Journal of Corporate Finance 18 (2012) 451–475

Contents lists available at SciVerse ScienceDirect

Journal of Corporate Finance

journal homepage: www.elsevier.com/locate/jcorpfin

What drives the valuation premium in IPOs versus acquisitions? An empirical analysis

Onur Bayar [a], Thomas J. Chemmanur [b,*]

[a] University of Texas at San Antonio, College of Business, San Antonio, TX 78249, USA
[b] Boston College, Carroll School of Management, Chestnut Hill, MA 02467, USA

ARTICLE INFO

Article history:
Received 4 March 2011
Received in revised form 30 January 2012
Accepted 31 January 2012
Available online 9 February 2012

JEL classification:
G24
G32
G34

Keywords:
Initial public offerings
Acquisitions
Valuation premium
Private firms
Exit mechanisms

ABSTRACT

Using a hand-collected data set of private firm acquisitions and IPOs, this paper develops the first empirical analysis in the literature of the "IPO valuation premium puzzle," which refers to a situation where many private firms choose to be acquired rather than to go public at higher valuations. We also test several new hypotheses regarding a private firm's choice between IPOs and acquisitions. Our analysis of private firm valuations in IPOs and acquisitions indicates that IPO valuation premia disappear for larger VC backed firms after controlling for various observable factors affecting a firm's propensity to choose IPOs over acquisitions. Further, after controlling for the long-run component of the expected payoff to firm insiders from an IPO exit, we find that the IPO valuation premium vanishes even for larger non-VC backed firms and shrinks substantially for smaller firms as well. Our Heckman-style treatment effects regression analysis demonstrates that the above results are robust to controlling for the selection of exit mechanism by firm insiders based on unobservables. Our findings on private firms' choice between IPOs and acquisitions can be summarized as follows. First, firms operating in industries characterized by the absence of a dominant market player (and therefore more viable against product market competition) are more likely to go public rather than to be acquired. Second, more capital intensive firms, those operating in industries characterized by greater private benefits of control, and those which are harder to value by IPO market investors are more likely to go public rather than to be acquired. Third, the likelihood of an IPO over an acquisition is greater for venture backed firms and those characterized by higher pre-exit sales growth.

1. Introduction

One of the most important events in the life of a private firm is the exit decision, where the original backers of the firm, namely, entrepreneurs and venture capitalists, liquidate (at least partially) some of their equity holdings in their private firm, while also raising external financing for new investment in the firm. "Going public" through an initial public offering (IPO) is an important and well-known exit mechanism that has been extensively studied in the literature both theoretically and empirically. However, an equally important but less studied exit option for private firms is an acquisition by another (usually larger) firm. The ratio of acquisitions to IPOs among private firm exits has increased dramatically in recent years. Over the last decade, a private firm was much more likely to have been acquired than to go public. According to the National Venture Capital Association (NVCA), there were more exits by venture capital backed firms through acquisitions than by IPOs in each of the last ten years. Moreover, acquisitions constituted 73% of the value of exits of venture backed firms in 2007. In 2008, there were only 6 venture-backed IPOs raising a total of $470.2 million according to the NVCA. On the other hand, the venture-backed M&A market continued to perform

* Corresponding author. Tel.: +1 617 552 3980; fax: +1 617 552 0431.
E-mail addresses: onur.bayar@utsa.edu (O. Bayar), chemmanu@bc.edu (T.J. Chemmanur).

0929-1199/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
doi:10.1016/j.jcorpfin.2012.01.007

relatively strongly in 2008 with 96 companies being acquired with a total value of $13.9 billion. Gao et al. (2011) provide additional evidence on the significant reduction in the number of IPOs relative to acquisitions in the last decade.

An important recent paper that analyzes a firm's choice between IPOs and acquisitions is Poulsen and Stegemoller (2008). Poulsen and Stegemoller (2008) use firm-level data on private firm acquisitions (from 1995 to 2004) to document that firms with greater growth opportunities, more capital constraints and VC backing are more likely to go public rather than be acquired. They also report that IPO firms have greater valuations and valuation multiples than acquired firms, suggesting that there exists a valuation premium for IPOs over acquisitions. In particular, in a comparison of returns earned by insiders of IPO firms vs. insiders of acquired firms, Poulsen and Stegemoller (2008) report that the median market value to book value of assets ratio and the median market value to sales ratio are higher for IPOs compared to acquisitions. Brau et al. (2003) use industry-level, aggregated data (from an earlier time period covering 1984 to 1998) to document that current cost of debt, relative "hotness" of the IPO market, firm size, and insider ownership are positively related to the probability of an IPO; conversely, they document that acquisitions are more likely in high market-to book and highly leveraged industries. They also find that, on average, insiders of private firm targets receive a takeover payoff that equals only 78% of an IPO payoff. Thus, in many cases, entrepreneurs and venture capitalists seem to choose to let their firms be acquired at a lower valuation relative to the value at which it could have gone public.

In a recent paper, Bayar and Chemmanur (2011) develop a theoretical analysis of a firm's choice between IPOs and acquisitions, and develop several new testable predictions regarding this choice, especially those based on product market competition and private benefits of control. They argue that the IPO valuation premium documented in the empirical literature is puzzling, since, in the face of such a valuation premium, rational insiders of a private firm would always choose an IPO over an acquisition. The main objective of this paper is to empirically analyze and resolve the above discussed "IPO valuation premium puzzle" for the first time in the literature.

We analyze two potential explanations for the "IPO valuation premium puzzle" based on the theoretical analysis of Bayar and Chemmanur (2011). First, we predict that the quality of firms going public and those being acquired will be different, which is an issue of self-selection. Therefore, when comparing their valuations, acquired firms must be matched carefully with comparable IPO firms with a similar propensity to go public, controlling for all observable firm- and industry-specific factors which affect the choice of IPOs vs. acquisitions. Second, even when IPO valuations are higher, the long-run expected payoff to entrepreneurs and venture capitalists may be higher in an acquisition as theoretically shown by Bayar and Chemmanur (2011). Since firm insiders liquidate only a small fraction of equity in the IPO, and they have private information that the firm's IPO valuations may not be sustainable in the long run, insiders will compare the acquisition value of their firm with the weighted average of its IPO value and its long-run post-IPO market value (where the long-run value is weighted by the fraction of equity insiders retain after the IPO). We empirically analyze the IPO valuation premium puzzle based on these two new predictions.

A secondary objective of this paper is to test several new hypotheses regarding a private firm's choice between IPOs and acquisitions, and to thus extend the insights generated by the analysis of Poulsen and Stegemoller (2008). These new hypotheses are developed mainly based on new insights about post-exit product market competition, asymmetric information between firm insiders and outsiders, and private benefits of control enjoyed by firm management generated by the theoretical analysis of Bayar and Chemmanur (2011): we discuss their model in more detail in Section 2. First, we test the hypothesis that more established firms with business models already viable against product market competition are more likely to go public through an IPO rather than to be acquired. Second, we test whether the likelihood of IPOs relative to acquisitions is smaller in more concentrated industries (where there is already a dominant firm) where the product market support arising from being acquired by a larger, established firm is greater. Third, we test whether firms operating in industries characterized by greater private benefits of control, firms which are harder to value by IPO market investors, and relatively more capital intensive firms are more likely to choose an IPO over an acquisition. Fourth, we test whether venture capital backed firms are more likely to choose an IPO over an acquisition relative to non-venture capital backed firms.

We use a hand-collected data set of private firm acquisitions by public companies from 1995 to 2007 and a data set of IPOs covering the same period. As a prelude to our analysis of the IPO valuation premium puzzle, we conduct univariate and multivariate tests (probit regressions) to empirically analyze a firm's choice between IPOs and acquisitions, and test several new hypotheses regarding this choice (this analysis is an input to our analysis of the IPO valuation premium puzzle: the propensity scores we use in our analysis of the valuation premium puzzle are obtained from the above analysis of IPOs vs. acquisitions). We then conduct our analysis of the IPO valuation premium puzzle by using a propensity score-based matching methodology to account for differences in observable firm and industry characteristics, and compare the valuation of acquired firms to the estimated value they could have received in an IPO. We then use theoretical insights from Bayar and Chemmanur (2011) to empirically distinguish between the short-run and the long-run payoffs to insiders of private firms in order to resolve the IPO valuation premium puzzle. Finally, we make use of Heckman-style treatment-effects regressions to control for the effects of the potential selection of exit mechanism by firm insiders based on unobservables.

Our empirical findings regarding the IPO valuation premium puzzle are as follows. First, after controlling for various firm- and industry-specific factors affecting a firm's choice between IPOs and acquisitions and matching acquired firms with comparable IPO firms (using the propensity score matching methodology), the IPO valuation premium essentially disappears for larger VC backed private firms with a deal value not less than $50 million. Second, for firms with a deal value below $50 million, the IPO valuation premium continues to exist; however, for these firms, the median valuation premium for VC backed firms is significantly smaller than the median valuation premium for non-VC backed firms. Third, we find that the IPO valuation premium vanishes for larger firms (regardless of VC backing) after controlling for the long-run component of the expected payoff to firm insiders

from an IPO exit (these are the firms that have a realistic chance to make a choice between an IPO and an acquisition, since smaller firms are unlikely to be able to go public). Finally, we document that, overall, the long-run IPO valuation premium (i.e., based on the weighted average of the IPO value and the long-run post-IPO market value) is much smaller than the short-run IPO valuation premium (i.e., based only on the IPO value) for the full sample of acquired firms. The results of our treatment-effects regression analysis demonstrate that our empirical results on IPO valuation premia are robust to controlling for the effects of potential selection of exit choice by firm insiders based on unobservables.

Our empirical findings about a private firm's choice between IPOs and acquisitions are as follows. First, we find that firms with higher pre-exit sales growth and firms which are larger in size (and are more viable against product market competition as stand-alone firms), are more likely to choose an IPO over an acquisition. Second, firms operating in more competitive industries and in those industries characterized by the absence of a dominant market player are more likely to choose an IPO over an acquisition.[1] Third, firms which are harder to value by IPO market investors, more capital intensive firms, and those operating in industries characterized by greater private benefits of control are more likely to choose an IPO over an acquisition. Fourth, we find that the likelihood of an IPO over an acquisition is greater for venture backed firms.[2,3]

The contribution made by this paper to the literature is twofold. The primary contribution is in developing the first empirical analysis of the IPO valuation premium puzzle in the literature. In particular, we show that, after controlling for various factors that affect a firm's propensity to choose an IPO over an acquisition, the valuation premium for IPOs over acquisitions disappears for larger VC backed firms. Further, we show that, once we account for the fact that firm insiders are able to sellonly a small fraction of equity in the firm at the IPO price (and hold their remaining shares in the firm over the long run post-IPO), the IPO valuation premium disappears even for larger non-VC backed firms, and becomes much smaller for smaller firms (VC backed or otherwise). A secondary contribution of this paper is to develop several new results on a private firm's exit choice between IPOs and acquisitions. Thus, we are the first to document that firms in those industries characterized by the lack of a dominant market player are more likely to choose an IPO over an acquisition. We are also the first to document that firms operating in industries characterized by greater private benefits of control to incumbent management are more likely to choose an IPO over an acquisition.[4,5]

The rest of the paper is organized as follows. Section 2 describes the underlying theoretical framework and develops testable hypotheses. Section 3 describes the data and variables. Section 4 presents our empirical tests on a firm's choice between IPOs and acquisitions which serves as a prelude to our empirical analysis of the IPO valuation premium puzzle. Section 5 presents the results of our empirical analysis of the IPO valuation premium puzzle. Section 6 concludes.

2. Theory and hypotheses

In this section, we develop the hypotheses we test in this paper. In Section 2.1, we review the theoretical model of Bayar and Chemmanur (2011) which we rely on mainly to develop testable hypotheses. Since our empirical analysis of the choice between IPOs and acquisitions serves as an input to our analysis of the IPO valuation premium puzzle, we first develop our testable hypotheses regarding a private firm's choice between IPOs and acquisitions (Section 2.2). We then develop testable hypotheses on the IPO valuation premium puzzle (Section 2.3).

2.1. The theoretical framework

In the setting of Bayar and Chemmanur (2011), insiders (entrepreneurs and VCs) of a private firm want to either sell some of their equity holdings in the firm or to issue new equity to raise capital for a new project, or both. They can realize these objectives

[1] This result is new to the literature. Brau et al. (2003) report that private firms in more concentrated industries are more likely to choose IPOs over acquisitions. Another paper that analyzes private firms' choice between IPOs and acquisitions is Aslan and Kumar (2011), who use U.K. data and also document a positive relationship between industry concentration and the probability of an acquisition.

[2] Poulsen and Stegemoller (2008) also report that the likelihood of an IPO over an acquisition is significantly positively associated with firm size, sales growth, capital intensity and venture capital backing. The subsequent paper of Chemmanur et al. (2011), who conduct a large sample study of the exit choices of entrepreneurial firms using U.S. Census data on manufacturing firms, also reports similar results. They, however, do not study the IPO valuation premium puzzle, which is our main focus here.

[3] The current paper makes use of the underlying theory developed by Bayar and Chemmanur (2011) to develop several new testable hypotheses and finds support for some of the testable predictionsof that model. However, this should not be construed as finding support for *all* the assumptions underlying that model. In particular, we do not wish to claim that our paper finds support for the assumption of the Bayar and Chemmanur (2011) model that acquirers can value firms more accurately than investors in the IPO market (which is not a crucial assumption behind the testable implications of that model). Thus, in practice, in some situations potential acquirers may be better at valuing the exiting private firm than IPO market investors (for example, when this firm is in the same industry as the acquirer) while in others, IPO market investors may be better at valuing these exiting private firms than potential acquirers.

[4] In addition to the small existing literature on IPOs versus acquisitions, our paper is also related (though more distantly) to the empirical literature on private-firm acquisitions. Koeplin et al. (2000) analyze a set of private firm acquisitions and public takeovers from 1984 to 1998, and find that private firm acquisitions are valued at a 20%–30% discount to similar public takeover deals. Officer (2007) finds an average acquisition discount for stand-alone private targets of 15%–30% relative to similar public targets from 1979 to 2003. Finally, Cooney et al. (2009) examine acquisitions of private firms with valuation histories and find a positive relation between acquirer announcement returns and target valuation revisions. None of the above papers, however, addresses the IPO valuation premium puzzle.

[5] A tangentially related paper is Purnanandam and Swaminathan (2004), who document that IPO firms are overvalued relative to matched seasoned firms. Unlike their paper, our focus is not on analyzing whether IPO firms are correctly valued relative to the fundamentals, but rather on the valuation of IPOs versus acquisitions. In particular, we show that, even given higher IPO valuations, it may nevertheless be optimal for entrepreneurs to choose acquisitions over IPOs in many situations, since firm insiders sell only a small fraction of their equity in the firm at the IPO price, and hold their remaining shares in the firm over the long run post-IPO.

in one of two ways. First, they can take the firm public in an IPO, and thereby sell some of their equity holdings in the firm to satisfy their liquidity demands, and issue new public equity to raise the required funding for the new project, with the entrepreneur continuing to manage the firm after the IPO. Second, they can sell their private firm to an acquirer, in which case they will divest their entire equity holdings in the firm, with the entrepreneur giving up control of the firm to the acquirer and the acquiring firm satisfying the private (target) firm's funding requirements. Firm insiders have private information about the viability of their business model (and the firm itself) against future (post-exit) competition in the product market. Firms with more viable business models and potentially dominant products (type H firms) have a better chance of success as stand-alone firms against established competitors in the product market than firms which are less viable and have products untested against product market competition (type L). The benefit of an acquisition over an IPO is that the acquiring firm can provide support to the acquired firm in product market competition by increasing its probability of success in the product market while a stand-alone firm has to fend for itself after an IPO. This benefit will be clearly greater for type L firms.

Bayar and Chemmanur (2011) consider three major costs of an acquisition over an IPO. First, they assume that potential acquirers have industry and product expertise and can value the private firm better than IPO market investors. Thus, an acquisition is costly to type L firms in the sense that private firm insiders have no information advantage against acquiring firms so that type L firms will be correctly valued in an acquisition. In contrast, given that the IPO market investors have less information than firm insiders, type L firms can get potentially higher valuations in the IPO market by pooling with type H firms, though this implies that type H firms will be undervalued in the IPO market.[6] Second, while the IPO market prices the firm's equity competitively (so that insiders can retain the entire net present value of their firm's project), acquirers will have considerable bargaining power, allowing them to extract some of the project's net present value from firm insiders. Third, after their firm is acquired, the insiders of a private firm will lose control of their firm. In contrast, after an IPO, they can continue to enjoy private benefits from being in control of their stand-alone firm.

Given the above trade-offs, the equilibrium exit choices of private firms between IPOs and acquisitions are determined as follows in the product market competition theory of Bayar and Chemmanur (2011). For type H firms, with viable business models against competition, the benefits of an acquisition in product market competition will be negligible. Thus, if the disadvantage of their equity being undervalued in the IPO market is overcome by the advantages arising from competitive pricing in that market and the entrepreneur's ability to retain private benefits of control, then type H firms will always prefer to remain stand-alone and choose an IPO over an acquisition. On the other hand, the insiders of type L firms will weigh the considerable synergy benefits of an acquisition in product market competition against the short-run valuation benefits of the IPO market and the advantage of retaining private benefits of control. Therefore, in equilibrium, type L firms play a mixed strategy: they choose an IPO with a positive probability, but choose to be acquired with the complementary probability. In summary, more viable (type H) firms go public with probability 1, whereas less viable (type L) firms play a mixed strategy between IPOs and acquisitions.

