The decline in public firms

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ABSTRACT

Since its peak in 1996, the number of publicly listed US firms has declined by approximately 50%. In addition, US publicly listed firms are now on average larger and older than they were two decades ago. We collect a set of empirical facts on the changes in the distributions as well as entry and exit rates for public and private firms. We develop a model to evaluate which of two mechanisms — an increase in the cost of being public or a shift in the supply of private firm financing — can explain the decline in US public listings and changes in the firm distribution. We calibrate the model to match the data prior to 1996 and then quantify the extent to which these two mechanisms can explain the changes observed in the data.

1 Introduction

Since a peak of approximately 7,500 firms in 1996, the number of US publicly listed firms has decreased by 50% in the last two decades. In contrast, the total number of US firms has steadily increased over this period. With a lower frequency of initial public offerings, fewer young and small firms are going public. The reason for this decline in the propensity of firms to go public, remains an open question.

In this paper, we evaluate two commonly cited explanations for the decline of public firms. The first is an improvement in private capital markets that has reduced the financing costs for private firms. That is, from a financing perspective, the relative benefits of being publicly listed have declined. The second explanation is an increase in the costs of operating as a publicly listed firm, resulting from regulation, disclosure requirements, activist investors, etc. While both explanations amount to a reduction in the net benefit to being public, they entail very different policy implications.

We start by collecting a set of empirical facts on the evolution of public and private firms in the US over the last 40 years. We show that while there has been significant growth in venture capital and private equity funding of young firms, the propensity of these firms to become public has declined. In general, we find evidence consistent with a decline in the net benefits to public listing. Both incumbent public firms as well as firms at their IPO date are larger and older than in previous periods.

We then develop an equilibrium model of the market for private capital in which entrepreneurs endogenously choose to enter and operate as a private firm. Once established, a private firm can pay a fixed cost and become publicly listed. In addition to this fixed cost, a public firm faces a higher ongoing operating cost, reflecting the increased burdens of dealing with regulation, disclosure, and investors. The benefit to public listing is a lower discount rate, resulting in a higher valuation. Thus, in choosing whether to publicly list, a firm trades off fixed costs of an IPO along with ongoing increased costs of operations against a lower cost of capital. The spread between the cost of capital for private and public firms is determined in equilibrium and we solve for the stationary distributions of private and public firms. We calibrate the model to the data for the period prior to 1996, when the decline in public listing began. Then, we use the model to evaluate the effect of an increase in the ongoing cost of being publicly listed, an increase in the cost of IPO, and an outward shift in the supply of private capital. We show in the model that increased costs of being public and a shift in private capital supply have distinct predictions for the distributions of public and private firms.

Our paper contributes to multiple strands of literature. First and foremost, our work complements recent studies that document the decline in the number of U.S. public firms, the so-called "U.S. listing gap," and investigate possible explanations for this phenomenon. Gao, Ritter, and Zhu (2013) are among the first to document the number of IPOs dropping more than threefold below the historical average. Doidge, Karolyi, and Stulz (2017) establish that these empirical patterns are novel to the U.S. The number of listings in non-U.S. developed countries, on the contrary, has increased over the same period. They also find that the decline in the number of public listings can be equally explained by a low number of new lists and a high number of delists, majority of which are acquisitions of public firms. Kahle and Stulz (2017) further show that in recent years U.S. public firms have become larger, older, and less profitable; they rely more on R&D investment relative to capital investment. Accordingly, Gao et al. (2013) document that the IPO rate is particularly low among small, young firms. Collectively, these empirical papers point to the possibility that something is amiss in the U.S. public markets.

