5
2008	1	0.1	23	1.2
2009	3	0.3	44	2.3
2010	11	1.1	108	5.6
2011	7	0.7	80	4.1
2012	42	4.2	72	3.7
2013	72	7.2	121	6.2
2014	99	10.0	178	9.2
2015	56	5.6	112	5.8
2016	34	3.4	76	3.9
Total	995	100	1,943	100

Panel B: Distribution across Industries

Industry Sector	IPO Sample		IPO Population	
	Number of Firms	% of Firms	Number of Firms	% of Firms
1 – Mining and construction products	34	3.4	78	4.0
2 – Light manufactured products	335	33.7	432	22.2
3 – Heavy manufactured products	201	20.2	439	22.6
4 – Transportation and public utilities	59	5.9	169	8.7
5 – Wholesale trade	77	7.7	150	7.7
7 – Services	231	23.2	551	28.4
8 – Health services	58	5.8	123	6.3
9 – Other	0	0.0	1	0.1
Total	995	100	1,943	100

This table presents the distribution of both the sample and the IPO population across time in Panel A and across industries in Panel B. Panel A focuses on the year of the IPO whereas Panel B is based on the one-digit SIC codes.

Table 2 – Descriptive Statistics

	Mean	Std.	1	2	3	4	5	6	7	8	9	10	11	12
1. Underpricing	0.225	0.413	1.000											
2. R&D to Total Assets	0.281	0.380	0.071	1.000										
3. Number of Patents	1.180	3.560	0.102	0.081	1.000									
4. VC Ownership	0.333	0.333	0.034	0.341	0.087	1.000								
5. Domestic VC Ownership	0.295	0.308	0.047	0.311	0.065	0.959	1.000							
6. Foreign VC Ownership	0.038	0.095	-0.038	0.192	0.058	0.401	0.126	1.000						
7. VC Age	52.263	64.006	0.066	0.271	0.094	0.762	0.732	0.302	1.000					
8. Domestic VC Age	45.471	56.961	0.098	0.237	0.092	0.732	0.757	0.115	0.949	1.000				
9. Foreign VC Age	6.792	20.617	-0.069	0.189	0.039	0.343	0.181	0.619	0.484	0.182	1.000			
10. Foreign Patent	1050.1	4548.1	-0.028	0.095	0.126	0.205	0.103	0.385	0.239	0.053	0.597	1.000		
11. Price Revision	-0.016	0.146	0.423	-0.086	0.008	-0.026	-0.003	-0.082	-0.011	0.027	-0.109	-0.077	1.000	
12. Underwriter Reputation	8.021	1.651	0.107	-0.112	0.028	0.083	0.078	0.037	0.093	0.102	0.008	-0.023	0.119	1.000
13. Market Return	0.054	0.091	0.262	-0.039	-0.023	-0.016	-0.013	-0.014	-0.059	-0.058	-0.024	-0.025	0.276	-0.042
14. Market Capitalization	569.7	907.9	0.087	-0.174	0.021	-0.157	-0.146	-0.077	-0.069	-0.047	-0.084	-0.037	0.169	0.244
15. Total Assets	475.6	2860.8	-0.030	-0.024	-0.018	-0.009	-0.015	0.015	-0.179	-0.164	-0.103	-0.019	-0.069	0.040
16. IPO Firm Age	15.617	21.432	-0.119	-0.262	-0.044	-0.331	-0.321	-0.120	-0.255	-0.253	-0.092	-0.070	-0.029	0.071
17. Hi-Tech	0.378	0.485	0.210	-0.100	0.115	0.034	0.062	-0.085	0.051	0.090	-0.092	-0.051	0.136	0.089
18. Leverage	0.774	0.905	-0.095	0.228	-0.013	-0.108	-0.115	-0.001	-0.094	-0.102	-0.004	-0.024	-0.081	-0.266
19. Loss	0.675	0.468	0.104	0.377	0.104	0.410	0.383	0.197	0.354	0.344	0.150	0.084	-0.035	-0.041
20. HH Index	0.045	0.042	-0.022	-0.265	-0.076	-0.029	-0.027	-0.016	-0.260	-0.243	-0.138	-0.084	0.024	0.056
21. Post-1980 Inception	0.536	0.499	-0.018	0.158	0.151	0.391	0.348	0.246	0.329	0.306	0.176	0.081	-0.110	-0.009
22. VC Cluster	0.490	0.500	0.048	0.039	0.141	0.267	0.246	0.138	0.231	0.226	0.092	0.069	0.081	0.042
23. CEO-VC Experience	0.151	0.358	0.014	0.025	-0.009	0.147	0.147	0.040	0.131	0.125	0.059	0.033	0.007	-0.002