2.2. Testable hypotheses of a private firm's choice between IPOs and acquisitions

The product market competition theory of Bayar and Chemmanur (2011) generates several new testable predictions regarding a private firm's choice between IPOs and acquisitions. First, it predicts that higher quality firms, which are more viable in the face of product market competition, are more likely to go public, while lower quality firms (less viable in the face of competition) are more likely to be acquired. Thus, the first hypothesis we test predicts that on average, more established firms with business models already viable against product market competition are more likely to go public through an IPO rather than to be acquired (**H1**).

Second, the product market competition theory implies that the likelihood of IPOs relative to acquisitions will be smaller in more concentrated industries where there is already a dominant firm so that the benefits of being acquired by a larger, established firm are greater (**H2**). This implies that the likelihood of a firm going public rather than being acquired is decreasing in the market share enjoyed by the dominant firm (if any) in the firm's industry. Further, the likelihood of a firm going public rather than being acquired will be decreasing in the extent of product market support provided by potential acquirers, which is expected to be larger in more concentrated industries where there is a dominant firm.

Third, the product market competition theory predicts that the likelihood of a firm going public rather than being acquired is increasing in the private benefits of control enjoyed by management in the industry the firm is operating in (**H3**). These control benefits will be retained by incumbent management after an IPO, but they will be lost to the incumbent in the event of an acquisition.

Fourth, the product market competition model of Bayar and Chemmanur (2011) assumes that potential acquirers have industry and product market expertise that allows them to value the private firm better than IPO market investors. Hence, less viable firms (type L firms) will be valued closer to their intrinsic value in an acquisition. In contrast, given that IPO market investors may find it harder to value certain kinds of firms than potential acquirers, such firms can obtain higher valuations in the IPO market compared to the valuation they can obtain in an acquisition by mimicking higher intrinsic value firms (taking advantage of the greater information asymmetry in the IPO market about such firms). Thus, firms for which the valuation ability of IPO market investors is poorer are more likely to choose an IPO over an acquisition (**H4**).[7] It should be noted here that, while Bayar and

[6] The extent of the valuation benefits enjoyed by the insiders (entrepreneurs and VCs) of type L firms from these higher IPO market valuations will depend on the fraction of existing shares sold by insiders to satisfy their liquidity demands (secondary share offerings) and the fraction of new shares issued (primary share offerings) to raise financing for new investment projects.

[7] We use asset tangibility and industry mean analyst forecast error as our measures of the difficulty of IPO market investors in valuing a firm.

Chemmanur (2011) assume that acquirers can value private firms more accurately than IPO market investors, this assumption is not crucial in generating the testable hypothesis **H4**. Thus, there may be industries where IPO market investors (with the help of investment banks underwriting the IPO) are able to produce equally (or more) accurate valuations of private firms compared to acquirers. Even in such situations, lower intrinsic value firms may choose to go public rather than be acquired with a positive mixing probability due to some of the other factors modeled by Bayar and Chemmanur (2011), such as the fact that acquirers may extract a fraction of the firm's project NPV from the entrepreneur due to their superior bargaining power relative to IPO market investors (who value the firm competitively). In summary, even if the IPO market is better at valuing private firms compared to potential acquirers, the propensity of firms to go public will be increasing with the difficulty of IPO market investors in valuing the private firm.[8]

Fifth, the product market competition theory also predicts that the likelihood of a firm going public rather than being acquired is increasing in the investment amount required to fund the firm's project (capital intensity of the firm's industry), which leads to the hypothesis that more capital intensive firms are more likely to choose an IPO over an acquisition (**H5**). The intuition underlying this result from Bayar and Chemmanur (2011) is that, the greater the investment amount required by the private firm, the greater the amount of equity issued by the firm in a potential IPO in order to raise the above investment amount (for any given amount of internal capital available). This, in turn, implies that any short-term advantage of an IPO over an acquisition (arising from potentially higher IPO valuations) will be greater for more capital intensive private firms.[9]

Our next hypothesis is about the exit choices in venture backed vs. non-venture backed firms. The product market competition theory of Bayar and Chemmanur (2011) predicts that, controlling for viability in the product market, firms which are venture backed are more likely to choose to go public (rather than to be acquired) relative to those which are non-venture backed, provided that the venture capitalist divests a significantly larger fraction of equity in the IPO (or soon after) compared to entrepreneurs. The latter assumption is likely to be satisfied in practice, since venture capitalists typically have shorter investment horizons because they need to raise capital for other projects or have to return capital to their limited partners for liquidity or diversification reasons. Further, Field and Hanka (2001) provide evidence documenting that VCs sell their shares more aggressively than other pre-IPO shareholders soon after the IPO.[10] Given the above, the product market competition theory of Bayar and Chemmanur (2011) implies that venture backed firms are more likely to go public compared to non-venture backed firms (**H6**).

2.3. Testable hypotheses on the IPO valuation premium puzzle

The second set of hypotheses we test in this paper relates to the differences in valuations between the two exit choices. Bayar and Chemmanur (2011) suggest two potential explanations for the IPO valuation premium puzzle, i.e., the empirical finding that many firms which are able to obtain higher valuations in the IPO market nevertheless choose to be acquired.

First, if the entrepreneur's control benefits are not too large, the average valuation across firms going public will be higher than the average valuation of firms that are acquired. The reason for this is that the average quality of the firms going public is predicted to be higher than that of firms that are acquired, yielding a greater average valuation for firms going public compared to those that are acquired.

Therefore, testing for the existence of an IPO valuation premium requires controlling for various observable factors affecting a firm's choice between IPOs and acquisitions which we mentioned above. We measure the propensity to go public for each firm in our sample using the factors discussed under hypotheses **H1** to **H6** above and then match each acquired firm with an IPO firm by the propensity to go public, industry, year, and VC backing in order to compare the valuations of IPOs and acquisitions and thus to test for the existence of an IPO valuation premium. The arguments above lead to the following first hypothesis about the IPO valuation premium puzzle (**H7**): Controlling for industry, time of transaction, and other observable characteristics affecting the choice of a firm between IPOs and acquisitions, there exists no IPO valuation premium, i.e., the valuation at which an acquired firm could have gone public is not higher than its acquisition value. Hereafter, we will refer to the valuation premium based on comparing the acquisition value of a firm to its imputed IPO value as the "short-run IPO valuation premium," so that the hypothesis **H7** above postulates that there will be no short-run IPO valuation premium after controlling for various observable factors affecting a firm's choice between IPOs and acquisitions.[11]

[8] In other words, the broad characteristics of the equilibrium in Bayar and Chemmanur (2011) does not crucially depend on acquirers being able to value the firm more accurately than IPO market investors. We thank an anonymous referee for suggesting that we clarify that this assumption is not crucial in generating this testable hypothesis.

[9] Note that Bayar and Chemmanur (2011) develop this comparative static result under the assumption that the acquirer has the funds to fully implement the entrepreneurial firm's project, so that this hypothesis *will not* depend on a comparison of the cash raised in the IPO versus the cash-generating ability of the acquirer. Even if the acquirer does not have enough internal funds to immediately fund the target firm's project fully, it is reasonable to believe that any additional financing required would be raised by selling the acquiring firm's equity (or its other securities), so that (as long as the target is relatively small relative to the combined firm) the characteristics of the target firm are unlikely to be an important determinant of the acquiring firm's ability to raise such external financing.

[10] Field and Hanka (2001) infer sales and distributions by VCs in the first public year after the IPO by examining how the post-IPO share ownership reported in the IPO prospectus differs from that reported in the proxy statement issued approximately one year later. They focus on the 1988 to 1992 period for which they hand-collected data from prospectuses and proxy statements. Panel C of Table VI of Field and Hanka (2001) shows that holdings by venture capitalists fall significantly more than those of executives and other pre-IPO investors.

[11] In the model of Bayar and Chemmanur (2011), a greater proportion of type L VC backed firms choose to go public rather than to be acquired in equilibrium. Given that type H firms always choose to go public in their equilibrium, this means that a greater proportion of VC backed firms going public will be type L (compared to the same proportion in the set of non-VC backed firms going public). This, in turn, implies that both the short-run and long-run IPO valuation premia will be smaller for VC backed firms compared to those for non-VC backed firms. While we will not formally test this prediction of the Bayar and Chemmanur (2011) model, it will be useful in interpreting our results on the IPO valuation premium puzzle.

Second, the valuation at which an acquired firm could have gone public in an IPO could be higher than its acquisition value even after controlling for its propensity to go public and matching it with a similar IPO firm (i.e., after controlling for observable factors which help determine its entry into the sample of acquisitions). However, firm insiders may have private information that their firm's business model is not viable in the face of aggressive competition in the product market, so that the firm's IPO valuation may not be sustained in the long run. Given that entrepreneurs and venture capitalists are able to liquidate only a small fraction of their equity holdings in the firm in the IPO, insiders can benefit from higher IPO valuations only if this valuation is sustained in the long run.[12] In contrast, firm insiders are able to liquidate much of their equity position in their private firm in the event of an acquisition, thus realizing their firm's value immediately. While this will be strictly true only if the acquisition is paid for mostly with cash, what matters here is that after an acquisition firm insiders hold very little stock in their pre-exit firm (about which they may have private information), but quite a large amount post-IPO. In other words, even if an acquisition is equity-financed and insiders have to hold a significant fraction of equity in the combined firm, the value of such equity holdings are not affected significantly by the private information held by insiders of the target (private) firm, since the target firm usually constitutes only a small fraction of the value of the combined firm. This contrasts with insider equity holdings in a (stand-alone) firm after it has gone public, since, in this case, insiders are likely to have significant private information about the long-run value of the post-IPO firm. For evidence that entrepreneurs and other insiders retain, on average, a lion's share (49.4%) of equity in the firm after an IPO, while liquidating almost all their equity holdings after an acquisition (they hold only 5.6% equity in the combined firm, post-acquisition) see Poulsen and Stegemoller (2008). Given that the weighted average of their firm's short-run IPO valuation and long-term stock market value may be lower than the value realized in an acquisition, entrepreneurs may choose an acquisition over an IPO even though their firm's valuation at its IPO price is higher than its valuation at the acquisition price.

Therefore, insiders choosing between an IPO and an acquisition will actually compare the acquisition value of their firm not to its IPO valuation, but to the weighted average of its IPO value and its (potentially lower) long-run stock market value where the weight on the IPO value is the fraction of equity insiders liquidate in the IPO. Hereafter, we will refer to the difference between the above weighted average value of a firm and its acquisition value as the "long-run IPO valuation premium." Thus, this explanation of the IPO valuation premium puzzle generated by the product market competition theory leads to the following hypothesis (**H8**): Even if an acquired firm's imputed IPO value is higher than its acquisition value, the weighted average of its current imputed IPO value and its long-run (three years post-IPO) imputed market value (where the weight on the long-run value is the fraction of equity retained by firm insiders subsequent to the IPO) is not higher than its acquisition value.[13] In other words, this hypothesis postulates that there will be no long-run IPO valuation premium.

Finally, since insiders have private information about the value of their own firm at the time of exit, and may make use of this information (unobservable to outsiders) to make their choice of exit mechanism, it is important to control for such selection based on unobservables as well. Since propensity score matching can only control for differences in observables, we will also test for the robustness of the above empirical tests of hypotheses **H7** and **H8** by conducting a Heckman-style treatment-effects regression analysis in Section 5.2.

3. Data and variables

3.1. Data and sample selection

The data used in this study are drawn from several databases. The initial list of IPOs and acquisitions were collected from the Thomson Financial Securities Data Company (SDC Platinum) databases on U.S. Global New Issues and U.S. Mergers & Acquisitions respectively. A large number of acquired private firms do not have adequate financial data in the SDC database. Financial data on such private companies was hand-collected from SEC's EDGAR database and from the SEC filings in Thomson Research database. Since SEC EDGAR began keeping electronic filings for acquired companies in 1995, the issue dates for IPOs and the announcement dates for acquisitions were restricted to the period between 1995 and 2007.

As is common in the IPO literature, we exclude from our IPO sample spin-offs, ADRs, unit offerings, reverse LBOs, foreign issues, REITS, close-end funds, offerings in which the offer size is less than $5 million, offerings of financial firms (SIC codes between 6000 and 6999) and regulated utilities (SIC codes between 4900 and 4999).[14] Further, we require that the IPO firms must be listed on the NYSE, AMEX, or NASDAQ, and the issuing firm must be present on the Compustat database at least in the fiscal year prior to the offering, as well as on the CRSP database within one week from the offer date. To minimize the effect of wrong data entries on our study, we corrected for several mistakes and typos in the SDC database following Jay Ritter's "Corrections to Security Data Company's IPO database" (http://bear.cba.ufl.edu/ritter/ipodata.htm). Thus, our final sample of IPOs consists of 2269 IPOs issued between 1995 and 2007. We then extract information on stock prices and the number of outstanding shares from CRSP, financial statement information for IPO firms from Compustat, analyst earnings forecast information from I/B/E/S. We also use the SDC

[12] As shown by Leland and Pyle (1977), if insiders sell a larger fraction of equity in their IPO relative to that required to satisfy their liquidity demands, IPO market investors will infer that the firm is less viable and value the firm accordingly.

[13] The fraction of equity retained is assumed to be 1 minus the sum of the fraction of equity sold by insiders in the secondary offering and the fraction of equity issued to outsiders in order to raise external financing for the firm.

[14] We do not rely only on SDC classification to identify ADRs, non-ordinary shares, REITs, and closed end funds. Instead, we use share codes from CRSP to implement these filters.

VentureXpert database in addition to the venture flag from the SDC database to distinguish between VC backed and non-VC backed IPOs. Out of the 2269 IPOs in our sample, there are only 1209 IPOs with at least two fiscal years of financial data prior to the IPO, for which we have pre-exit growth measures (e.g., sales growth, growth in capital expenditures, etc.) available to be used in univariate and multivariate empirical analyses.

We collect our sample of acquisitions from the SDC U.S. Mergers & Acquisitions database. We only include 100% acquisitions of US private firms by US public firms between 1995 and 2007, in which the acquiring firms must be listed on the NYSE, AMEX, or NASDAQ and the deal value is greater than or equal to $5 million. We also remove financial firms and utilities. This initial sample consists of 6811 private target firms. Since SDC does not have enough financial data for a large number of private target firms, we use the SEC's EDGAR database to hand-collect financial statements of private target firms. Securities regulations (regulation S-X, Rule 1-02(w)) require that public acquirers disclose financial information of their private target firmsin their SEC filings (S4, S3, 8K, Proxy, Prospectus) if the acquisition has a material impact to the acquiring public firm (for example, acquisitions with a deal value more than 10% to 20% of the acquirer's total assets would satisfy this materiality requirement). Further, according to Regulation S-X, Rule 3-05 acquirers must disclose financial information on private targets if "securities are being registered to be offered to the security holders of the business to be acquired". In our sample, 2017 private firm acquisitions satisfy these data requirements with at least one fiscal year of financial data before their exit. Due to data availability, we can compute pre-exit growth measures for only 1507 out of 2017 acquisitions.

Panel A of Table 1 presents the number of deals and summary statistics about deal valuations for both the IPO and the acquisition sample for the entire period 1995–2007 and for each separate year in this period. The frequency distribution of the number of deals over the sample period follows a similar pattern for both the IPOs and the acquisitions, with a peak of activity in 1999 (330 IPOs vs. 290 acquisitions) and a decrease thereafter. The frequency of the deals seems to pick up again in 2004. The deal value for an IPO is defined as the offering price multiplied by the number of shares outstanding and the deal value for an acquisition is equal to the total value of consideration paid by the acquirer, excluding fees and expenses. All dollar values are adjusted for inflation. The median deal value of IPOs in the full sample is $206.58 million whereas the median deal value of acquisitions is $37.03 million. Thus, a typical IPO is approximately 5.6 times as large as a typical acquisition in our sample. Panel B of Table 1 also shows an industry decomposition of IPOs and acquisitions in our sample. Panel B of Table 1 reports the rankings of the top 20 industries of IPOs and acquisitions (at the two-digit SIC level) respectively.

Table 2 reports the summary statistics for all the firm- and industry-specific variables that we construct for our samples of IPOs and acquisitions respectively. The accounting values reported belong to the fiscal year prior to the exit transaction. Using the book value of total assets as a measure of size, the median IPO firm is 2.8 times as large as the median acquired firm ($24.83 million vs. $8.90 million). IPOs have also larger sales revenues than acquisitions ($25.17 million vs. $14.02 million). The median growth rate in sales, capital expenditures, and R&D expenditures are larger for IPO firms than for acquired firms prior to the exit event. Another clear difference between IPOs and acquisitions in our sample is the extent of venture capital backing. The percentage of IPOs backed by venture capital is 54.7% whereas the percentage of VC backed target firms is only 25.4%.[15]

3.2. Measures of firm and industry specific test variables and control variables

In this subsection we discuss the construction and measurement of the various firm-specific and industry-specific test variables and control variables that we use in the univariate and multivariate econometric analyses reported in the next section of this paper.