A common explanation is that the regulatory changes of the early 2000s imposed additional compliance costs on publicly traded firms and made being public less attractive. One prominent example is the Sarbanes-Oxley Act of 2002 (SOX), which made disclosure requirements stricter and increased the administrative costs of preparing accounting statements (e.g., Leuz 2007; Zhang 2007; Engel, Hayes, and Wang 2007; Iliev 2010). However, the increased regulatory hurdles can only partially explain the U.S. listing gap. Kahle and Stulz (2017) note that the drop in public firms predates the regulatory changes, and the fraction of firms that go from public to private is small compared to the fraction of firms exiting public markets because of merges. More recently, Dambra, Field, and Gustafson (2015) points to the 2012 Jumpstart Our Business Startups (JOBS) Act, which exempts emerging growth companies from certain accounting and disclosure requirements mandated by the SOX, as effective in promoting IPO activity among such companies. This finding is consistent with the regulatory overreach hypothesis being a potential explanation for the listing gap. At the same time, Chaplinsky, Hanley, and Moon (2017) find no evidence of lower direct costs of issue, such as accounting, legal, or underwriting fees, following the Act. On the contrary, they document an increase in indirect costs of going public as measured by the underpricing of the firm's shares at the time of the IPO. Similarly, Barth, Landsman, and Taylor (2017) show larger IPO underpricing for emerging growth companies.

An alternative driver behind the decline in U.S. public listings could be positive changes in the private equity markets. Ewens and Farre-Mensa (2017) provide evidence that the deregulation of securities laws in the 1990s made it easier for firms to raise capital privately. For example, the National Securities Markets Improvement Act of 1996 exempted private sales of securities from state regulations known as blue-sky laws, thereby facilitating private firms' access to a larger set of investors. Late-stage startups benefited the most by being able to finance large funding rounds and raise capital from the out-of-state investors. Davis (2016) further argues that the firms' ability to rent capital or outsource reduces their need to accumulate large amounts of physical assets and, hence, to rely on public markets to secure funding for capital expenditures. Other studies posit that the Internet has reduced the costs of finding investors for private firms and as such public markets no longer offer the benefit of lower search costs relative to private markets (Goldmanis, Hortaçsu, Syverson, and Emre 2010; Gao, Ritter, and Zhu 2013; Doidge, Karolyi, and Stulz 2017; Kahle and Stulz 2017; Doidge, Kahle, Karolyi, and Stulz 2018). The contribution of our paper is to shed light on whether the decline in U.S. public listings is a symptom of a broader issue with public markets or a result of improved conditions in private markets. In this sense, our study is a key step towards informing future economic policies and regulations targeted at promoting IPO activity.

Generally, public ownership of equity allows firms to obtain large scale financing at a cost that is not feasible for a privately owned company. Yet, they must pay a large fixed cost to become a publicly listed firm (Lowry et al. 2017; Doidge et al. 2017) and incur additional ongoing costs stemming from regulatory scrutiny and disclosure requirements (Leuz 2007; Zhang 2007; Engel et al. 2007; Iliev 2010). These benefits and costs are explicitly captured in our model. However, there are a number of other factors that might affect a firm's going-public decision which we do not incorporate in our model. First, companies entering public capital markets face increased visibility. While increased visibility can allow firms to sell their shares at a higher price to public investors as compared to private investors (Chemmanur and Fulghieri 1999), it can also attract additional competition in the product market (Maksimovic and Pichler 2001) and reveal trade secrets Farre-Mensa (2017). Second, there are factors related to acquisitions and control. Zingales (1995) argues that going public makes it easier to find a potential buyer to acquire the firm. Others argue the reverse, that firms conduct an IPO in order to more easily acquire other firms (Brau and Fawcett 2006; Celikyurt, Sevilir, and Shivdasani 2010). On a different note, firms may choose to go public in order to divert ownership away from venture capitalists and re-establish the control (Black and Gilson 1998).

More broadly, this paper is related to other theoretical studies analyzing the economic factors underlying a firm's decision to go public. One view is that going public serves as an opportunity for an entrepreneur who wishes to sell his firm. Bayar and Chemmanur (2011) study a private firm's choice between conducting an IPO and exiting private markets through an acquisition by another firm. Zingales (1995) shows that going public before selling a firm to an interested buyer increases the sale's proceeds. Another view is that going public is attractive because of liquidity and diversification benefits, yet involves giving up advantages of being private. Pástor, Taylor, and Veronesi (2008) and Boot, Gopalan, and Thakor (2006) argue that it is easier to maintain control of a firm under private ownership. Going public can also incur increased information production costs (Chemmanur and Fulghieri 1999) or signal a new technology's viability to potential entrants and encourage product market competition

(Maksimovic and Pichler 2001). Pástor and Veronesi (2005) emphasize the role of changing market conditions for IPO decisions and focus on rationalizing IPO waves. In contrast to these studies, we develop a real option model which allows us not only to assess the key trade-offs to a company being publicly versus privately owned quantitatively, but also to characterize the shifts in the cross-sectional distribution of public and private firms. Our analysis builds upon the real option model presented in Dixit and Pindyck (1994) and, therefore, is methodologically similar to other studies using these tools, though topically different (Miao 2005; Luttmer 2007; Hartman-Glaser, Lustig, and Xiaolan 2019).