	12	13	14	15	16	17	18	19	20	21	22
13. Market Return	1.000										
14. Market Capitalization	0.021	1.000									
15. Total Assets	0.011	0.157	1.000								
16. IPO Firm Age	0.021	0.220	0.122	1.000							
17. Hi-Tech	0.088	0.017	-0.081	-0.144	1.000						
18. Leverage	-0.008	-0.019	0.018	0.043	-0.025	1.000					
19. Loss	0.058	-0.147	-0.021	-0.334	0.100	0.046	1.000				
20. HH Index	0.038	0.152	0.039	0.288	-0.156	-0.007	-0.290	1.000			
21. Post-1980 Inception	-0.097	0.007	0.042	-0.175	-0.135	0.050	0.248	-0.310	1.000		
22. VC Cluster	0.008	-0.090	-0.065	-0.220	0.148	-0.042	0.223	-0.208	0.200	1.000	
23. CEO-VC Experience	-0.046	-0.042	-0.039	-0.063	0.002	-0.042	0.109	-0.074	0.088	0.076	1.000

Pearson correlation coefficients were used for the continuous variables, whereas point biserial correlation coefficients were used for the dichotomous variables. Correlations above 0.062 (0.082) or below -0.090 (-0.120) are significant at the level of 0.05 (0.01). Our sample includes 995 observations, except for underpricing, price revision, market capitalization, leverage, and loss.

Table 3 – Foreign VC Ownership and the Association between R&D and Foreign Patent Activity

Dependent Variable	VC Ownership	R&D to Total Assets		Ln Number of Patents	
	(1)	(2a)	(2b)	(3a)	(3b)
Constant	0.386***	0.746***	0.771***	0.030	0.031
	0.000	*0.000*	*0.000*	*0.819*	*0.812*
Domestic VC Ownership		0.231***[c1]	0.248***[c2]	0.116	0.117
		0.000	*0.000*	*0.153*	*0.151*
Foreign VC Ownership		0.351***[c1]		0.872***	
		0.002		*0.000*	
Foreign VC Ownership from High Patent Countries			1.184***[c3,c2]		0.851***
			0.004		*0.202*
Foreign VC Ownership from Low Patent Countries			0.237*[c3]		0.927**
			0.092		*0.045*
LnAssets	-0.019***	-0.077***	-0.077***	0.022	0.022
	0.001	*0.000*	*0.000*	*0.119*	*0.119*
IPO Firm Age		0.000	0.000	-0.001	-0.001
		0.841	*0.837*	*0.666*	*0.665*
Hi-tech	0.108***	-0.170***	-0.168***	-0.105**	-0.105**
	0.002	*0.000*	*0.000*	*0.048*	*0.048*
HH Index		-1.484***	-1.483***	-2.931***	-2.928***
		0.001	*0.001*	*0.009*	*0.009*
Post-1980 Inception	-0.025				
	0.359				
VC Cluster	0.080***				
	0.000				
CEO-VC Experience	0.060***				
	0.006				
Industry Effects	Yes	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes	Yes
N.	995	995	995	995	995
R-squared	0.395	0.335	0.336	0.213	0.213
Chi2	655.830	524.200	526.490	272.630	272.650

Prob.	0.000	0.000	0.000	0.000	0.000

This table presents the results of 3SLS regressions explain VC ownership and R&D expenditures to total assets. Specifications (2a) and (2b) and Specifications (3a) and (3b) consist of the second-stage regressions explaining R&D to total assets and the pre-IPO number of patents, respectively; whereas the regression explaining VC ownership in Specification (1) is used as the first-stage regression. Both the domestic and foreign VC ownership variables are orthogonalized to alleviate multi-collinearity concerns. The t-statistics are based on White (1980) heteroskedasticity-consistent standard errors and covariances. P-values are reported in italic below the coefficients. ***, **, and * denote significance at the 1 percent, 5 percent, and 10 percent level (two-tailed). c: Pairs of coefficients significantly different from each other at the 10 percent level.