First, we define three proxies of firm viability: 1) firm size measured by the log of total assets in the fiscal year (year −1) prior to the exit transaction, 2) sales growth up to three years prior to an IPO or an acquisition,[16] and 3) return on assets (ROA) defined as the ratio of net income to the book value of total assets in year −1. Second, we construct four industry-specific competition measures. Similar to Brau et al. (2003), and Chemmanur et al. (2011), we use the Herfindahl index in order to measure the concentration of the industry in which a private firm operates. The Herfindahl index is calculated by summing up the squares of the market share in sales of all Compustat firms within a particular industry (at the three-digit SIC level) at the year of the exit transaction, using sales data obtained from Compustat. The higher the Herfindahl index, the higher the industry concentration. To determine if there is a dominant firm in a private firm's industry, we define a "big player" dummy variable which is equal to 1 if there is a public firm with a market share more than 30% at the time of IPO/Acquisition in the same industry (three-digit SIC level) as the private firm and zero otherwise.[17] As a third measure of industry competition and barrier to entry, we define a continuous test variable "Leader Market Share" which is equal to the market share of the public firm with the largest market share at the time of exit in the same industry as the private firm (three-digit SIC level). Finally, the fourth proxy for the intensity of product market competition is the price–cost margin, which is based on the Lerner Index and commonly used to assess the intensity of competition in an industry (see, for example, Aghion et al., 2005; Gaspar and Massa, 2006; Irvine and Pontiff, 2009; Nickell,

[15] In Poulsen and Stegemoller (2008), the percentage of VC backing is 55.5% for IPOs versus 41.4% of acquisitions. The apparent difference between our sample and their sample in terms of VC backing for acquisitions can be explained by the fact that Poulsen and Stegemoller exclude acquisitions with a deal value less than $50 million from their sample. In our sample, for deals worth more than $50 million, the percentage of VC backed IPOs is 57.4% and the percentage of VC backed acquisitions is 37.8%.

[16] Since there are many private firms that have zero sales initially, we define the sales growth of a particular private firm as the average annual change in sales from year −3 (or year −2 if data for year −3 is not available) to year −1 divided by the average size of total assets over that time period.

[17] As a robustness check, we set the threshold market share to be a big player to be 20%, 25%, 35%, or 40%. Our results remain qualitatively unchanged under these alternative specifications.

Table 1
Deal values and industry decomposition of IPOs and acquisitions. Panel A reports summary statistics about the number and size of exit deals in each year from 1995 to 2007. The IPO sample excludes spin-offs, ADRs, unit offerings, reverse LBOs, foreign issues, REITS, close-end funds, offerings with a size less than $5 million, offerings of financial firms (SIC codes between 6000 and 6999) and regulated utilities (SIC codes between 4900 and 4999). IPO firms must be listed on the NYSE, AMEX, or NASDAQ, and relevant financial information about the issuing firm must be present on the Compustat database at least in the fiscal year prior to the offering, as well as on the CRSP database within one day from the offer date. The final sample of IPOs consists of 2269 IPOs issued between 1995 and 2007. The sample of acquisitions includes 100% acquisitions of US private firms by US public firms between 1995 and 2007. The acquirers must be listed on the NYSE, AMEX, or NASDAQ. Financial firms, utilities and acquisitions with a deal value less than $5 million are excluded. This initial sample consists of 6811 private target firms. Given the availability of hand-collected financial statements from SEC's EDGAR database, the final sample of acquisitions consists of 2017 private firm acquisitions completed between 1995 and 2007. The deal value of an acquisition is defined as the total value of consideration paid by the acquirer, excluding fees and expenses. The deal value for an IPO is defined as the offering price multiplied by the number of shares outstanding. The mean, median and total columns are reported in millions of dollars. All dollar values are adjusted for inflation. Panel B reports the top 20 industries (two-digit SIC level) for the samples of IPO and acquisition firms respectively.

Panel A: summary statistics of the deal values of IPOs and acquisitions

	IPOs				Acquisitions			
Year	*N*	Mean	Median	Sum	*N*	Mean	Median	Sum
1995	264	$218.77	$125.00	$57,754.72	93	$78.09	$43.54	$7,261.98
1996	395	$193.88	$122.18	$76,583.38	156	$101.90	$40.27	$15,896.40
1997	277	$217.79	$117.22	$60,327.96	256	$96.07	$23.54	$24,593.79
1998	176	$281.29	$167.24	$49,507.53	254	$81.78	$26.38	$20,771.97
1999	330	$473.11	$305.56	$156,127.30	290	$155.01	$41.42	$44,952.87
2000	264	$604.85	$401.14	$159,681.02	263	$187.91	$67.00	$49,419.96
2001	45	$485.47	$338.45	$21,846.04	96	$92.93	$35.98	$8,921.34
2002	43	$527.47	$298.90	$22,681.34	73	$84.12	$34.94	$6,140.44
2003	44	$450.00	$286.59	$19,799.95	90	$93.47	$47.99	$8,412.11
2004	118	$442.31	$235.98	$52,192.91	136	$96.85	$31.20	$13,171.59
2005	96	$408.73	$238.46	$39,238.49	103	$102.85	$40.57	$10,593.42
2006	109	$415.41	$250.43	$45,279.33	103	$93.50	$41.94	$9,630.26
2007	108	$501.62	$287.23	$54,175.17	104	$99.75	$44.74	$10,373.78
Total	2269	$359.28	$206.58	$815,195.11	2017	$114.10	$37.03	$230,139.92

Panel B: industry decomposition of IPOs and acquisitions

IPOs			Acquisitions		
Industry	SIC Code	*N*	Industry	SIC Code	*N*
Business Services	73	748	Business Services	73	749
Chemicals and Allied Products	28	223	Electronic & other electric equipment	36	159
Electronic & other electric equipment	36	216	Engineering & Management Services	87	127
Instruments and Related Products	38	177	Instruments and Related Products	38	119
Communication	48	102	Communication	48	93
Industrial Machinery and Equipment	35	93	Chemicals and Allied Products	28	75
Engineering & Management Services	87	85	Health Services	80	67
Health Services	80	64	Industrial Machinery and Equipment	35	61
Miscellaneous Retail	59	57	Wholesale Trade – Durable Goods	50	57
Oil and Gas Extraction	13	49	Oil and Gas Extraction	13	48
Wholesale Trade – Durable Goods	50	36	Printing and Publishing	27	30
Transportation Equipment	37	34	Miscellaneous Retail	59	30
Eating and Drinking Places	58	32	Wholesale Trade – Nondurable Goods	51	27
Food and Kindred Products	20	24	Fabricated Metal Products	34	23
Educational Services	82	20	Food and Kindred Products	20	22
Wholesale Trade – Nondurable Goods	51	19	Transportation Equipment	37	22
Primary Metal Industries	33	18	Primary Metal Industries	33	19
Printing and Publishing	27	17	Misc. Manufacturing Industries	39	19
Fabricated Metal Products	34	17	Trucking and Warehousing	42	18
Hotels and Other Lodging Places	70	15	Automotive Dealers & Service Stations	55	18

1996). Following the literature, we define the annual price–cost margin (PCM) as operating income before depreciation divided by sales. We then compute the industry average of PCM at the three-digit SIC industry level for all Compustat firms in the year prior to the exit.[18]

In order to measure cross-sectional variation in private benefits of control across different industries, we construct an industry wide dummy variable inspired by Rajan and Wulf (2006), who empirically analyze perk consumption by firm executives (CEOs

[18] It should be pointed out that all of our measures are only looking at a subset of the product markets, since firms not covered by Compustat (e.g., some private firms and foreign firms) are excluded. The main advantage of using the PCM over our first three competition measures is that these other concentration-based measures rely more directly on precise definitions of geographic and product markets. Since many Compustat firms in the same industry as the private firm operate in international markets and face competition from foreign firms and domestic private firms not covered by Compustat, the PCM measure can be a more accurate proxy for the intensity of competition as it is not solely affected by the product market performance of domestic competitors covered by Compustat.

Table 2
Summary statistics and univariate tests. This table provides summary statistics and reports the results of the univariate tests on some of the test variables from the samples of IPOs and acquisitions from 1995 to 2007. All variables are measured as of the nearest fiscal year prior to the transaction except Sales growth, CAPEX growth, and R&D growth, which are measured from year −3 to −1 or from year −2 to −1 depending on data availability. Total Assets is the book value of total assets. Total Sales is the net revenue of the firm in the fiscal year prior to exit. Sales growth is the firm's average annual change in sales (from year −3 to −1 or from year −2 to −1 depending on data availability) scaled by the average level of total assets prior to exit. ROA is net income divided by total assets. Herfindahl Index is the lagged value of Herfindahl Index at the three-digit SIC level. Big Player is a dummy variable that is equal to 1 if there is another company in the firm's industry (three-digit SIC level) with a market share of more than 30% at the time of exit. Leader Market Share is the market share of the leading public firm in the same industry (three-digit SIC level) as the private firm, with the largest market share at the time of exit. Price-cost margin (PCM) is the industry average of the ratio of operating income before depreciation to sales at the three-digit SIC level. Private Benefits is a dummy variable to be equal to 1 if and only if a private firm's industry is among both one of the top five CEO perk consumption industries of Rajan and Wulf (2006) and one of those industries in which the CEO-Divisional Manager differential in the Rajan-Wulf perk consumption score is greater than 1. These four industries have two-digit SIC codes of 13 (oil & gas production), 28 (chemicals and allied products), 29 (oil refining), and 37 (transportation equipment). Tangible Assets/TA is net property and equipment scaled by total assets. Mean Error is the industry mean (three-digit SIC level) of average analysts forecast errors in the year prior to exit. CAPEX/TA is capital expenditures scaled by total assets. VC backing is a dummy variable that is equal to 1 if the firm was financed by venture capital. Market/Book is the ratio of the market value of total assets to the book value of total assets in the year prior to exit. The market value of assets is measured as the sum of deal value (market value of equity) and the book value of liabilities. The deal value for an IPO is defined as the offering price multiplied by the number of shares outstanding, and the deal value for an acquisition is defined as the total value of consideration paid by the acquirer, excluding fees and expenses. CRSP index return is the lagged six-month return of the equally-weighted CRSP market index. Industry return is the lagged six-month return of an equally-weighted portfolio of all public firms in the same three-digit SIC industry as the firm. R&D/TA is research and development (R&D) expenses scaled by total assets. Leverage is the sum of long-term debt and short-term debt scaled by total assets. Preferred Stock/TA is the liquidation value of preferred stock scaled by total assets. CAPEX growth is the firm's average annual change in annual capital expenditures scaled by the average level of total assets prior to exit. R&D growth is the firm's average annual change in R&D expenditures scaled by the average level of total assets prior to exit. Asterisks ***, **, * represent significance levels at the 1%, 5%, and 10% levels of the two sample *t*-tests for the difference in means and the Wilcoxon signed rank test for the difference in distributions for key test variables across the samples of IPOs and acquisitions, respectively.

	IPOs				Acquisitions					
	N	Mean	Median	St. Dev.	*N*	Mean	Median	St. dev.	Difference in means	Difference in medians
Total assets	2269	151.55	24.83	682.93	2017	42.09	8.90	168.24	109.46***	15.93***
Total sales	2269	145.50	25.17	551.08	2017	53.82	14.02	149.49	91.68***	11.16***
Sales growth	1209	0.48	0.30	0.70	1507	0.43	0.24	1.18	0.05**	0.06***
ROA	2269	−0.34	−0.03	1.04	2017	−0.50	0.02	2.28	0.16***	−0.05***
Herfindahl index	2269	0.11	0.07	0.11	2017	0.13	0.07	0.13	−0.02***	−0.00***
Big player	2269	0.14	0.00	0.34	2017	0.20	0.00	0.40	−0.06***	−0.00***
Leader market share	2269	22.07	19.20	12.77	2017	24.24	19.48	14.48	−2.17***	−0.28***
Price-cost margin	2269	−6.21	−2.32	13.56	2017	−4.71	−2.32	9.57	−1.50***	0.00***
Private benefits	2269	0.14	0.00	0.34	2017	0.07	0.00	0.26	0.06***	+0.00***
Tangible assets/TA	2269	0.22	0.15	0.21	2017	0.24	0.16	0.26	−0.02***	−0.02*
Mean error	2269	685.35	1.81	1589.61	2017	138.11	1.15	1294.92	547.23***	0.66***
CAPEX/TA	2269	0.10	0.06	0.11	2017	0.09	0.05	0.12	0.00	0.01***
VC backing	2269	0.55	1.00	0.50	2017	0.25	0.00	0.44	0.29***	1.00***
Market/book	2269	24.37	7.42	132.39	2017	16.66	4.48	59.63	7.71***	2.94***
CRSP index return	2269	0.12	0.10	0.11	2017	0.09	0.08	0.13	0.02***	0.01***
Industry return	2269	0.20	0.14	0.32	2017	0.15	0.09	0.34	0.06***	0.05***
R&D/TA	2269	0.23	0.07	0.67	2017	0.29	0.00	0.85	−0.06***	0.07***
Leverage	2269	0.36	0.22	0.62	2017	0.46	0.24	0.96	−0.09***	−0.02
Preferred stock/TA	2269	0.90	0.18	1.82	2017	0.95	0.00	3.08	−0.05	0.18***
CAPEX growth	1209	0.04	0.02	0.13	1507	0.03	0.01	0.24	0.01	0.01***
R&D growth	1209	0.11	0.00	1.12	1507	0.10	0.00	0.50	0.02	0.002***

and divisional managers) of a large sample of public firms.[19] Rajan and Wulf rank CEO perk consumption and CEO-Divisional Manager perk consumption differentials across different industries in their sample at the two-digit SIC level. We define our "private benefits" dummy variable to be equal to 1 if and only if a private firm's industry is among *both* one of the top five CEO perk consumption industries of Rajan and Wulf (2006) *and* one of those industries in which the CEO-Divisional Manager differential in the Rajan-Wulf perk consumption score is greater than 1. The CEO-Divisional Manager differential in perk consumption measures the extent to which a CEO values his or her perks as a unique privilege. We require the CEO-Divisional differential to be greater than 1, since Bayar and Chemmanur (2011) predict that the entrepreneurs and founders of many IPOs will remain in top management even after the IPO, whereas in the case of acquisitions, they are likely to exit the firm completely or serve as managers of a division or a subsidiary in the acquiring firm. We predict that the higher both the consumption and the privilege of perks in a particular industry, the more incentives would the entrepreneur of a private firm have to take his firm public through an IPO. The four industries that satisfy these two filtering criteria include oil & gas production (SIC code 13), chemicals & allied products (SIC code 28), petroleum refining (SIC code 29), and transportation equipment (SIC code 37).

We use two measures for the difficulty of IPO market investors in valuing private firms. First, we define the "tangibility of assets" of a private firm by the ratio of net property & equipment to the book value of total assets as of the fiscal year preceding the IPO or acquisition. Our assumption is that the higher the observed asset tangibility of a private target firm, the easier it will be

[19] The types of perquisite consumption enjoyed by high level executives and analyzed in Rajan and Wulf (2006) include the use of company plane, chauffer service, and country club membership.

for the IPO market investors to value that firm. Second, we construct an industry-wide measure of valuation difficulty using analysts' earnings forecasts from I/B/E/S. Similar to Christie (1987), Krishnaswamy and Subramaniam (1999), and Chemmanur et al. (2011), we use the average industry analysts' forecast error ("mean error") at the three-digit SIC level as a proxy for industry-wide valuation difficulty. The size of the average analysts' forecast error in the industry of a firm is expected to be positively correlated with the difficulty of IPO market investors valuing private firms in that industry. Third, we measure the capital intensity of a firm by the ratio of its capital expenditures to its book value of assets (*CAPEX/TA*) as of year −1. Finally, the venture capital backing of a private firm is measured by a dummy variable, which is equal to 1 if the firm is backed by venture capital and 0 otherwise.

Similar to Poulsen and Stegemoller (2008), we define the *market-to-book* ratio as one of our control variables that proxies for the growth prospects of the firm. It is measured as the ratio of the market value of total assets to the book value of total assets in the year prior to the exit. The market value of assets is measured as the sum of deal value (market value of equity) and the book value of liabilities. We expect this growth proxy to be positively associated with the likelihood of an IPO over an acquisition.[20] Other control variables used in the multivariate probit regression analyses include the lagged six-month return of the equally weighted CRSP market index, leverage, defined as the ratio of the sum of long-term debt and short-term debt over the book value of total assets, R&D ratio, defined as the ratio of the research and development expenses over the book value of assets, year dummies and industry dummies.[21]

4. Empirical tests and results on the choice between IPOs and acquisitions

In this section, we present our empirical results of the tests of several new hypotheses on private firms' choice between IPOs and acquisitions. The results of univariate tests on our test variables (hypotheses **H1** to **H6**) will be followed by the multivariate probit regression analysis of the choice of IPOs vs. acquisitions. We use the latter analysis as an input into our analysis of the IPO valuation premium puzzle.