The rest of the paper is organized as follows. Section 2 discusses the data and provides key empirical facts. In Section 3 we set up an economic model to interpret the empirical evidence. In Section 4 we describe the main model mechanisms and in Section 5 we assess them quantitatively, followed by the Conclusion and Appendix.

2 Data and Empirical Results

To measure the number of publicly listed firms in the U.S., we use the Center for Research in Security Prices (CRSP) Monthly Stock File and follow the definition of Doidge et al. (2017). Specifically, we include all U.S. domiciled common stocks (share codes 10 and 11) listed on the NYSE, AMEX, and NASDAQ stock exchanges (exchange codes 1, 2, and 3), except the investment funds and trusts (SIC codes 6722, 6726, 6798, and 6799).[1] We keep only December observations to identify whether a company satisfies the above criteria in a given year. Our benchmark sample covers the period from 1980 until 2018.

To understand how public firms have changed over the sample period, we merge our CRSP dataset with the Standard & Poor's Compustat Annual. When examining the public

[1]However, in contrast to Doidge et al. (2017) we do not exclude a company in a given year from the firms count if it does not satisfy the above criteria temporarily. For example, consider a firm that goes public in year t and immediately has its equity shares traded on Amex. In year $t+10$ the firm's shares are temporarily delisted from the exchange, but in year $t+12$ the shares are again traded up until the firm exits. In our measure, we count this firm towards our measure in all years between its IPO date (or the first trading date) and exit date as long as it satisfies the criteria of Doidge et al. (2017) at least in one year. Nonetheless, both measures are very similar quantitatively.

firms characteristics, we use the intersection of CRSP and Compustat firms.[2] The dataset provides firms' total revenues (*sale*), total earnings (*oibdp*), total book assets (*at*), debt in current liabilities (*dlcc*), long-term debt (*dlt*), and number of employees (*emp*)[3]. For some firms, Compustat reports financial data few years prior to the initial public offering. Backfilled data can bias upward the number of publicly listed firms. To tackle this issue, we use the offer dates for firms going public collected by Jay R. Ritter and exclude observations prior to the firm's offer date. For the listed firms that are not in the Ritter dataset we assign the first trading day as the offer date.[4] Moreover, we use the Ritter founding dates to construct firm age.

The biggest challenge when measuring the number of private firms in the U.S. is the lack of comprehensive data tracking the U.S. private sector. Another challenge is identifying a set of private firms that are very likely to consider whether to go public or stay private. That said, we use three alternative measures for private firms counts to establish our main empirical findings.

First, we consider all companies backed with financing from venture capital (VC) and private equity (PC) funds in the Thomson Reuters VentureXpert database. All firms that have raised at least one round of financing after 1980 are included.[5] The sample includes 52,941 unique portfolio companies. The two main types of financing instruments are VC equity investment and convertible preferred stock. They constitute approximately 43% and 24% of all investments, respectively. Importantly, the VentureXpert dataset provides the amount of capital raised at each financing round.

Focusing on VC/PE-backed private firms offers a number of advantages. First, we are able to directly measure the flow of capital into the private sector. Second, the prevalence of the VC-financed firms among the publicly traded firms allows us better to identify a set

[2]Firms that are listed on CRSP but not covered by Compustat account for less than 3% of the aggregate market capitalization of all listed firms (see Kahle and Stulz (2017)).

[3]We replace *sale*, *at*, *dlcc*, *dlt*, and *emp* with a missing value when they are less than or equal to zero.

[4]For companies with multiple securities (*permno*), we use the first trading day of a security which is listed on an exchange earlier.