Table 4 – IPO Underpricing, Foreign VC Ownership and the Association between R&D and Foreign Patent Activity

Dependent Variable	VC Ownership	R&D to Total Assets	Underpricing		
	(4)	(5)	(6a)	(6b)	(6c)
Constant	0.279***	0.481***	-0.557***	-0.552***	-0.562**
	0.006	*0.000*	*0.002*	*0.002*	*0.015*
R&D to Total Assets			0.780***	0.789***	1.067**
			0.000	*0.000*	*0.030*
Domestic VC Ownership		0.191***[b]	-0.110*[a]	-0.116*[a]	-0.075
		0.000	*0.075*	*0.088*	*0.290*
Foreign VC Ownership		0.410***[b]	-0.518***[a]		
		0.000	*0.008*		
Foreign VC Ownership from High Patent Countries				-0.467**[a]	0.622
				0.044	*0.308*
R&D to Total Assets x Foreign VC Ownership from High Patent Countries					-3.266*
					0.089
Foreign VC Ownership from Low Patent Countries				-0.747	-6.166
				0.470	*0.111*
R&D to Total Assets x Foreign VC Ownership from Low Patent Countries					17.877
					0.132
Price Revision			0.910***	0.908***	0.948***
			0.000	*0.000*	*0.000*
Ln Market Capitalization			0.068***	0.068***	0.056***
			0.001	*0.001*	*0.006*
Loss		0.071***	-0.042	-0.040	-0.003
		0.001	*0.245*	*0.279*	*0.938*
Leverage		0.028**	-0.070***	-0.071***	-0.061**
		0.043	*0.004*	*0.003*	*0.014*
Underwriter Reputation			0.006	0.005	0.005
			0.587	*0.633*	*0.669*
Market Return			1.088***	1.093***	1.019***
			0.000	*0.000*	*0.000*
LnAssets	-0.023***	-0.057***			
	0.001	*0.000*			
IPO Firm Age		0.000	-0.001	-0.001	-0.001
		0.620	*0.395*	*0.363*	*0.386*
Hi-tech	0.114***	-0.080***	0.044	0.046	0.042
	0.001	*0.000*	*0.411*	*0.394*	*0.424*
HH Index		-1.623***			
		0.000			
Post-1980 Inception	0.011				
	0.743				

VC Cluster	0.086***				
	0.000				
CEO-VC Experience	0.103***				
	0.000				
Industry Effects	Yes	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes	Yes
N.	753	753	753	753	753
R-squared	0.323	0.359	0.268	0.266	0.332
Chi2	370.540	451.120	441.610	444.520	436.410
Prob.	0.000	0.000	0.000	0.000	0.000

This table presents the results of 3SLS regressions explaining VC ownership, R&D to total assets, and underpricing. Specifications (6a), (6b), and (6c) consist of the second-stage regressions explaining underpricing, whereas Specifications (4) and (5) consist of the first-stage regressions explaining VC ownership and R&D to total assets. Both the domestic and foreign VC ownership variables are orthogonalized to alleviate multi-collinearity concerns. The t-statistics are based on White (1980) heteroskedasticity-consistent standard errors and covariances. P-values are reported in italic below the coefficients. ***, **, and * denote significance at the 1 percent, 5 percent, and 10 percent level (two-tailed), respectively. a: Pairs of coefficients significantly different from each other at the 1 percent level.

Table 5 – Foreign Corporate VC Ownership and the Association between R&D and Foreign Patent Activity

Dependent Variable	VC Ownership	R&D to Total Assets	
	(7)	(8a)	(8b)
Constant	0.386***	0.745***	0.762***
	0.000	*0.000*	*0.000*
Domestic VC Ownership		0.217***	0.200***
		0.000	*0.000*
Foreign Corporate VC Ownership		0.696**	
		0.034	
Foreign Corporate VC Ownership from High Patent Countries			0.977**[c]
			0.049
Foreign Corporate VC Ownership from Low Patent Countries			0.074
			0.762
Foreign Non-Corporate VC Ownership		0.635***	
		0.001	
Foreign Non-Corporate VC Ownership from High Patent Countries			0.309*[c]
			0.063
Foreign Non-Corporate VC Ownership from Low Patent Countries			1.609
			0.364
LnAssets	-0.019***	-0.077***	-0.077***
	0.001	*0.000*	*0.000*
IPO Firm Age		0.000	0.000
		0.842	*0.905*
Hi-tech	0.108	-0.170***	-0.181***
	0.002	*0.000*	*0.000*
HH Index		-2.150***	-2.151***
		0.000	*0.000*
Post-1980 Inception	-0.025		
	0.359		
VC Cluster	0.080***		
	0.000		
CEO-VC Experience	0.060***		
	0.007		
Industry Effects	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes
N.	995	995	995
R-squared	0.395	0.335	0.336
Chi2	655.860	524.510	517.740
Prob.	0.000	0.000	0.000

This table presents the results of 3SLS explaining VC ownership and R&D to total assets. Specifications (8a) and (8b) consist of the second-stage regressions explaining R&D to total assets, whereas Specification (7) consists of the first-stage regression explaining VC ownership. Both the domestic and foreign VC ownership variables are orthogonalized to alleviate multi-collinearity concerns. The t-statistics are based on White (1980) heteroskedasticity-consistent standard errors and covariances. P-values are reported in italic below the coefficients. *** and ** denote significance at the 1 percent and 5 percent level (two-tailed), respectively. c: Pairs of coefficients significantly different from each other at the 10 percent level.