4.1. Univariate tests

Table 2 reports the means and medians of our key test variables as well as the *p*-values of two-sample *t*-tests for the difference in means and Wilcoxon–Mann–Whitney tests for evaluating the significance of the difference in medians between the test variables of our samples of IPOs and acquisitions respectively.

Hypothesis **H1** predicts that more established firms with business models already viable against product market competition are more likely to go public through an IPO rather than be acquired. Consistent with **H1**, we find that IPO firms are larger than acquired firms in terms of size, defined by the book value of assets. The median IPO firm has total assets of $24.83 million vs. the median acquired firm with total assets of $8.90 million. Another measure of firm viability we use is the pre-exit sales growth rate of the private firm. Table 2 also reports that IPO firms have greater sales growth rates compared to firms that are acquired. Consistent with **H1**, we find that the median sales growth rate for the IPO firms in our sample is 30% vs. the median sales growth rate of 24% for acquired firms, and the difference in medians is statistically significant. The univariate results on the difference in profitability between IPOs and acquisitions are mixed. Even though the mean ROA for IPO firms is less negative than the mean ROA for acquired firms (−34% vs. −50%), the median ROA for acquisitions is significantly higher than the median IPO firm ROA (2% vs. −3%).[22] Overall, our univariate test results support the predictions of hypothesis **H1**, and they are also consistent with the results of Poulsen and Stegemoller (2008) who find that firms with greater growth opportunities and larger firms are more likely to go public.

To examine the predictions of hypothesis **H2**, which states that the likelihood of IPOs relative to acquisitions will be smaller in more concentrated industries (where there is already a dominant firm), we look at the tests for univariate differences for four measures. The Wilcoxon signed rank test statistics for differences in distribution show that acquired private firms are in more concentrated industries (at the three-digit SIC level) with a higher Herfindahl index and they are more likely to be in industries (at the three-digit SIC level) dominated by a big player. Further, the market share of the biggest player in the same industry as the private firm is larger for acquired firms than for IPO firms, and acquisitions are more likely than IPOs in industries where incumbent public firms have higher average profit-cost margins. Consistent with hypothesis **H3**, Table 2 also reports that the fraction of firms going public rather than being acquired is greater in industries characterized by greater private benefits of control. To the best of our knowledge, this is the first paper in the literature to document these results.

Hypothesis **H4** predicts that firms which are harder to value by IPO market investors are more likely to go public rather than to be acquired. Consistent with **H4**, Table 2 reports that IPO firms have less tangible assets as a fraction of total assets, and are in industries with higher average analyst forecast errors.[23] Finally, the results of the univariate tests reported in Table 2 also show that the median ratio of capital expenditures to assets is significantly higher for firms going public through an IPO and that the fraction

[20] Since it is a valuation-based measure, we exclude the *market-to-book* ratio from our list of independent variables in our analysis of the IPO valuation premium puzzle.

[21] Brau et al. (2003) report that IPOs are more likely in hotter markets and acquisitions are more likely in more leveraged industries. Poulsen and Stegemoller (2008) also document that IPO firms use less financial leverage than acquired firms.

[22] Poulsen and Stegemoller (2008) find in their univariate tests that acquired firms are more profitable than IPO firms in years −2 and −1.

[23] Poulsen and Stegemoller (2008) find that firms with a higher fraction of intangible assets (goodwill etc.) are more likely to be acquired than to go public. However, their sample covers firms only with a deal size above $50 million, and our measure of asset tangibility (net property & equipment scaled by total assets) is different from theirs.

of VC backed firms going public rather than being acquired is significantly larger, supporting the implications of hypotheses **H5** and **H6** respectively. Poulsen and Stegemoller (2008) also find that VC backed firms and firms with higher scaled capital expenditures are more likely to go public.

The results of univariate tests also show that the likelihood of an IPO vs. an acquisition is positively correlated with the lagged six-month return of the CRSP equally weighted market index, which is consistent with the prediction that the likelihood of IPOs over acquisitions is higher in better market conditions than in unfavorable market conditions. Univariate tests for other control variables show that IPO firms have higher market-to-book ratios and lower leverage ratios than acquired firms.

In summary, the results of our univariate tests support the predictions of our new hypotheses on private firms' choice of between IPOs and acquisitions based on the product market competition theory of Bayar and Chemmanur (2011). In the next subsection, we examine whether these results hold in a multivariate framework as well.

4.2. Multivariate tests: maximum likelihood probit regressions

In this subsection, we analyze the determinants of a firm's choice between IPOs and acquisitions integrating all the test and control variables in a multivariate probit regression framework. On the basis of the hypotheses developed in Section 2, the likelihood of an IPO over an acquisition is estimated using the following probit regression on a pooled cross section data set covering both IPOs and acquisitions:

$$\begin{aligned} Pr(IPO_i = 1) = F(&\beta_0 + \beta_1 SIZE_i + \beta_2 SALESGTH_i + \beta_3 ROA_i + \beta_4 HERFINDEX_i + \beta_5 PRIVBEN_i + \beta_6 TANG_i + \beta_7 FORERR_i \\ &+\beta_8 CAPEXTA_i + \beta_9 VC_i + \beta_{10} MB_i + \beta_{11} CRSP_i + \beta_{12} R\&D_i + \beta_{13} LEVER_i + \varepsilon_{it}) \end{aligned} \quad (1)$$

Individual firms are indexed by *i*, and *t* represents the year of the IPO or the acquisition. IPO_i is a dummy variable, which is equal to 1 if the firm i goes public, or to 0 if the firm *i* is acquired by a public company at time *t*. $F(\cdot)$ is the cumulative distribution function of a standard normal variable.

Table 3 reports the maximum likelihood estimates of the various specifications of the probit model in (1). In Column 1, which includes all the test variables, we see that almost all of the test variables are significant and have signs consistent with the hypotheses described earlier. Column 2 includes all firm observations, but due to data availability, the variable *Sales Growth* is excluded. Consistent with **H1**, Column 1 in Table 3 reports that two proxies for firm viability, firm size and sales growth, are both positively associated with the probability of an IPO vs. an acquisition. The coefficient on *ROA* (net income divided by total assets) is statistically insignificant in all regression specifications. Overall, these results indicate that larger firms and firms with higher pre-exit sales growth are more likely to choose an IPO over an acquisition, since these kinds of firms are likely to be more viable against product market competition as stand-alone firms.[24]

Consistent with **H2**, Table 3 also reports that firms in more competitive industries, which are not dominated by a "big player," are more likely to choose an IPO over an acquisition. In regression specifications in Columns 1 and 2, we see that the Herfindahl index is significantly and negatively associated with the likelihood of an IPO vs. an acquisition with a *p*-value less than 0.03. To check the robustness of this result, we replace the Herfindahl index variable with our other proxies for product market competition: the "big player" dummy, the "leader market share" variable, and profit-cost margin (PCM). Results reported in Columns 3 to 6 show that the "big player" dummy variable and the "Leader Market Share" variable are negatively and significantly associated with the probability of an IPO over an acquisition. Thus, regression results using alternative concentration-based competition measures also support the prediction of **H2** that IPOs tend to be in less concentrated industries where product market competition is not dominated by "big player" public firms. Our results on the relationship between industry concentration and probability of a private firm choosing an IPO over an acquisition is opposite to that of Brau et al. (2003), who find, using an earlier data set (1984–1998), that firms in more concentrated industries are more likely to choose an IPO over an acquisition. It is worth pointing out that our results on the relationship between industry concentration and the probability of an IPO are consistent in both our univariate as well as our multivariate tests;[25] further, they are also consistent with the related results reported in Columns 7 and 8 of Table 3 that the average profit-cost margin in a private firm's industry has a significantly negative association with the likelihood of an IPO over an acquisition. To the best of our knowledge, ours is the first paper to document these results in the literature.

Next, the "private benefits" dummy variable has significantly positive coefficients in almost all regression specifications in Table 3. This supports our hypothesis **H3** predicting that firms in industries characterized by greater private benefits of control are more likely to choose an IPO over an acquisition. Ours is the first paper to document this result as well.

The next group of independent variables relates to the hypothesis **H4** about the relationship between IPO market investors' difficulty in valuing private firms and the propensity to go public. The coefficient on the ratio of tangible assets to total assets is negative and significant in all specifications at the 1% level. The coefficient on the industry mean of average analysts' forecast error is positive and also statistically significant in almost all specifications. Overall, the results of the probit regressions are

[24] In unreported tests, we checked if our variables that proxy for firm viability are indeed related to whether an IPO firms delists for performance reasons within three years after IPO. Our findings show that firm size and ROA are significantly negatively associated with the likelihood of delisting for performance reasons, while sales growth has a negative, but insignificant association with it.

[25] See also Aslan and Kumar (2011), who also document a positive relationship between industry concentration and the probability of an acquisition using U.K. data.

Table 3

Probit regressions on the choice of IPO vs. acquisition. This table presents the effects of firm-specific, industry-specific and marketwide variables on a private firm's choice of exit mechanism. The dependent variable is equal to 0 if the observation is an acquisition and equal to 1 if it is an IPO. All independent variables are measured as of the nearest fiscal year prior to the transaction except Sales growth. Log (Total Assets) is log of the book value of total assets. Sales growth is the firm's average annual change in sales (from year −3 to −1 or from year −2 to −1 depending on data availability) scaled by the average level of total assets prior to exit. ROA is net income divided by total assets. Herfindahl Index is the lagged value of Herfindahl Index at the three-digit SIC level. Big Player is a dummy variable that is equal to 1 if there is another company in the firm's industry (three-digit SIC level) with a market share of more than 30% at the time of exit. Leader Market Share is the market share of the leading public firm in the same industry (three-digit SIC level) as the private firm, with the largest market share at the time of exit. Price-cost margin (PCM) is the industry average of the ratio of operating income before depreciation to sales at the three-digit SIC level. Private Benefits is a dummy variable to be equal to 1 if and only if a private firm's industry is among both one of the top five CEO perk consumption industries of Rajan and Wulf (2006) and one of those industries in which the CEO-Divisional Manager differential in the Rajan-Wulf perk consumption score is greater than 1. These four industries have two-digit SIC codes of 13 (oil & gas production), 28 (chemicals and allied products), 29 (oil refining), and 37 (transportation equipment). Tangible Assets/TA is net property and equipment scaled by total assets. Mean Error is the industry mean (three-digit SIC level) of average analysts forecast errors in the year prior to exit. CAPEX/TA is capital expenditures scaled by total assets. VC backing is a dummy variable that is equal to 1 if the firm was financed by venture capital. Market/Book is the ratio of the market value of total assets to the book value of total assets in the year prior to exit. The market value of assets is measured as the sum of deal value (market value of equity) and the book value of liabilities. The deal value for an IPO is defined as the offering price multiplied by the number of shares outstanding, and the deal value for an acquisition is defined as the total value of consideration paid by the acquirer, excluding fees and expenses. CRSP index return is the lagged six-month return of the equally-weighted CRSP market index. R&D/TA is research and development (R&D) expenses scaled by total assets. Leverage is the sum of long-term debt and short-term debt scaled by total assets. Year fixed effects are included in all regressions specifications. Industry fixed effects are included in specifications 13 and 14. Firm-specific variables are adjusted by their respective industry means (three-digit SIC level) in specifications 11 and 12. Asterisks ***, **, * represent significance levels at the 1%, 5%, and 10% levels, respectively. Observations are clustered by year and industry to adjust for possible correlation within the clusters. Heteroskedasticity-robust *p*-values are reported in brackets.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Log (total assets)	0.448***	0.381***	0.448***	0.383***	0.446***	0.380***	0.450***	0.384***	0.439***	0.353***	0.432***	0.361***	0.529***	0.452***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Sales growth	0.141***		0.140***		0.141***		0.138***		0.144***		0.141***		0.131**	
	[0.002]		[0.002]		[0.002]		[0.002]		[0.002]		[0.001]		[0.011]	
ROA	0.003	−0.009	0.004	−0.007	0.003	−0.009	0.001	−0.009	−0.022	−0.049	−0.011	−0.010	−0.017	−0.023
	[0.948]	[0.819]	[0.929]	[0.849]	[0.943]	[0.828]	[0.972]	[0.814]	[0.557]	[0.105]	[0.565]	[0.595]	[0.711]	[0.579]
Herfindahl index	−0.560**	−0.533**							−0.555**	−0.494**	−1.236**	−0.793*	−0.936**	−0.657**
	[0.030]	[0.014]							[0.033]	[0.022]	[0.020]	[0.075]	[0.022]	[0.025]
Big player			−0.164**	−0.189***										
			[0.046]	[0.009]										
Leader market share					−0.005**	−0.005**								
					[0.038]	[0.015]								
Profit-cost margin							−0.008***	−0.008***						
							[0.006]	[0.001]						
Private Benefits	0.417***	0.308***	0.418***	0.310***	0.405***	0.297**	0.299*	0.198	0.415***	0.307***	0.405***	0.316***		
	[0.002]	[0.009]	[0.002]	[0.008]	[0.002]	[0.011]	[0.054]	[0.124]	[0.002]	[0.008]	[0.002]	[0.004]		
Tangible assets/TA	−0.810***	−0.859***	−0.792***	−0.849***	−0.811***	−0.862***	−0.759***	−0.827***	−0.829***	−0.853***	−0.703***	−0.632***	−1.010***	−0.959***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Mean error	0.000**	0.000*	0.000**	0.000*	0.000**	0.000*	0.000**	0.000*	0.000**	0.000*	0.000	0.000***	0.000**	0.000***
	[0.014]	[0.065]	[0.013]	[0.058]	[0.017]	[0.070]	[0.015]	[0.054]	[0.017]	[0.074]	[0.168]	[0.004]	[0.036]	[0.001]
CAPEX/TA	1.142***	1.065***	1.095***	1.037***	1.138***	1.064***	1.181***	1.106***	1.257***	1.175***	1.322***	0.965***	1.367***	1.128***
	[0.003]	[0.002]	[0.006]	[0.002]	[0.003]	[0.002]	[0.004]	[0.001]	[0.001]	[0.000]	[0.000]	[0.002]	[0.007]	[0.008]
VC backing	0.750***	0.758***	0.752***	0.754***	0.752***	0.759***	0.758***	0.767***	0.754***	0.771***	0.797***	0.815***	0.760***	0.720***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Market/book	0.003**	0.003***	0.003**	0.003***	0.003**	0.003***	0.003**	0.003***			0.003**	0.003**	0.002	0.003***
	[0.037]	[0.007]	[0.037]	[0.007]	[0.037]	[0.007]	[0.043]	[0.007]			[0.038]	[0.021]	[0.182]	[0.007]
CRSP index return	1.258***	1.026***	1.251***	1.016***	1.254***	1.024***	1.246***	1.033***	1.279***	1.053***	1.281***	1.043***	1.510***	1.215***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
RD/TA	0.097	0.019	0.099	0.020	0.097	0.019	0.091	0.011	0.126	0.006	0.065	0.012	0.080	−0.003
	[0.203]	[0.763]	[0.195]	[0.748]	[0.204]	[0.760]	[0.259]	[0.861]	[0.161]	[0.910]	[0.211]	[0.799]	[0.323]	[0.968]
Leverage	−0.033	−0.015	−0.032	−0.012	−0.033	−0.015	−0.036	−0.015	−0.014	−0.014	−0.044	−0.032	−0.033	−0.014
	[0.567]	[0.705]	[0.576]	[0.755]	[0.567]	[0.699]	[0.544]	[0.703]	[0.817]	[0.723]	[0.467]	[0.406]	[0.683]	[0.743]
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	No	No	No	No	No	No	No	No	No	No	No	No	Yes	Yes
Observations	2716	4286	2716	4286	2716	4286	2716	4286	2716	4286	2716	4286	2716	4286
Pseudo R-squared	0.268	0.243	0.268	0.243	0.268	0.243	0.270	0.244	0.265	0.229	0.266	0.238	0.373	0.331

consistent with the prediction that firms which are harder to value by IPO market investors (firms with less tangible assets as a fraction of total assets, in industries with higher average analyst forecast error) are more likely to choose an IPO over an acquisition.

The positive and statistically significant coefficient that we find on venture capital backing in all specifications (at the 1% level) gives support to our hypothesis **H6**, which predicts that venture backed firms are more likely to choose an IPO over an acquisition compared to non-venture backed firms. Further, the results of our multivariate probit analysis also suggest that more capital-intensive firms are more likely to go public rather than be acquired (**H5**), since the coefficient on the capital expenditure ratio (*CAPEX/TA*) is positive and significant in all specifications.

Finally, the results in Table 3 show that the likelihood of an IPO over an acquisition is positively associated with the lagged six-month return of the equally weighted CRSP market index at the 1% level, which is consistent with the empirical evidence of Brau et al. (2003).[26] The control variable market-to-book ratio has a positive and statistically significant coefficient, which is consistent with the evidence of Poulsen and Stegemoller (2008). The other control variables leverage and R&D expenses to total assets ratio have statistically insignificant coefficients in all specifications.