[5]We exclude firms receiving leveraged buyout financing from our analysis.

of private firms that are likely to go public in their life cycle. Even though only 0.1% of all privately-held firms ever received venture capital funding (Puri and Zarutskie 2012), in our sample VC/PE-backed firms account for over 36% of all IPOs over the period 1980-2018.[6] Finally, we are also able to analyze the entry rates of the private firms into the public markets through an acquisition by a public firm rather than through an IPO. Therefore, we focus on the number of VC/PE-backed companies as our baseline count of private firms in the U.S. By no means, this measure captures all potential entrants in the public equity markets.

To construct the number of VC/PE-backed companies, we rely on the firms' founding dates reported by the VenturExpert. For the firms with no reported founding date, we assign the date of the first financing round as the birth date (around 30% of all firms in our analysis sample). We track firms from their entry year to the year of their first exit event or until 2018 when our sample ends. A private firm can exit either by going public, being acquired by another firm, or failing. The VenturExpert does not provide a comprehensive data on the firms' exit dates. We merge the CRSP dataset with the VenturExpert using name and address matching to identify the IPO dates for the VC/PE-backed firms. Appendix A.1 contains a detailed description of how we match the two databases. Further, we merge the Thomson Reuters SDC Platinum Mergers and Acquisitions database to the VenturExpert using the deal numbers. This merge allows us to identify firms exiting private markets via an acquisition (i.e., acquisition targets) along with their exit dates.[7] For firms without a successful exit – either via an IPO or acquisition, we impute failure dates based on the last round of financing: if a firm has not raised any financing for five years since its last round, we classify it as being shut down. This assumption is on the conservative side, since an average gap between the two consecutive financing rounds for a VC/PE-financed is less than 2 years. For robustness, we show that changing the failure date to 3,4,6, or 7 years from the last financing round does not produce a large quantitative impact on our results.

To corroborate our benchmark empirical findings, we also consider alternative measures

[6] This number is comparable to the numbers documented by Ritter (2017).

[7] Since SDC Platinum M&A database has a greater coverage of larger acquisitions and acquisitions by public acquirers, an exit event for some firms could be missclassified (see e.g., Puri and Zarutskie (2012)).

of the number of private firms. Specifically, we use business tax statistics prepared by the Internal Revenue Services (IRS). The IRS provides balance sheet, income statement, and other selected financial data for all active corporations filing Form 1120 from 1964 until 2015. The data are available at the aggregate level and for the subsets of firms classified by the size of business receipts and total assets. To better capture a set of potential public market entrants, we restrict our attention to sufficiently large private firms, since these are the firms with the resources necessary to go public and maintain a public listing. In particular, we focus on firms with total assets above \$50m and \$100m, and with revenues above \$50m.

The key downside of measuring the number of private firms using the IRS data is that corporations are classified into size groups based on nominal rather than real cutoff values for business receipts and total assets, making it difficult to compare private firms' counts and characteristics across years. For instance, we can observe the growth in the number firms with the nominal total assets above \$50m, even if the number of large firms with the revenues above the corresponding real cutoff values remains constant. Such growth would be purely driven by inflation, rather than by growth of large businesses. To address these inflation concerns, we also construct the number of firms with the real total assets above \$50m by linearly extrapolating the data within each size bucket.

Finally, we complement our analysis with firm counts from the U.S. Census Bureau based on the number of employees. Specifically, we focus on firms with more than 500 employees. Importantly, these counts are not subject to inflation issues.

In addition to firms' financial data, we also use data on CPI inflation from the Bureau of Labor Statistics. The price level is normalized to 1 in December of 2009. All nominal quantities are deflated by the CPI to obtain real measures.

Propensity to go public. In this section, we revisit the evolution of U.S. public listings over the past few decades. Figure 1 shows that the number of public firms has increased rather steadily from 1980 until 1996 and then decreased almost twofold since 1996. In their paper, Doidge et al. (2017) document that this dramatic decline is unique to the United

States and has not arisen in the rest of the world, constituting the so-called U.S. listing gap. We also find that this pattern is present for publicly listed firms that have received VE/PE financing. Specifically, the number of VC/PE-backed firms drops on average by 35% between the periods 1994–1998 and 2011–2015 (see Table 1).