Table 6 – Foreign VC Experience and the Association between R&D and Foreign Patent Activity

Dependent Variable	LnAverageVC Age	R&D to Total Assets	
	(9)	(10a)	(10b)
Constant	1.928***	0.681***	0.682***
	0.000	*0.000*	*0.000*
Ln Average Domestic VC Age		0.038***[b]	0.038***[b]
		0.000	*0.000*
Ln Average Foreign VC Age		0.013*[b]	
		0.089	
Ln Average Foreign VC Age in High Patent Countries			0.015*[b]
			0.081
Ln Average Foreign VC Age in Low Patent Countries			0.004
			0.800
LnAssets	-0.092***	-0.077***	-0.077***
	0.000	*0.000*	*0.000*
IPO Firm Age		0.000	0.000
		0.869	*0.855*
Hi-tech	0.386**	-0.183***	-0.181***
	0.016	*0.000*	*0.000*
HH Index		-2.146***	-2.138***
		0.000	*0.000*
Post-1980 Inception	-0.625***		
	0.000		
VC Cluster	0.246***		
	0.003		
CEO-VC Experience	0.177*		
	0.099		
Industry Effects	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes
N.	995	995	995
R-squared	0.364	0.335	0.335
Chi2	577.260	513.570	514.260
Prob.	0.000	0.000	0.000

This table presents the results of 3SLS regressions explain VC age and R&D to total assets. Specifications (10a) and (10b) consist of the second-stage regressions explaining R&D to total assets, whereas Specification (9) consists of the first-stage regression explaining VC age. Both the average domestic and foreign VC age variables are used as proxies for VC experience, and they orthogonalized to alleviate multi-collinearity concerns. The t-statistics are based on White (1980) heteroskedasticity-consistent standard errors and covariances. P-values are reported in italic below the coefficients. *** and ** denote significance at the 1 percent and 5 percent level (two-tailed), respectively.

Table 7 – Robustness Test Using Foreign vs. Domestic VC Ownership and the Association between R&D and Foreign Patent Activity

Dependent Variable	Domestic VC Ownership	Foreign VC Ownership	R&D to Total Assets	
	(11)	(12)	(13a)	(13b)
Constant	0.325***	0.091***	0.745***	0.770***
	0.000	*0.000*	*0.000*	*0.000*
Domestic VC Ownership			0.218***	0.235***[c2]
			0.000	*0.000*
Foreign VC Ownership			0.398***	
			0.000	
Foreign VC Ownership from High Patent Countries				1.200***[c1,c2]
				0.008
Foreign VC Ownership from Low Patent Countries				0.281*[c1]
				0.064
LnAssets	-0.017***	-0.002	-0.077***	-0.077***
	0.001	*0.200*	*0.000*	*0.000*
IPO Firm Age			0.000	0.000
			0.821	*0.819*
Hi-tech	0.105***	-0.004	-0.168***	-0.166***
	0.002	*0.741*	*0.000*	*0.000*
HH Index			-1.471***	-1.470***
			0.002	*0.002*
Post-1980 Inception	-0.019	-0.041***		
	0.459	*0.000*		
VC Cluster	0.067***			
	0.000			
CEO-VC Experience	0.064***	0.003		
	0.005	*0.677*		
Foreign CEO		0.078***		
		0.000		
Industry Effects	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes
N.	995	995	995	995
R-squared	0.343	0.223	0.335	0.337
Chi2	523.320	289.110	522.310	524.260
Prob.	0.000	0.000	0.000	0.000

This table presents the results of 3SLS regressions explaining R&D to total assets, domestic VC ownership, and foreign VC ownership. Specifications (13a) and (13b) consist of the second-stage regressions explaining R&D to total assets, whereas Specifications (11) and (12) consist of the first-stage regressions explaining domestic VC ownership and foreign VC ownership, respectively. Both the domestic and foreign VC ownership variables are orthogonalized to alleviate multi-collinearity concerns. The t-statistics are based on White (1980) heteroskedasticity-consistent standard errors and covariances. P-values are reported in italic below the coefficients. *** and * denote significance at the 1 percent and 10 percent level (two-tailed). c: Pairs of coefficients significantly different from each other at the 10 percent level.