In summary, the results of our multivariate probit analysis in Table 3 show that the empirical evidence on the choice of IPOs vs. acquisitions is broadly consistent with the new testable hypotheses that we developed in Section 2. We find that the proxies for the viability of the firm against product market competition, measures of the IPO market investors' difficulty in valuing private firms, the extent of private benefits of control in the firm's industry, the capital intensity of the firm and venture capital backing have a significant impact on a firm's exit choice between IPOs and acquisitions.[27] In summary, our paper provides new empirical evidence on how the nature of the product market competition in a firm's industry and private benefits of control influence private firms' exit choice between IPOs and acquisitions for the first time in the literature.

One potential concern about the empirical analysis of the choice between IPOs and acquisitions is about the sample selection of acquired firms specifically. Ideally, one would like to include into the sample only those acquisitions in which the acquired private firm could realistically face a choice between going public through an IPO and getting acquired by another company. One can argue that the flotation costs of an IPO (fixed costs of an IPO such as cost of road-shows, underwriting spread, other investment banking and auditing fees etc.) can be prohibitively expensive for many small firms, and moreover, these firms cannot meet the listing requirements set by public stock exchanges and other requirements by SEC. If that is the case, for a significantly large number of acquired firms the only successful exit choice would be an acquisition by another company.

This concern is addressed in this paper in the following manner. Similar to Poulsen and Stegemoller (2008), we exclude from our sample those acquisitions and IPOs with a deal value less than $50 million and carry out the empirical analysis without these smaller deals.[28] The rationale for this is that larger private firm acquisitions could be more comparable to IPOs (recall from Table 1 that the median deal value for an IPO is $206.58 million vs. the median deal value of $37.03 million for an acquisition). Hence, we can expect that the target firms of these larger acquisition deals indeed face a realistic choice between an IPO and an acquisition.

Table 4 reports the results of our probit regressions where we include only deals worth more than or equal to $50 million. Clearly, the signs and the statistical significances of the test variables of interest largely remain as predicted and the results continue to support the hypotheses developed above. The results in Table 4 also indicate that more viable firms (larger firms and firms which have higher pre-exit sales growth) are more likely to choose an IPO over an acquisition consistent with **H1** even if we exclude smaller deals. Further, we find that firms in industries characterized by greater private benefits of control (**H3**), firms which are harder to value by IPO market investors (**H4**), and firms backed by venture capital (**H6**) are more likely to choose an IPO over an acquisition. The coefficients of the test variables related to hypotheses **H2** and **H5** (Herfindahl index and *CAPEX/TA*) are still in the predicted directions, though their statistical significance is reduced after we exclude smaller deals.

5. Empirical analysis of the IPO valuation premium puzzle

In this section, we present the results of our analysis of the IPO valuation premium puzzle using propensity score matching analysis and treatment-effects regression analysis.

5.1. Propensity score matching analysis

When we compare the valuations of IPOs and acquisitions, we need to account for self-selection by private firms into their exit choices between the two alternatives. Therefore, in the empirical analysis of the IPO valuation premium puzzle, the first step is to estimate for each acquired firm the IPO valuation at which it could have gone public. For this purpose, we use a propensity score based comparable firm approach, where we compute an imputed IPO value for each acquired private firm using the price multiples of a similar (matched) IPO firm. We find a similar IPO firm for the acquired firm by matching it along several dimensions that include all observable firm-specific, industry-specific and macroeconomic characteristics that are predicted to determine the

[26] Using the CRSP value-weighted index as a proxy for market return does not change our results.

[27] In the regression specifications used in Columns 11 and 12 of Table 3, firm-specific variables are adjusted by their industry averages (at the three-digit SIC level). Further, in specifications 13 and 14, industry fixed effects are included while firm-specific variables are not industry-adjusted. In specifications 13 and 14, the private benefits variable drops out due to its collinearity with industry fixed effects. The regression results reported in Columns 11 to 14 show that an industry adjustment of our variables does not influence our main findings.

[28] Poulsen and Stegemoller (2008) exclude deals with a disclosed value less than $50 million from their empirical analysis completely.

Table 4

Probit regressions on the choice of IPO vs. acquisition (deal value greater than $50 million). This table presents the effects of firm-specific, industry-specific and marketwide variables on a private firm's choice of exit mechanism only for transactions valued more than $50 million. The dependent variable is equal to 0 if the observation is an acquisition and equal to 1 if it is an IPO. All independent variables are measured as of the nearest fiscal year prior to the transaction except Sales growth. Log (Total Assets) is log of the book value of total assets. Sales growth is the firm's average annual change in sales (from year −3 to −1 or from year −2 to −1 depending on data availability) scaled by the average level of total assets prior to exit. ROA is net income divided by total assets. Herfindahl Index is the lagged value of Herfindahl Index at the three-digit SIC level. Big Player is a dummy variable that is equal to 1 if there is another company in the firm's industry (three-digit SIC level) with a market share of more than 30% at the time of exit. Leader Market Share is the market share of the leading public firm in the same industry (three-digit SIC level) as the private firm, with the largest market share at the time of exit. Price-cost margin (PCM) is the industry average of the ratio of operating income before depreciation to sales at the three-digit SIC level. Private Benefits is a dummy variable to be equal to 1 if and only if a private firm's industry is among both one of the top five CEO perk consumption industries of Rajan and Wulf (2006) and one of those industries in which the CEO-Divisional Manager differential in the Rajan-Wulf perk consumption score is greater than 1. These four industries have two-digit SIC codes of 13 (oil & gas production), 28 (chemicals and allied products), 29 (oil refining), and 37 (transportation equipment). Tangible Assets/TA is net property and equipment scaled by total assets. Mean Error is the industry mean (three-digit SIC level) of average analysts forecast errors in the year prior to exit. CAPEX/TA is capital expenditures scaled by total assets. VC backing is a dummy variable that is equal to 1 if the firm was financed by venture capital. Market/Book is the ratio of the market value of total assets to the book value of total assets in the year prior to exit. The market value of assets is measured as the sum of deal value (market value of equity) and the book value of liabilities. The deal value for an IPO is defined as the offering price multiplied by the number of shares outstanding, and the deal value for an acquisition is defined as the total value of consideration paid by the acquirer, excluding fees and expenses. CRSP index return is the lagged six-month return of the equally-weighted CRSP market index. R&D/TA is research and development (R&D) expenses scaled by total assets. Leverage is the sum of long-term debt and short-term debt scaled by total assets. Year fixed effects are included in all regressions specifications. Industry fixed effects are included in specifications 13 and 14. Firm-specific variables are adjusted by their respective industry means (three-digit SIC level) in specifications 11 and 12. Asterisks ***, **, * represent significance levels at the 1%, 5%, and 10% levels, respectively. Observations are clustered by year and industry to adjust for possible correlation within the clusters. Heteroskedasticity-robust *p*-values are reported in brackets.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Log (total assets)	0.273***	0.180***	0.272***	0.181***	0.272***	0.180***	0.272***	0.181***	0.272***	0.161***	0.246***	0.159***	0.312***	0.224***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Sales growth	0.281***		0.281***		0.282***		0.279***		0.281***		0.267***		0.271***	
	[0.004]		[0.004]		[0.004]		[0.004]		[0.004]		[0.004]		[0.009]	
ROA	0.055	0.049	0.057	0.050	0.056	0.049	0.058	0.050	0.054	0.024	−0.000	0.009	−0.016	0.019
	[0.273]	[0.256]	[0.257]	[0.239]	[0.267]	[0.249]	[0.253]	[0.244]	[0.309]	[0.503]	[0.985]	[0.612]	[0.773]	[0.663]
Herfindahl index	−0.437	−0.384							−0.437	−0.358	−0.698	−0.511	−0.769	−0.869**
	[0.132]	[0.117]							[0.132]	[0.147]	[0.240]	[0.308]	[0.146]	[0.023]
Big player			−0.121	−0.120										
			[0.198]	[0.161]										
Leader market share					−0.004	−0.003								
					[0.107]	[0.109]								
Profit-cost margin							−0.004	−0.004*						
							[0.193]	[0.095]						
Private benefits	0.495***	0.381***	0.496***	0.383***	0.484***	0.373***	0.444***	0.328**	0.495***	0.384***	0.480***	0.375***		
	[0.001]	[0.004]	[0.001]	[0.003]	[0.001]	[0.004]	[0.009]	[0.022]	[0.001]	[0.003]	[0.001]	[0.001]		
Tangible assets/TA	−0.793***	−0.866***	−0.780***	−0.861***	−0.795***	−0.869***	−0.759***	−0.848***	−0.794***	−0.862***	−0.688***	−0.671***	−0.977***	−1.061***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.001]	[0.000]	[0.000]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]
Mean error	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000**	0.000***	0.000***
	[0.264]	[0.160]	[0.256]	[0.153]	[0.283]	[0.169]	[0.286]	[0.154]	[0.267]	[0.175]	[0.181]	[0.012]	[0.000]	[0.002]
CAPEX/TA	0.688	0.843**	0.645	0.819**	0.682	0.839**	0.697	0.863**	0.692	0.886**	0.898**	0.730**	0.745	0.948**
	[0.104]	[0.021]	[0.143]	[0.029]	[0.111]	[0.023]	[0.119]	[0.023]	[0.106]	[0.014]	[0.018]	[0.033]	[0.234]	[0.045]
VC backing	0.624***	0.554***	0.625***	0.554***	0.623***	0.554***	0.634***	0.562***	0.624***	0.549***	0.659***	0.592***	0.647***	0.535***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Market/book	0.000	0.001*	0.000	0.001*	0.000	0.001*	0.000	0.001*			−0.000	0.001*	−0.001	0.001*
	[0.924]	[0.084]	[0.940]	[0.083]	[0.922]	[0.084]	[0.946]	[0.085]			[0.825]	[0.094]	[0.311]	[0.079]
CRSP index return	1.265***	1.029***	1.266***	1.028***	1.264***	1.028***	1.250***	1.033***	1.266***	1.043***	1.285***	1.069***	1.478***	1.190***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.001]
RD/TA	0.209*	0.079	0.212*	0.081	0.208*	0.080	0.209*	0.076	0.210*	0.063	0.092	0.035	0.094	0.033
	[0.059]	[0.125]	[0.052]	[0.114]	[0.058]	[0.123]	[0.060]	[0.146]	[0.053]	[0.200]	[0.107]	[0.418]	[0.208]	[0.560]
Leverage	0.006	0.014	0.007	0.017	0.006	0.014	0.001	0.012	0.007	0.022	−0.015	−0.023	−0.072	−0.007
	[0.933]	[0.778]	[0.922]	[0.736]	[0.926]	[0.778]	[0.984]	[0.813]	[0.919]	[0.670]	[0.804]	[0.600]	[0.451]	[0.892]
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	No	No	No	No	No	No	No	No	No	No	No	No	Yes	Yes
Observations	1822	2927	1822	2927	1822	2927	1822	2927	1822	2927	1822	2927	1822	2927
Pseudo R-squared	0.149	0.109	0.148	0.109	0.149	0.109	0.148	0.109	0.149	0.105	0.143	0.103	0.289	0.234

likelihood of an IPO vs. an acquisition.[29] Using these observable factors which are expected to determine a firm's choice between IPOs and acquisitions, it is possible to estimate for each private firm the propensity to go public through an IPO and match each acquired firm with an appropriate IPO firm with a similar propensity to go public from the same industry, same VC backing status, and year of exit. Please see Part 1 of the Appendix A for a more detailed description of our propensity score matching (PSM) methodology.

The PSM method allows us to mitigate the "selection on observables" problem by accounting for observable differences in firm-specific operating performance characteristics (such as sales growth, firm size, profitability, etc.), industry-, and market-specific characteristics between an acquired firm being valued and a candidate matching IPO firm in a multivariate framework. In subsection 4.2, we showed which of those factors predicted by our model have a significant impact on the choice of IPOs vs. acquisitions. Therefore, we use the probit regression specification in Column 9 of Table 3 (without the VC Backing dummy) to estimate for each firm's propensity to go public.[30] Since sales growth is a very important observable variable that determines both the choice between IPOs and acquisitions (the treatment choice) and the market valuation of a firm (treatment outcome), we prefer to use the regression specification in Column 9, and therefore, exclude those firms for which data about sales growth is not available (1209 IPOs and 1507 acquisitions remain in the sample). Further, since we use the *deal value/sales* multiple to calculate the imputed IPO value of an acquired firm, we also exclude 158 firms that have either zero or very small sales (less than $200,000) in the fiscal year prior to exit (we impose the latter restriction to avoid outliers in terms of this multiple).

When applying the PSM method, an important condition requires that at the propensity scores used in matching, both treatment (IPOs) and non-treatment (acquisitions) selections are possible. This "common support" condition fails at a given score if only treated or untreated firms are observable at that score. We impose our common support condition by dropping IPO observations whose propensity scores are higher than the maximum score of acquisitions (0.99) and acquisition observations whose scores are lower than the minimum score of IPOs (0.01). This requirement eliminates 143 IPOs and 274 acquisitions. With the propensity score values estimated by probit regression, we match each acquired firm to a single IPO company with the closest propensity score, within the same industry (two-digit SIC level), with the same year of exit and same VC backing status. The number of ultimately matched acquisition-IPO pairs is 1030.[31] We impose the industry and year of exit restrictions to mitigate differences between an acquired firm and its matched IPO firm due to industry and year fixed effects. Similarly, we impose the absolute restriction that the matched IPO firm has the same VC backing status as the acquired firm, since the existing literature has documented that VC backed firms tend to have different operating performance and other characteristics relative to non-VC backed firms. Once the matched IPO firm is obtained, we use a *price/sales* multiple based valuation approach to estimate the imputed IPO value of each acquired firm as follows:

$$\hat{V}_{ipo} = Sales_{acqu} \times \frac{V_{match}}{Sales_{match}}, \tag{2}$$

where $\hat{V}_{ipo}$ is the imputed IPO value of an acquired company and V_{match} is the deal value of the matched IPO firm defined as the IPO offer price multiplied by the number of shares outstanding. Thus, we multiply the sales figure of the acquiring firm, $Sales_{acqu}$, as of the fiscal year prior to the acquisition by the *Deal Value/Sales* multiple of the matching IPO firm, and the result yields the imputed IPO valuation of the acquired firm.[32]

We first test hypothesis **H7** which postulates that controlling for industry, time of transaction, and other observable firm- and industry-specific characteristics affecting the choice between IPOs and acquisitions, there exists no short-run IPO valuation premium, i.e., the valuation at which an acquired firm could have gone public is not higher than its acquisition value. Before applying the PSM methodology to match acquisitions with similar IPOs and then compare their valuations, we first reestablish the empirical evidence that the population of IPOs on average indeed have higher valuations than the population of acquired private firms. Table 5 reports the summary statistics for the valuations and valuation multiples of IPOs and acquisitions and the results of the difference tests. According to the results reported in Panel A, IPOs have mean and median valuations that are significantly higher than those of acquisitions in the entire sample as well as in the sub-samples of VC backed firms and non-VC backed firms respectively. In Panel B, we use only the sample of matched pairs of acquisitions and IPOs, but the difference tests are done as if the acquisitions and the IPOs were unpaired and are coming from two independent samples in order to compare the two populations. The results of the two-sample difference tests in Panel B of Table 5 show that the valuations of IPOs are significantly higher than those of acquired firms in the matched sample as well. Further, Panel C reports that in the unmatched sample, IPO firms have significantly greater *deal value/sales* multiples than acquired firms.

[29] These observable characteristics are motivated by our earlier empirical analysis (in Section 4), and they proxy for the viability of the firm in product market competition, the competitive environment of its industry, the IPO market investors' difficulty in valuing private firms, the extent of private benefits of control in the firm's industry, the capital intensity of the firm, venture capital backing, and other control variables.

[30] Since we use the VC backing status as an exact matching variable, we do not include it in the estimation of propensity scores.

[31] As Tucker (2010) points out, the dimension reduction by PSM is worthwhile only if the covariates of treated and control firms have similar distributions after being matched by propensity scores. After applying the PSM method, we also checked for "balancing", i.e., checking the similarity of firm-, industry-, and market characteristics for the treated (IPO) and untreated (acquisition) groups. Difference tests show that the mean of each independent variable in the treatment group (IPOs) is statistically not different from the mean of the same variable in the control group (acquisitions). Thus, our control group resembles (in terms of distributional similarity) the treated group on all the observable characteristics (independent covariates) specified in Column 9 of Table 3.

[32] The imputed IPO valuation of an acquired firm can also be estimated by using *Deal Value/EBITDA* and *Deal Value/Book Value of Equity* multiples. However, for many private firms the measures of EBITDA and the book value of equity are negative. Therefore, in order not to introduce estimation bias due to massive sample truncation, we report the valuation premium results only by using the *Deal Value/Sales* multiple as the main valuation multiple.