Admittedly, the size of the public market as measured with the aggregate market value of public firms has not shrank over our sample period. It has increased dramatically from $10 trillion in 1980 to $25 trillion in 1999, thereafter experiencing two large drops during the dot-com crash and the recent financial crises. Nonetheless, the size of the public market remains significantly larger in the post-1996 period as compared to the pre-1996 period. This is in line with the evidence that mostly small public firms have been disappearing in the recent two decades.

We further investigate whether this decline is specific to publicly listed firms or applies to private ones as well. To this end, we construct the firm propensity to go public over time, defined as the ratio of the number of public firms to the number of private firms. Note that if the decrease in the number of public firms coincides with a corresponding decrease in the number of private firms, this ratio would remain constant. Instead, Panel B of Figure 1 displays substantial growth in the number of VC/PE-backed private firms over the period from 1980 until 2018. This finding is further supported by Figure 2 which shows that both the number of new private firms receiving financing from VC/PE funds and the amount of received capital are trending upwards over the sample period. The steady increase in the number of private firms rules out the possibility that the decrease in the number of public firms is the product of a widespread downwards trend in the number of potential public market entrants. Accordingly, due to the number of public and private firms moving in opposite directions, we observe a steady decline in the firm's propensity to go public (see Panel C of Figure 1). The trend is quite similar regardless of whether we consider the set of all publicly traded firms or restrict attention only to VC/PE-backed public firms.

For robustness, we consider alternative measures of the number of private firms: the number of private firms with more than 500 employees, the number of private S&C-corporations

with with total assets above $50m and $100m, and with revenues above $50m. Moreover, we recalculate the number of VC/PE-financed firms when the failure date is set to 3,4,6, and 7 years from the last financing round if a firm has not exited earlier via an IPO or acquisition. We again find a downward trend in the firm's propensity to go public over the period of interest (see Appendix Figure B.1 and Table B.1). Across all measures, the firm's propensity to go public has decreased by 50-70% over the period from 1996 until 2015.

The decline in the number of public listing in the U.S. may have resulted either from a decline in the IPO rate or from an increase in the exit rate. Figure 3 plots the number of IPOs and IPO rate over time. The latter is calculated as the ratio of the number of IPOs to the number of private firms. The IPO rate declines from about 6% in 1996 to 1% in 2018, indicating that the decline in the number of public firms can be to a great extent explained by the decline in the IPO rate. Again, we find that this pattern also holds for a subset of VC/PE-backed private firms choosing to go public.

An alternative driving force of the U.S. listing gap could be an increased number of exits among public firms. Panel A of Figure 4 depicts the number of public firms that have delisted from a stock exchange either volutarily or involuntarily. As can be seen from the figure, the number of exits has been fluctuating between 200 and 500 firms per year in the pre-1996 period. However, it has increased dramatically thereafter, reaching its peak of 875 in 1998 and then reverting back to near the pre-1996 values. This large increase in firm exits in the late '90s and early '00s has contributed to the decline in the number of public listings. At the same time, historically low number of exits since 2002 cannot solely explain a further drop in the propensity to go public. We also plot the number of exits scaled by the total number of public firms, i.e. the exit rate (see Panel B of Figure 4). The dynamics of the exit rate follow very closely the dynamics of the raw number of firm exits. If we focus only on VC/PE-backed firms we find quite similar dynamics over time, though the exit rate is relatively higher in the latter period as compared to the pre-1996 period.

We further examine the delisted firms by decomposing the exit rate depending on a reason for the exit. First, we examine delists for "negative" reasons (e.g. company liquidation or bankruptcy), defined as securities with delisting codes $4xx$ and $5xx$ (excluding "gone private" exits with the delisting code 573). Panel D demonstrates that the exit rate for "negative" delists has been fluctuating mostly between 2% and 5% both for all public firms and for VC/PE-backed firms, without exhibiting any secular trends. Second, we examine exits through mergers and acquisitions, defined as securities with delisting codes $2xx$ and $3xx$. Panel F demonstrates that the exit rate for mergers and acquisitions fluctuates between 2% and 6%, with sharp increase in the early '90s until 2000, dip in 2001, and end value around the 1996 rate. Again, for VC/PE-backed firms the exit rate is slightly higher in the recent years as compared to the 1996 level.