Table 5
Valuations of IPOs and acquisitions in the full sample and the matched sample. This table presents the summary statistics (mean, median, and number of observations) for the valuations and deal-value/sales multiples of IPOs and acquisitions and reports the results of the tests for differences in mean and median valuations of IPOs and acquisitions. The value for an IPO is defined as the offering price multiplied by the number of shares outstanding and the value of an acquired firm is the deal value reported by SDC. Sales is equal to net revenues of a private firm as of nearest prior fiscal year. Panels A and C report the difference test results of deal values and deal-value/sales multiples of IPOs and acquisitions for the full sample respectively. Panel B reports the difference tests results of deal valuations of IPOs and acquisitions for the matched sample. In each panel, firms are divided into sub-samples based on whether they were backed by venture capital or not. Panel B reports the valuation comparisons between IPOs and acquisitions for the matched sample without pairing the observations as if IPOs and acquisitions are obtained from independent samples. Deal values are reported in millions of dollars, and all dollar values are adjusted for inflation. Asterisks ***, **, * represent significance levels of the *t*-tests for differences in sample means and the Wilcoxon rank-sum tests for differences in distributions between IPOs and acquisitions at the 1%, 5%, and 10% levels, respectively. The *p*-values are also reported to show the statistical significance of the tests.

Panel A: Full sample (deal values)

All firms				Non-VC backed firms				VC backed firms			
	Mean	Median	*N*		Mean	Median	*N*		Mean	Median	*N*
IPOs	359.275	206.580	2269	IPOs	377.503	190.055	1027	IPOs	344.202	222.588	1242
Acquisitions	114.100	37.030	2017	Acquisitions	87.203	29.174	1504	Acquisitions	192.956	75.182	513
Difference	245.175	169.550		Difference	290.300	160.881		Difference	151.246	147.406	
p-values	0.0000***	0.0000***		*p*-values	0.0000***	0.0000***		*p*-values	0.0000***	0.0000***	

Panel B: Matched sample (deal values)

All firms				Non-VC backed firms				VC backed firms			
	Mean	Median	*N*		Mean	Median	*N*		Mean	Median	*N*
IPOs	266.833	158.188	1030	IPOs	275.214	150.699	700	IPOs	249.057	180.546	330
Acquisitions	128.893	43.499	1030	Acquisitions	95.005	34.878	700	Acquisitions	200.777	71.778	330
Difference	137.941	114.689		Difference	180.209	115.820		Difference	48.281	108.768	
p-values	0.0000***	0.0000***		*p*-values	0.0000***	0.0000***		*p*-values	0.1332	0.0000***	

Panel C: full sample (deal value/sales)

All firms				Non-VC backed firms				VC backed firms			
	Mean	Median	*N*		Mean	Median	*N*		Mean	Median	*N*
IPOs	52.20	5.56	2099	IPOs	15.79	2.48	983	IPOs	84.28	13.52	1116
Acquisitions	25.23	2.01	1877	Acquisitions	11.21	1.60	1427	Acquisitions	69.68	5.37	450
p-value		0.0000***		*p*-value		0.0000***		*p*-value		0.0000***	

To formally test the hypothesis **H7**, which claims that there is no short-run IPO valuation premium after controlling for various observable factors, one must compare acquired firms' valuations with the valuations of their paired IPO firms which are matched by the propensity score matching method. Table 6 reports the comparison of the *deal value/sales* multiples of acquired firms and their matched IPOs. Panel A shows the results for the entire matched sample. Clearly, the median *deal value/sales* ratio of the matched IPOs is higher than the median ratio of the acquired firms (7.04 vs. 2.50). When we look at sub-samples of VC backed acquisitions and non-VC backed acquisitions, we also verify that the valuation multiples of matched IPO firms are greater than the valuation multiples of acquired firms for both VC backed acquisitions as well as non-VC backed acquisitions.[33]

Table 7 presents the comparison of acquired firms' deal valuations and their imputed IPO valuations calculated from Eq. (2). For each acquired firm, its short-run IPO valuation premium is defined as follows:

$$\text{Premium} = log\left(\hat{V}_{ipo}/V_{acqu}\right), \tag{3}$$

where V_{acqu} is the deal value of the acquisition and log is the natural logarithm function. This is called the "short-run" premium because the implicit assumption is that the insiders of the firm can sell all of their stakes in an IPO firm for the offer price just at the time of the initial public offering. Table 7 reports that the median short-run IPO valuation premium for all acquired firms is 75.47% and it is highly significant at the 1% level. Similarly, the median short-run IPO valuation premium for all non-VC backed acquired firms is reported to be 86.36%. However, for acquired firms with VC backing, the median valuation premium is only 42.43%, but still significantly different from zero.

To further address the concern that the target firms of very small acquisitions could not have been eligible to go public at all in the first place, we also analyze the IPO valuation premia of acquisitions worth not less than $50 million exclusively. Restricting our analysis to acquired firms with deal values not less than $50 million can also be justified based on the "common support" requirement of the PSM method mentioned earlier. For the sample of acquisitions worth not less than $50 million (466 firms), the mean propensity score is 0.439. For this subsample, the mean propensity score for the matched IPO firms is 0.486. For the sample

[33] The results reported in Table 7 further confirm the results reported in Panel A of Table 6.

Table 6
Valuation multiples of acquisitions and matching IPOs. This table presents summary statistics of the valuation multiples of acquisitions and their matching IPOs and reports the results of the Wilcoxon signed rank tests for differences in the distribution of valuation multiples of acquisitions and their matching IPOs. The value for an IPO is defined as the offering price multiplied by the number of shares outstanding and the value of an acquired firm is the deal value reported by SDC. Sales is equal to net revenues of a private firm as of nearest prior fiscal year. The unmatched sample contains all deals with sales not less than $200,000 in the fiscal year prior to exit and only if the sales growth data for the firm is available. This initial unmatched sample contains 2558 observations (1430 acquisitions and 1128 IPOs). The propensity scores are generated using the probit regression specification in Column 9 of Table 3 without the VC dummy variable. After applying the common support requirement, each acquired firm is matched to an IPO firm with the closest propensity score, within the same industry (two-digit SIC level), with the same year of exit and same VC backing status. The matched sample contains 1030 pairs of acquisitions and their matched IPOs. Panel A reports the comparisons of deal value/sales ratios for the full sample of acquisitions and their matching IPOs. The acquired firms and their matching IPO firms in Panel A are also divided into sub-samples based on whether they were backed by venture capital or not, and the difference tests are performed for the sub-samples as well. Panel B reports the comparisons of deal value/sales ratios for the matched sample of acquisitions and their matching IPOs where the acquired firms are valued more than $50 million. Panel B also decomposes the sample according the VC backing status of firms and reports the results of the difference tests for these sub-samples. Asterisks ***, **, * represent significance levels for the paired sample Wilcoxon signed rank tests for differences in distributions at the 1%, 5%, and 10% levels. The *p*-values are also reported to show the statistical significance of the tests.

Panel A: Deal value/sales, full matched sample

All acquisitions				Non-VC backed acquisitions				VC backed acquisitions			
	N	Mean	Median		*N*	Mean	Median		*N*	Mean	Median
Acquisitions	1030	36.95	2.50	Acquisitions	700	14.61	1.79	Acquisitions	330	84.34	5.95
Matched IPOs	1030	33.36	7.04	Matched IPOs	700	19.80	5.42	Matched IPOs	330	62.12	11.76
p-value:			0.0000***	*p*-value:			0.0000***	*p*-value:			0.0011***

Panel B: Deal value/sales, matched sample with acquired firms valued greater than or equal $50 million

All acquisitions				Non-VC backed acquisitions				VC backed acquisitions			
	N	Mean	Median		*N*	Mean	Median		*N*	Mean	Median
Acquisitions	466	74.55	4.37	Acquisitions	269	30.96	2.54	Acquisitions	197	134.06	8.46
Matched IPOs	466	51.23	7.01	Matched IPOs	269	25.64	4.26	Matched IPOs	197	86.17	13.69
p-value:			0.0149**	*p*-value:			0.0022***	*p*-value:			0.44

Panel C: Deal value/sales, matched sample with acquired firms valued less than $50 million

All acquisitions				Non-VC backed acquisitions				VC backed acquisitions			
	N	Mean	Median		*N*	Mean	Median		*N*	Mean	Median
Acquisitions	564	5.88	1.80	Acquisitions	431	4.40	1.46	Acquisitions	133	10.70	3.98
Matched IPOs	564	18.60	7.05	Matched IPOs	431	16.16	6.84	Matched IPOs	133	26.50	7.77
p-value:			0.0000***	*p*-value:			0.0000***	*p*-value:			0.0000***

of acquisitions worth less than $50 million (564 firms), the mean propensity score of acquired firms is 0.209, and the mean propensity score for their matched IPO firms is 0.366. Thus, the common support condition of the PSM method appears to be better satisfied for larger acquisitions. Panel B of Table 6 reports the deal value/sales multiples of acquisitions worth greater than or equal to $50 million. Similarly, Panel B of Table 7 reports the comparison of acquired firms' deal valuations and their imputed IPO valuations where the acquired firms were purchased for not less than $50 million.

Panel B of Table 6 shows that the difference in distributions of the *deal value/sales* multiple is still statistically significant for all acquisitions worth not less than $50 million and their matched IPOs. Compared with the overall matched sample, the median valuation multiple of acquisitions increases from 2.50 to 4.37 whereas the median valuation multiple of the matched IPOs decreases from 7.04 to only 7.01. When we look at the sample of VC backed acquisitions worth not less than $50 million, we find that the difference in median valuation multiples between acquired firms and their matched IPOs is statistically insignificant. The *p*-value of the paired sample Wilcoxon signed rank test is 0.44 (the median is 13.69 for matched IPOs vs. 8.46 for acquired firms). For non-VC backed acquisitions worth not less than $50 million, however, the difference in valuation multiples is still statistically significant (2.54 for acquisitions vs. 4.26 for their matched IPOs as reported in Panel B). Panel C of Table 6, on the other hand, shows that the median valuation multiples of acquired firms worth less than $50 million are significantly less than those of their matched IPO firms regardless of their VC backing status.

Next, Panel B of Table 7 shows the short-run IPO valuation premia for deals worth not less than $50 million are much smaller than the ones reported for the entire matched sample in Panel A of Table 7. Panel B reports that the median short-run IPO valuation premium for all acquired firms with a deal value not less than $50 million is 32.92% (down from 75.47% for all target firms) and statistically significant. The median premium for non-VC backed firms is 40.75% (down from 86.36% in Panel A). The median short-run IPO valuation premium for larger VC backed acquisitions is 16.50% (down from 42.43% in Panel A) and it is statistically not different from 0 (*p*-value is 0.2953).

Finally, Panel C of Table 7 reports that short-run IPO valuation premia for smaller target firms (with a deal value less than $50 million) are considerably larger compared to larger target firms, and they remain statistically significant after propensity score matching regardless of VC backing status. However, for these smaller firms, the median valuation premium for VC backed

Table 7
Short-run valuations (propensity score matching). This table reports the results of the propensity score matching analysis testing for the significance of the short run valuation premium between IPOs and acquisitions. The unmatched sample contains all deals with sales not less than $200,000 in the fiscal year prior to exit and only if the sales growth data for the firm is available. This initial unmatched sample contains 2558 observations (1430 acquisitions and 1128 IPOs). The propensity scores are generated using the probit regression specification in Column 9 of Table 3 without the VC dummy variable. After applying the common support requirement, each acquired firm is matched to an IPO firm with the closest propensity score, within the same industry (two-digit SIC level), with the same year of exit and same VC backing status. The matched sample contains 1030 pairs of acquisitions and their matched IPOs. Panel A reports the mean and the median of the acquisition deal values reported by SDC and the mean and the median of the imputed short-run IPO valuations of the acquired firms obtained from Eq. (2) for the sample of all acquisitions, the sample of non-VC backed acquisitions, and the sample of VC backed acquisitions. The short run value V_{match} of the matched IPO firm is defined as the offering price multiplied by the number of shares outstanding after the IPO. This value is then divided by the net sales revenue of the IPO firm of the fiscal year prior to the IPO and the resulting ratio is then multiplied by the net sales revenue of the acquired firm to estimate the imputed short-run IPO valuation of the acquired firm given in (2). Panel A then reports the summary statistics and the tests of the short-run IPO valuation premia of acquisitions. The short-run IPO valuation premium for each acquisition-matched IPO pair is calculated as the natural log of the ratio of the imputed short-run IPO valuation of the acquired firm to the deal value of the acquired firm. Panel B reports the summary statistics and the results of the difference tests for the sample of acquisitions with deal values not less than $50 million only. Panel C reports the results of the difference tests for the sample of acquisitions with deal values less than $50 million only. Deal values and imputed valuations are reported in millions of dollars, and all dollar values are adjusted for inflation. Asterisks ***, **, * represent significance levels for the paired sample Wilcoxon signed-rank tests for the significance of the valuation premia at the 1%, 5%, and 10% levels respectively. The *p*-values of the tests are also reported to show the statistical significance.

Panel A: Short run valuation premia for all acquisitions

All acquisitions				Non-VC backed acquisitions				VC backed acquisitions			
	Mean	Median	*N*		Mean	Median	*N*		Mean	Median	*N*
Acquisition value	128.893	43.499	1030	Acquisition value	95.005	34.878	700	Acquisition value	200.777	71.778	330
Imputed IPO value	662.943	104.103	1030	Imputed IPO value	508.160	102.500	700	Imputed IPO value	991.270	106.388	330
Premium	71.99%	75.47%	1030	Premium	87.20%	86.36%	700	Premium	39.72%	42.43%	330
p-value		0.0000***		*p*-value		0.0000***		*p*-value		0.0000***	

Panel B: Short run valuation premia for acquisitions with a deal value greater than or equal to $50 million

All acquisitions				Non-VC backed acquisitions				VC backed acquisitions			
	Mean	Median	*N*		Mean	Median	*N*		Mean	Median	*N*
Acquisition value	257.406	129.665	466	Acquisition value	212.373	122.162	269	Acquisition value	318.896	147.994	197
Imputed IPO value	1249.399	186.266	466	Imputed IPO value	1031.991	191.086	269	Imputed IPO value	1546.266	169.388	197
Premium	20.97%	32.92%	466	Premium	30.25%	40.75%	269	Premium	8.31%	16.50%	197
p-value		0.0012***		*p*-value		0.0007***		*p*-value		0.2953	

Panel C: Short run valuation premia for acquisitions with a deal value less than $50 million

All acquisitions				Non-VC backed acquisitions				VC backed acquisitions			
	Mean	Median	*N*		Mean	Median	*N*		Mean	Median	*N*
Acquisition value	22.710	20.597	564	Acquisition value	21.751	20.000	431	Acquisition value	25.818	23.535	133
Imputed IPO value	178.389	64.380	564	Imputed IPO value	181.222	68.401	431	Imputed IPO value	169.209	49.637	133
Premium	114.14%	112.64%	564	Premium	122.75%	122.23%	431	Premium	86.24%	86.00%	133
p-value		0.0000***		*p*-value		0.0000***		*p*-value		0.0000***	

acquisitions is significantly smaller than the median valuation premium for non-VC backed firms as was the case for larger acquisitions reported in Panel B.[34]

In summary, the results of the empirical analysis of the short-run IPO valuation premium suggest that after controlling for the observable determinants of the choice between IPOs and acquisitions and matching acquired firms with comparable IPO firms, the IPO valuation premium still remains statistically significant. However, it vanishes for larger private target firms with VC backing. Further, for the overall sample, the magnitude of the short-run IPO valuation premia is significantly smaller for VC backed target firms and larger acquisition deals.

Earlier we pointed out that even after controlling for all factors that determine a private firm's choice between IPOs and acquisitions, one can reject hypothesis **H7** that there is no short-run IPO valuation premium. Thus, the valuation at which an acquired firm could have gone public could be higher than its acquisition value even after controlling for its propensity to go public and matching it with a similar IPO firm. Recall our second explanation for the IPO valuation premium puzzle. The theoretical model of Bayar and Chemmanur (2011) implies that even if an acquired firm's imputed IPO valuation is higher than its acquisition value, the weighted average of its current imputed IPO value and its long-run (three years post-IPO) imputed market value (where the weight on the IPO value is the fraction of equity liquidated by firm insiders) is not higher than its acquisition value (**H8**). Since entrepreneurs and VCs are able to liquidate only a small fraction of their equity holdings in the IPO, whereas they are able to liquidate almost their entire equity position in an acquisition, we argue that this is the correct comparison of expected payoffs. Moreover, the empirical evidence presented above rejects hypothesis **H7** except for the sample of larger acquired firms with VC backing. Therefore, in the remainder of this section, we present our results from testing hypothesis **H8**.

[34] Our finding that short-run as well as long-run IPO valuation premia for VC backed firms are smaller than those for non-VC backed firms is consistent with the predictions of the theoretical analysis of Bayar and Chemmanur (2011): please see footnote 2.3 for details of these predictions.

Table 8 presents the comparison of acquired firms' deal valuations and their imputed long-run IPO valuations $\hat{V}_{ipo}$ calculated from Eq. (2). Now, the valuation of the matching firm, V_{match} in Eq. (2) is calculated as follows:

$$V_{match} = \alpha V_{ipo,0} + (1-\alpha)V_{ipo,3}, \tag{4}$$

where α is the fraction of shares sold in the IPO by firm insiders. $V_{ipo,0}$ denotes the IPO valuation of the matched firm and $V_{ipo,3}$ stands for the stock market valuation of the matched IPO firm three years after the IPO. Panel A of Table 8 reports that the median long-run IPO valuation premium for all acquired firms is 49.00% (down from 75.47% in the short run). The median long-run premium for non-VC backed acquired firms is 65.07% (down from 86.36% in the short run). Finally, the median long-run premium for VC backed acquisitions is 24.42% (down from 42.43% in the short run). Table 9 reports the test results regarding the difference between the short-run premia and long-run premia. The results reported in Panel A of Table 9 show that the long-run IPO valuation premia are significantly smaller than the short-run IPO valuation premia for all acquired firms by a margin of about 26.5%.

The results presented in Panel B of Table 8 are consistent with our earlier findings in Panel B of Table 7 and our second empirical prediction with regard to the IPO valuation premium puzzle (**H8**). Panel B of Table 8 reports the results of the analysis of long-run IPO valuation premia for acquired firms with a deal value not less than $50 million. We see that the median long-run IPO premium for all large private firm targets is 3.46% (down from 32.92% in the short run) and it is statistically not different from zero. Similarly, the median long-run IPO premium for non-VC backed large private firm targets is 11.80% (down from 40.75% in the

Table 8

Long-run valuations (propensity score matching). This table reports the results of the propensity score matching analysis testing for the significance of the long-run valuation premium between IPOs and acquisitions. The unmatched sample contains all deals with sales not less than $200,000 in the fiscal year prior to exit and only if the sales growth data for the firm is available. This initial unmatched sample contains 2558 observations (1430 acquisitions and 1128 IPOs). The propensity scores are generated using the probit regression specification in Column 9 of Table 3 without the VC dummy variable. After applying the common support requirement, each acquired firm is matched to an IPO firm with the closest propensity score, within the same industry (two-digit SIC level), with the same year of exit and same VC backing status. The matched sample contains 1030 pairs of acquisitions and their matched IPOs. Panel A reports the mean and the median of the acquisition deal values reported by SDC and the mean and the median of the imputed long-run IPO valuations of the acquired firms obtained from Eq. (2) for the sample of all acquisitions, the sample of non-VC backed acquisitions, and the sample of VC backed acquisitions. The long run value V_{match} of the matched IPO firm is defined as the weighted average of its current IPO value and its long run (three years post-IPO) market value as defined in Eq. (4). The current IPO value $V_{ipo,0}$ of the matched IPO firm is defined as the offering price multiplied by the number of shares outstanding after the IPO. The long run market value $V_{ipo,3}$ is defined as the closing price of the firm three years after the IPO multiplied by the number of shares outstanding at that point in time. If the firm was delisted within the three years after the IPO for any reason (e.g., a post-IPO acquisition), or there is still remaining time to completing a period of three years, we take the most recent available closing price of the IPO firm. The long run value V_{match} of the matched IPO firm is then divided by the net sales revenue of the IPO firm as of the fiscal year prior to the IPO and the resulting ratio is then multiplied by the net sales revenue of the acquired firm to estimate the IPO valuation of the acquired firm given in (2). Panel A then reports the summary statistics and the tests of the long run IPO valuation premia of acquisitions. The long-run IPO valuation premium for each acquisition-matched IPO pair is calculated as the natural log of the ratio of the imputed long-run IPO valuation of the acquired firm to the deal value of the acquired firm. Panel B reports the summary statistics and the results of the difference tests for the sample of acquisitions with deal values not less than $50 million only. Panel C reports the results of the difference tests for the sample of acquisitions with deal values less than $50 million only. Deal values and imputed valuations are reported in millions of dollars, and all dollar values are adjusted for inflation. Asterisks ***, **, * represent significance levels for the *t*-tests and the Wilcoxon signed-rank test at the 1%, 5%, and 10% levels. The null hypothesis for the *t*-tests is that mean premium is equal to zero. The null hypothesis for the signed-rank test is that the difference between long run and short run valuation premia is from a distribution with a median value of zero. The *p*-values of the tests are also reported to show the statistical significance.

Panel A: Long run valuation premia for all acquisitions

All acquisitions				Non-VC backed acquisitions				VC backed acquisitions			
	Mean	Median	*N*		Mean	Median	*N*		Mean	Median	*N*
Acquisition value	128.893	43.499	1030	Acquisition value	95.005	34.878	700	Acquisition value	200.777	71.778	330
Imputed IPO value	602.679	83.148	1030	Imputed IPO value	493.819	85.814	700	Imputed IPO value	833.595	77.935	330
Premium	57.66%	49.00%	1030	Premium	76.41%	65.07%	700	Premium	17.89%	24.42%	330
p-value		0.0000***		*p*-value		0.0000***		*p*-value		0.0300**	

Panel B: Long run valuation premia for acquisitions with a deal value greater than or equal to $50 million

All acquisitions				Non-VC backed acquisitions				VC backed acquisitions			
	Mean	Median	*N*		Mean	Median	*N*		Mean	Median	*N*
Acquisition value	257.406	129.665	466	Acquisition value	212.373	122.162	269	Acquisition value	318.896	147.994	197
Imputed IPO value	1116.145	150.857	466	Imputed IPO value	983.908	164.438	269	Imputed IPO value	1296.713	124.298	197
Premium	1.12%	3.46%	466	Premium	15.90%	11.80%	269	Premium	−19.07%	−9.23%	197
p-value		0.6623		*p*-value		0.1784		*p*-value		0.3929	

Panel C: Long run valuation premia for acquisitions with a deal value less than $50 million

All acquisitions				Non-VC backed acquisitions				VC backed acquisitions			
	Mean	Median	*N*		Mean	Median	*N*		Mean	Median	*N*
Acquisition value	22.710	20.597	564	Acquisition value	21.751	20.000	431	Acquisition value	25.818	23.535	133
Imputed IPO value	178.432	49.500	564	Imputed IPO value	187.940	52.634	431	Imputed IPO value	147.623	37.580	133
Premium	104.38%	90.73%	564	Premium	114.18%	106.17%	431	Premium	72.64%	56.25%	133
p-value		0.0000***		*p*-value		0.0000***		*p*-value		0.0000***	

Table 9
Differences in valuation premia (short run vs. long run). This table reports the summary statistics of the differences between the long run valuation premia reported in Table 9 and the short run valuation premia reported in Table 8 and the results of the empirical analysis testing the significance of the premium difference. The short run IPO valuation premium for each acquisition-matched IPO pair is calculated as the natural log of the ratio of the short run IPO valuation of the acquired firm to the deal value of the acquired firm. The long run IPO valuation premium for each acquisition-matched IPO pair is calculated as the natural log of the ratio of the long run IPO valuation of the acquired firm to the deal value of the acquired firm. Panel A reports the results for all acquisitions whereas Panel B reports the results for the sample of acquisitions with deal values not less than $50 million. Panel C reports the results for the sample of acquisitions with deal values less than $50 million. Each panel is divided into three categories where the test results and summary statistics are reported for all acquired firms, non-VC backed acquired firms, and VC-backed acquired firms. Asterisks ***, **, * represent significance levels for the *t*-tests and the Wilcoxon signed-rank test at the 1%, 5%, and 10% levels. The null hypothesis for the *t*-tests is that mean premium is equal to zero. The null hypothesis for the signed-rank test is that the difference between long run and short run valuation premia is from a distribution with a median value of zero. The *p*-values of the tests are also reported to show the statistical significance.

Panel A: differences in valuation premia (short run vs. long run)

All acquisitions				Non-VC backed acquisitions				VC backed acquisitions			
	Mean	Median	*N*		Mean	Median	*N*		Mean	Median	*N*
Short Run	71.99%	75.47%	1030	Short Run	87.20%	86.36%	700	Short Run	39.72%	42.43%	330
Long Run	57.66%	49.00%	1030	Long Run	76.41%	65.07%	700	Long Run	17.89%	24.42%	330
Difference	14.32%	26.47%		Difference	10.79%	21.29%		Difference	21.83%	18.00%	
p-value	0.0000***	0.0000***		*p*-value	0.0008***	0.0000***		*p*-value	0.0000***	0.0000***	

Panel B: differences in valuation premia (short run vs. long run) for acquisitions with a deal value greater than or equal to $50 million

All acquisitions				Non-VC backed acquisitions				VC backed acquisitions			
	Mean	Median	*N*		Mean	Median	*N*		Mean	Median	*N*
Short Run	20.97%	32.92%	466	Short Run	30.25%	40.75%	269	Short Run	8.31%	16.50%	197
Long Run	1.12%	3.46%	466	Long Run	15.90%	11.80%	269	Long run	−19.07%	−9.23%	197
Difference	19.86%	29.47%		Difference	14.35%	28.95%		Difference	27.38%	25.73%	
p-value	0.0000***	0.0000***		*p*-value	0.0075***	0.0012***		*p*-value	0.0000***	0.0000***	

Panel C: differences in valuation premia (short run vs. long run) for acquisitions with a deal value less than $50 million

All acquisitions				Non-VC backed acquisitions				VC backed acquisitions			
	Mean	Median	*N*		Mean	Median	*N*		Mean	Median	*N*
Short run	114.14%	112.64%	564	Short run	122.75%	122.23%	431	Short run	86.24%	86.00%	133
Long run	104.38%	90.73%	564	Long run	114.18%	106.17%	431	Long run	72.64%	56.25%	133
Difference	9.75%	21.91%		Difference	8.57%	16.06%		Difference	13.61%	29.74%	
p-value	0.0050***	0.0004***		*p*-value	0.0318**	0.0064***		*p*-value	0.0552*	0.0198**	

short run) and it is not significantly different from zero either. Finally, the median long-run IPO premium for VC backed large private firm targets is −9.23% (down from 16.50% in the short run), but still not statistically different from zero. These findings suggest that the acquisition value of a large private firm is not significantly different from the weighted average of its current imputed IPO value and its long-run (three years post-IPO) imputed market value. The results in Panel B of Table 9 further confirm these findings by showing that the long-run premia for large acquisitions are significantly smaller than their short-run premia both statistically and economically. The results reported in Panels A and C of Table 8 suggest that an IPO valuation premium persists for smaller acquisitions with a deal value less than $50 million, even though long-run valuation premia are significantly less than short-run premia for smaller acquisitions as well. One should also note that our result on lower long-run IPO valuation premia is consistent with the empirical evidence about the long-run underperformance of IPO stocks documented in the IPO literature (see, e.g., Ritter, 1991).

In summary, our empirical analysis of the IPO valuation premium puzzle using the PSM approach shows that there exists no IPO valuation premium for large acquisitions with VC backing after controlling for various observable firm- and industry-specific factors affecting a firm's choice between IPOs and acquisitions, which is consistent with hypothesis **H7**. Further, consistent with hypothesis **H8**, the IPO valuation premium vanishes for all large target firms after controlling for the long-run component of the expected payoff to firm insiders from an IPO exit. Finally, we also find that long-run valuation premia are much smaller than short-run valuation premia for all private target firms.

5.2. Treatment-effects regression analysis

In this section, we use a treatment-effects regression model, which is a variant of the Heckman Inverse-Mills-Ratio (IMR) method, to further analyze the IPO valuation premium puzzle. Heckman-type IMR methods are used to address selection bias that may arise due to unobservable factors that simultaneously affect both the probability of a private firm self-selecting its treatment (the exit choice between IPOs and acquisitions in our context) and the treatment outcome (the valuation of the firm at the time of exit in our context). In the analysis of the IPO valuation premium puzzle, the PSM method that we implemented above mitigates selection bias due to *observable* factors motivated by the theoretical predictions of Bayar and Chemmanur (2011). However, it does not alleviate selection bias due to *unobservables*. An important prediction of Bayar and Chemmanur (2011) is that

Table 10
Treatment-effects regressions with short-run valuations. This table reports the results of the treatment-effects regression analysis of the short-run valuation premium between IPOs and acquisitions. Regressions in Panel A include all observations for which the variable sales growth is defined. Regressions in Panel B include only observations with deal values not less than $50 million. In the first-stage (1) of each panel, probit regressions are estimated to predict the probability of an IPO vs. an acquisition, and calculate inverse Mills ratios for IPO firms and acquired firms respectively. The dependent variable IPO dummy is equal to 0 if the observation is an acquisition and equal to 1 if it is an IPO. All independent variables are measured as of the nearest fiscal year prior to the transaction except Sales growth. Log (Total Assets) is log of the book value of total assets. Sales growth is the firm's average annual change in sales (from year −3 to −1 or from year −2 to −1 depending on data availability) scaled by the average level of total assets prior to exit. ROA is net income divided by total assets. Herfindahl Index is the lagged value of Herfindahl Index at the three-digit SIC level. Tangible Assets/TA is net property and equipment scaled by total assets. Mean Error is the industry mean (three-digit SIC level) of average analysts forecast errors in the year prior to exit. CAPEX/TA is capital expenditures scaled by total assets. VC backing is a dummy variable that is equal to 1 if the firm was financed by venture capital. CRSP index return is the lagged six-month return of the equally-weighted CRSP market index. R&D/TA is research and development (R&D) expenses scaled by total assets. Leverage is the sum of long-term debt and short-term debt scaled by total assets. In the second stage (2) of each panel, we regress the log of each private firm's deal value on a set of independent variables that include the IPO dummy variable, the observable covariates used in the first stage (1), and the inverse Mills ratio obtained in the first stage (1). The deal value for an IPO is defined as the offering price multiplied by the number of shares outstanding, and the deal value for an acquisition is defined as the total value of consideration paid by the acquirer, excluding fees and expenses. Year and industry fixed effects are included in all regression specifications. Asterisks ***, **, * represent significance levels at the 1%, 5%, and 10% levels, respectively. Heteroskedasticity-robust *p*-values are reported in brackets.

	Panel A (all deals)		Panel B (deal value ≥ 50)	
	(1)	(2)	(1)	(2)
Variables	IPO dummy	Log (value)	IPO dummy	Log (value)
Log (total assets)	0.523***	0.535***	0.318***	0.439***
	[0.000]	[0.000]	[0.000]	[0.000]
Sales growth	0.132***	0.069***	0.268***	0.078***
	[0.000]	[0.000]	[0.000]	[0.009]
ROA	−0.038	−0.057***	0.006	−0.123***
	[0.268]	[0.000]	[0.912]	[0.000]
Herfindahl index	−0.904**	0.090	−0.761	0.072
	[0.038]	[0.643]	[0.173]	[0.712]
Tangible assets/TA	−1.011***	−0.195*	−0.956***	−0.179*
	[0.000]	[0.056]	[0.001]	[0.100]
Mean error	0.000*	0.000	0.000*	−0.000
	[0.065]	[0.661]	[0.052]	[0.406]
CAPEX/TA	1.474***	1.187***	0.687	1.014***
	[0.000]	[0.000]	[0.169]	[0.000]
VC backing	0.763***	0.230***	0.645***	0.111**
	[0.000]	[0.000]	[0.000]	[0.041]
CRSP index return	1.512***	−0.031	1.468***	0.055
	[0.000]	[0.830]	[0.000]	[0.729]
RD/TA	0.080	0.080***	0.099	−0.013
	[0.248]	[0.006]	[0.258]	[0.679]
Leverage	−0.043	−0.050**	−0.066	−0.096***
	[0.444]	[0.032]	[0.422]	[0.002]
IPO dummy		1.139***		0.523**
		[0.000]		[0.015]
Inverse mills ratio		−0.276***		−0.161
		[0.003]		[0.213]
Observations	2,716	2,716	1,822	1,822

private firm insiders will have private information about the intrinsic quality of their firms (viability as a stand-alone firm against product market competition) which will determine both the firm's equilibrium exit choice between IPOs and acquisitions, and therefore, its market valuation. Thus, even after controlling for all observable firm-, industry-, and market-specific characteristics that affect both the exit choice and the valuation of the firm, private firm insiders may still have important residual information that we as researchers cannot observe, and these unobservable factors may cause a selection bias in our analysis of the IPO valuation premium if they are not controlled for.

The econometric procedure we implement in this section is discussed in detail in Maddala (1983), and it is a generalized version of the traditional two-step Heckman selection model (see Heckman, 1979), and therefore accounts for the effect of unobservables (which may affect both the exit choice and the firm valuation at the same time) by using inverse Mills ratios. In particular, we use a first-stage probit regression model to predict the probability of an IPO vs. an acquisition, and determine the inverse Mills ratios for IPO firms and acquired firms respectively. The independent variables in the first stage are the same as those in the probit specification of Column 9 in Table 3 except the private benefits variable, and we also include industry fixed effects.[35] The inverse Mills ratios calculated for each firm in the first stage capture unobservable information which will be used by firm insiders to make their exit choices and will also affect the firm's market valuation at the time of exit. In the second stage of the estimation procedure, we then regress private firm valuations (log of the firm value) on a set of independent variables that include the

[35] The private benefits dummy variable drops out due to its multicollinearity with industry fixed effects.

Table 11
Treatment-effects regressions with long-run valuations. This table reports the results of the treatment-effects regression analysis of the long-run valuation premium between IPOs and acquisitions. Regressions in Panel A include all observations for which the variable sales growth is defined. Regressions in Panel B include only observations with deal values not less than $50 million. In the first-stage (1) of each panel, probit regressions are estimated to predict the probability of an IPO vs. an acquisition, and calculate inverse Mills ratios for IPO firms and acquired firms respectively. The dependent variable IPO dummy is equal to 0 if the observation is an acquisition and equal to 1 if it is an IPO. All independent variables are measured as of the nearest fiscal year prior to the transaction except Sales growth. Log (Total Assets) is log of the book value of total assets. Sales growth is the firm's average annual change in sales (from year −3 to −1 or from year −2 to −1 depending on data availability) scaled by the average level of total assets prior to exit. ROA is net income divided by total assets. Herfindahl Index is the lagged value of Herfindahl Index at the three-digit SIC level. Tangible Assets/TA is net property and equipment scaled by total assets. Mean Error is the industry mean (three-digit SIC level) of average analysts forecast errors in the year prior to exit. CAPEX/TA is capital expenditures scaled by total assets. VC backing is a dummy variable that is equal to 1 if the firm was financed by venture capital. CRSP index return is the lagged six-month return of the equally-weighted CRSP market index. R&D/TA is research and development (R&D) expenses scaled by total assets. Leverage is the sum of long-term debt and short-term debt scaled by total assets. In the second stage (2) of each panel, we regress the log of each private firm's long-run adjusted values on a set of independent variables that include the IPO dummy variable, the observable covariates used in the first stage (1), and the inverse Mills ratio obtained in the first stage (1). The long-run adjusted value of an IPO firm is defined as the weighted average of its deal value and its long run (three years post-IPO) market value. The deal value of an IPO firm is defined as the offering price multiplied by the number of shares outstanding after the IPO. The long run market value of an IPO firm three years after the IPO is defined as the closing price of the firm three years after the IPO multiplied by the number of shares outstanding at that point in time. If the firm was delisted within the three years after the IPO for any reason (e.g., a post-IPO acquisition), or there is still remaining time to completing a period of three years, we take the most recent available closing price of the IPO firm. The value of an acquired firm is the deal value for an acquisition defined as the total value of consideration paid by the acquirer, excluding fees and expenses. Year and industry fixed effects are included in all regression specifications. Asterisks ***, **, * represent significance levels at the 1%, 5%, and 10% levels, respectively. Heteroskedasticity-robust *p*-values are reported in brackets.

	Panel A (all deals)		Panel B (deal value ≥ 50)	
	(1)	(2)	(1)	(2)
Variables	IPO dummy	Log (value)	IPO dummy	Log (value)
Log (total assets)	0.523***	0.573***	0.318***	0.513***
	[0.000]	[0.000]	[0.000]	[0.000]
Sales growth	0.132***	0.081***	0.268***	0.135***
	[0.000]	[0.000]	[0.000]	[0.002]
ROA	−0.038	−0.057***	0.006	−0.124***
	[0.268]	[0.002]	[0.912]	[0.000]
Herfindahl index	−0.904**	−0.134	−0.761	−0.370
	[0.038]	[0.579]	[0.173]	[0.201]
Tangible assets/TA	−1.011***	−0.121	−0.956***	−0.203
	[0.000]	[0.343]	[0.001]	[0.210]
Mean error	0.000*	0.000	0.000*	−0.000
	[0.065]	[0.268]	[0.052]	[0.993]
CAPEX/TA	1.474***	1.298***	0.687	1.125***
	[0.000]	[0.000]	[0.169]	[0.000]
VC backing	0.763***	0.190***	0.645***	0.158*
	[0.000]	[0.001]	[0.000]	[0.053]
CRSP index return	1.512***	−0.467***	1.468***	−0.352
	[0.000]	[0.010]	[0.000]	[0.135]
RD/TA	0.080	0.115***	0.099	0.032
	[0.248]	[0.001]	[0.258]	[0.484]
Leverage	−0.043	−0.058**	−0.066	−0.132***
	[0.444]	[0.044]	[0.422]	[0.004]
IPO dummy		0.975***		−0.096
		[0.000]		[0.766]
Inverse mills ratio		−0.251**		0.117
		[0.031]		[0.543]
Observations	2716	2716	1822	1822

IPO dummy variable, the observable covariates used in the first stage, and the inverse Mills ratio obtained in the first stage. Our objective is to test if the IPO dummy variable in this second-stage regression has a statistically significant coefficient even after controlling for all observable factors and unobservable factors (inverse Mills ratios), which would indicate whether an IPO valuation premium exists or not. Please see Part 2 of the Appendix A for a more detailed description of this methodology.

The results of our treatment-effects regression analysis are reported in Tables 10 and 11. In the regression models estimated in Table 10, the dependent variable Y_i in the second stage is equal to the log of the deal value of each observation, i.e., $Y_i = log(V_i)$, where V_i is the deal value of firm *i*. In the regression models estimated in Table 11, however, the intrinsic value V_i of each IPO firm is calculated as a weighted average of its deal value at the time of exit (time 0) and its long-run post-IPO market value three years after the IPO (as in Eq. (4) of our PSM analysis in Section 5.2); the weight on the deal value is equal to the fraction of shares sold in the IPO by firm insiders.

The second-stage regression results presented in Panel A of Table 10 show that the coefficients of both the IPO dummy variable and the inverse Mills ratio are statistically significant at 1%, when we include all 2716 observations for which the sales growth variable is defined. The statistical significance of the IMR variable indicates that there indeed exist unobservable factors which affect both a private firm's exit decision and its market valuation. Further, the positive coefficient of the IPO dummy variable in the second-stage valuation regression provides evidence for the existence of an IPO valuation premium consistent with the results of

our PSM analysis. In Panel B of Table 10, we report the results of our treatment-effects model regressions, where we only include observations with deal values not less than $50 million. The second-stage regression results of Panel B show that the inverse Mills ratio variable loses its statistical significance, and the coefficient of the IPO dummy variable, albeit still significant, decreases from 1.139 to 0.523. Thus, these results suggest that for larger deals, unobservable factors play a less important role than observable factors when private firm exit decisions and market valuations are simultaneously determined. Further, the short-run IPO valuation premium has a smaller magnitude when we exclusively focus on larger private firms, which is consistent with the results of our PSM analysis.

When we focus on long-run IPO valuation premia, the regression results reported in Panel A of Table 11 show that the IPO valuation premium continues to be statistically significant when we use our sample of all 2716 firms, even though the coefficient of the IPO dummy variable decreases from 1.139 (in Panel A of Table 10) to 0.975. The results reported in Panel B of Table 11, however, suggest that the IPO valuation premium vanishes for larger deals worth not less than $50 million, since the coefficient of the IPO dummy variable is statistically insignificant (along with the coefficient of the inverse Mills ratio variable).

Overall, the results of our treatment-effects regressions indicate that the results of our empirical tests in Section 5.1 are robust to the selection of exit choice by firm insiders based on unobservables.

6. Conclusion

Using a hand-collected data set of private firm acquisitions and IPOs, this paper has developed the first empirical analysis in the literature of the "IPO valuation premium puzzle," which refers to a situation where many private firms choose to be acquired rather than to go public at higher valuations. We also tested several new hypotheses regarding a private firm's choice between IPOs and acquisitions. Our analysis of private firm valuations in IPOs and acquisitions indicated that IPO valuation premia disappear for larger VC backed firms after controlling for various factors affecting a firm's propensity to choose IPOs over acquisitions. Further, after controlling for the long-run component of the expected payoff to firm insiders from an IPO exit, we found that the IPO valuation premium vanishes even for larger non-venture backed firms and shrinks substantially for smaller firms as well. Our Heckman-style treatment effects regression analysis demonstrated that the above results are robust to controlling for the selection of exit mechanism by firm insiders based on unobservables. Our findings on private firms' choice between IPOs and acquisitions can be summarized as follows. First, firms operating in industries characterized by the absence of a dominant market player (and therefore more viable against product market competition) are more likely to go public rather than to be acquired. Second, firms which are harder to value by IPO market investors, more capital intensive firms, and those operating in industries characterized by greater private benefits of control, are more likely to go public rather than to be acquired. Third, the likelihood of an IPO over an acquisition is greater for venture backed firms and those characterized by higher pre-exit sales growth.

Acknowledgements

We are grateful to Alan Marcus, Hassan Tehranian, Robert Taggart, Deborah Lucas, Gustavo Grullon as well as conference participants at the FMA meetings, the Financial Intermediation Research Society meetings, and seminar participants at Boston College, University of Texas at San Antonio, Brock University, University of Waterloo, Wilfrid Laurier University, Clarkson University, and Southern Illinois University at Carbondale for helpful comments and discussions. In addition, we acknowledge the valuable research assistance of Artem Mikhlyukov, Jullavut Kittiakarasakun, Lin Zhao, and Sina Ehsani. Special thanks to an anonymous referee and Jeffry Netter (the editor) for several helpful comments and suggestions.

Appendix A. Details of methodology underlying our propensity score matching analysis and our treatment-effects regression analysis

1. Propensity score matching methodology

The propensity score matching (PSM) method has two major advantages over a simple matching method. First, it allows to match an acquired firm with a similar IPO firm along multiple dimensions. The propensity score aggregates information from multiple matching characteristics which are hypothesized to affect the choice between IPOs and acquisitions, and thereby avoids the "curse of dimensionality" problem which plagues simple matching methods. Second, there is a growing theoretical and empirical literature in econometrics about the estimation of treatment effects in the presence of "self-selection on observables", which proposes the application of the PSM approach. We, therefore, make use of the PSM method proposed by Dehejia and Wahba (1999, 2001) which is based on Rosenbaum and Rubin's (1983) propensity score theorem. This technique allows one to accommodate a large number of matching characteristics and has proven to be rather successful in producing accurate treatment effect estimates in a non-experimental setting where the event group (treatment group) significantly differs from the population of potential matching subjects (control group) in terms of observable factors that determine the probability of treatment. It mitigates potential selection bias on these observable factors due to systematic differences between treatment and control subjects (in our setting, an IPO firm that we select as a "comparable firm" and an acquired private firm which we wish to value). The PSM method has already been used in the finance literature to pair-match companies based on a given set of characteristics. In particular, Villalonga (2004) use the PSM method in her study of diversification discount to find the appropriate benchmark

companies for diversifying firms. Hillion and Vermaelen (2004) apply propensity score matching in their study of the operating performance of companies issuing death spiral convertibles.[36]

We use the "nearest neighbor matching" version of the PSM method that works as follows. Let X_i be a vector of independent characteristics observed for a private firm i (acquired firms as well as IPO firms) in the fiscal year prior to the exit. Let D_i be a dummy variable that is equal to 1 for an IPO firm and 0 for an acquired firm. We estimate the propensity score for each firm i, i.e., the probability of going public, as

$$P_i = P(D_i = 1|X_i), \qquad i = 1\ldots N, \tag{A.1}$$

using the regression specification in Column 9 of Table 3 except the VC backing dummy, which is used as an exact matching filter after the estimation of propensity scores.

2. Treatment-effects regression methodology

Formally, our treatment-effects model estimates the effect of an endogenous binary treatment (the choice between IPO and acquisition), T_i, on a continuous outcome variable Y_i ($Y_i = log(V_i)$, where V_i is the market value of firm i in our case), conditional on the independent variables X_i and Z_i:

$$Y_i = X_i\beta + \delta T_i + \varepsilon_i, \tag{A.2}$$

where T_i is an endogenous dummy variable indicating whether the treatment is assigned or not ($T_i = 1$ if the private firm exits through an IPO, $T_i = 0$ if the firm chooses to be acquired by a public firm). We refer to (A.2) as our valuation equation. The binary decision to obtain the treatment T_i is modeled as the outcome of an unobserved latent variable, T_i^*, as follows:

$$T_i^* = Z_i\gamma + u_i, \tag{A.3}$$

where the observed decision is made according to the rule

$$T_i = \begin{cases} 1, & \text{if} T_i^* > 0, \\ 0, & \text{otherwise}, \end{cases} \tag{A.4}$$

where ε_i and u_i are bivariate normal with mean zero and covariance ρ. Maddala (1983) derives a two-step estimator for this model. In the first stage, probit estimates of γ are obtained from the treatment equation in (A.3), where $Pr(T_i = 1|Z_i) = \Phi(Z_i\gamma)$. From these estimates, the inverse Mills ratio, IMR_i, for each observation i is computed as

$$IMR_i = \begin{cases} \dfrac{\phi(Z_i\hat{\gamma})}{\Phi(Z_i\hat{\gamma})}, & T_i = 1, \\ \dfrac{-\phi(Z_i\hat{\gamma})}{((1-\Phi(Z_i\hat{\gamma}))}, & T_i = 0, \end{cases} \tag{A.5}$$

where ϕ is the standard normal density function, and Φ is the standard normal cumulative distribution function. The two-step parameter estimates of β and δ in the valuation Eq. (A.2) are obtained by augmenting this regression equation with the inverse Mills ratios, IMR_i obtained from (A.5). In our setting, the observable independent variables in the valuation Eq. (A.2) and the treatment Eq. (A.3) are the same, i.e., $X_i = Z_i$ for each firm i.[37]

References

Aghion, P., Bloom, N., Blundell, R., Griffith, R., Howitt, P., 2005. Competition and innovation: an inverted-U relationship. Q. J. Econ. 120, 701–728.
Aslan, H., Kumar, P., 2011. Costly information and public financing: takeovers or IPOs? Working Paper. University of Houston.
Bayar, O., Chemmanur, T.J., 2011. IPOs versus acquisitions and the valuation premium puzzle: a theory of exit choice by entrepreneurs and venture capitalists. J. Financ. Quant. Anal. 46 (6).
Brau, J., Francis, F., Kohers, N., 2003. The choice of IPO versus takeover: empirical evidence. J. Bus. 76, 583–612.
Chemmanur, T.J., He, J., He, S., Nandy, D., 2011. The exit choices of entrepreneurial firms. Working paper. Boston College.
Christie, A., 1987. On cross-sectional analysis in accounting research. J. Account. Econ. 9, 231–258.
Cooney, J., Moeller, T., Stegemoller, M., 2009. The underpricing of private targets. J. Financ. Econ. 93, 51–66.
Dehejia, R.H., Wahba, S., 1999. Causal effect in non-experimental studies: re-evaluating the valuation of training programs. J. Am. Stat. Assoc. 94, 1053–1062.
Dehejia, R.H., Wahba, S., 2001. Propensity score matching methods for non-experimental causal studies. Rev. Econ. Stat. 84, 151–161.
Field, L.C., Hanka, G., 2001. The expiration of IPO share lockups. J. Finance 56, 471–500.
Gao, X., Ritter, J., Zhu, Z., 2011. Where have all the IPOs gone? Working Paper. University of Florida.
Gaspar, J.M., Massa, M., 2006. Idiosyncratic volatility and product market competition. J. Bus. 79, 3125–3152.
Heckman, J., 1979. Sample selection bias as a specification error. Econometrica 47, 153–161.
Hillion, P., Vermaelen, T., 2004. Death spiral convertibles. J. Financ. Econ. 71, 381–415.
Irvine, P., Pontiff, J., 2009. Idiosyncratic return volatility, cash flows, and product market competition. Rev. Financ. Stud. 22, 1149–1177.

[36] In our setting, the treatment group isthe sample of IPO firms, and the control group is the sample of acquisitions. Once can think of the treatment to a private firm as going public through an IPO. Our objective is to estimate the average treatment effect on the untreated, or the control group of acquisitions. If the average treatment effect on the control group is positively significant, it would mean that there exists an IPO valuation premium. See also Tucker (2010) for a very informative review on the application of the PSM method in Accounting and Finance research.

[37] Maddala (1983, p.120–121) shows that identification of the model is achieved even when $X_i = Z_i$.

Koeplin, J., Sarin, A., Shapiro, A., 2000. The private company discount. J. Appl. Corp. Financ. 12, 94–101.
Krishnaswamy, S., Subramaniam, V., 1999. Information asymmetry, valuation, and the corporate spin-off decision. J. Financ. Econ. 53, 73–112.
Leland, H.E., Pyle, D.H., 1977. Informational asymmetries, financial structure, and financial intermediation. J. Finance 32, 371–387.
Maddala, G.S., 1983. Limited dependent and qualitative variables in econometrics. Econometric Society Monographs No.3. Cambridge University Press, Cambridge.
Nickell, S., 1996. Competition and corporate performance. J. Polit. Econ. 104, 724–746.
Officer, M., 2007. The price of corporate liquidity: acquisition discounts for unlisted targets. J. Financ. Econ. 83, 571–598.
Poulsen, A., Stegemoller, M., 2008. Moving firms from private to public ownership: selling out to public firms vs. initial public offerings. Financ. Manage. 37, 81–101.
Purnanandam, A.K., Swaminathan, B., 2004. Are IPOs really underpriced? Rev. Financ. Stud. 17, 811–848.
Rajan, R.G., Wulf, J., 2006. Are perks purely managerial excess? J. Financ. Econ. 79, 1–33.
Ritter, J., 1991. The long-run performance of initial public offerings. J. Finance 46, 3–27.
Rosenbaum, P.R., Rubin, D.B., 1983. The central role of propensity score in observational studies for causal effects. Biometrical 70, 41–55.
Tucker, J.W., 2010. Selection bias and econometric remedies in accounting and finance research. J. Account. Lit. 29, 31–57.
Villalonga, B., 2004. Does diversification cause the “diversification discount?”. Financ. Manage. 33, 5–27.