We also analyze how frequently public firms re-exit the private markets. The CRSP records such exit events with the delisting code 573. Panel A of Appendix Figure B.2 shows that the number of such exits is negligible. Alternatively, a public firm can go private via an acquisition by a private firm, in which case the delisting code is either $2xx$ or $3xx$. To identify public firms re-exiting the private markets, we merge the SDC Platinum M&A database to the CRSP and count the number of deals with a public target and non-public acquirer.[8] More details on the merge are provided in Appendix A.2. Panel C of Appendix Figure B.2 demonstrates that the number of public firms going private via an acquisition fluctuates between 50 and 150, with a large spike before the dot-com bubble. In order to preserve model tractability, we do not incorporate that a firm has an option to go back private after conducting an IPO.

Size distribution of public firms. Over our sample period, there has been a significant shift in the distribution of publicly listed U.S. firms. We find that over the last few decades the typical public firm has become larger. As shown in Figure 5, the average size of public firms as measured with the market firm value has increased more than twofold from about \$3b in 1996 to \$8b in 2018. We document similar secular trends when calculating the median firm size or when measuring the firm size with total book assets, market equity value, revenues, earnings, age, or number of employees (see Appendix Figures B.8, B.9 and

[8] We classify a firm to be *public* if it satisfies the criteria in Doidge et al. (2017) in at least one year between its IPO date (or the first trading date) and exit date.

Table B.3). Again, our findings continue to hold for a subset of VC/PE-financed public firms.

Figure 6 further supports that the right tail of the public firm size distribution has increased in mass in the recent two decades. The Figure depicts the power law exponent γ, which is given by the solution to the equation $Pr\,(size > X) = kX^{-\gamma}$ for some constant k. When measuring the size with total book assets, the estimates of the power law exponent coefficient fluctuate around 1.2-1.3 from 1980 till 1990, sharply decline to 1 thereafter, and only increase to 1.1 from 2010 onward. The secular trend in the power law coefficient is qualitatively similar if we measure the firm's size with revenues, though the sharp drop in the coefficient occurs only in mid 2000s.

Firm characteristics at IPO. Not only does the typical public firm becomes larger in the recent years, but so does the typical firm that goes public. As shown in Panel A of Figure 7, firm size at IPO year increases almost threefold from prior to the decline in public firms to the end of the sample. This finding continues to hold if we measure the firm's size with total book assets, market equity value, revenues, earnings, age, or number of employees (see Appendix Figure B.10, B.11 and Table B.3). We find very similar dynamic of the firm's size at IPO year for firms receiving funding from VC/PE funds.

A larger size threshold needed to IPO could be indicative of a lower net benefit of going public, but likely not if the underlying reason is a shift to the right in the firm size distribution. As such, we investigate by how much firm size at IPO year has changed relative to other public firms. Specifically, we identify the percentile of median firm size at IPO year within the distribution of public firms. As shown in Panel A of Figure 8, both in in the beginning and end of the sample firms conducting IPOs are larger than 30-40% of public firms, with the exception of late '90s when this ratio increases to 60%. We find similar patterns when measuring firm size using firms' market value and total book assets. This behavior suggests that the firms conducting IPOs are not larger relative to existing public firms.

Changes around IPO. Next, we explore changes in firms' characteristics such as capital stock and profitability around the IPO date. To measure changes in each variable of interest, we follow the approach in Davis, Haltiwanger, and Schuh (1996) and compute the growth rates using the following formula:

$$\Delta x_{j,t} = \frac{x_{j,t+1} - x_{j,t-1}}{0.5(|x_{j,t+1}| + |x_{j,t-1}|)},$$

where t is the year of an IPO. The growth rates are between the post- and pre-IPO values of x. This approach allows us to mitigate the effect of outliers, as well as account for possible negative values of x.

First, we examine the changes in firms' capital stock, which is measured with net property, plant, and equipment (*ppent*). We rely on the backfilled data from the Compustat when measuring firms' characteristics one year prior to an IPO. Panel A of Figure 9 demonstrates that firms' capital increases by $40\% - 80\%$ on average following an IPO. This finding is consistent with the existence of a positive premium on cost of capital for private firms over that for public firms. If the cost of capital decreases once a firm goes public, we would expect firms to increase their capital investment after an IPO. The figure also shows that there is a regime shift around 2000: the capital growth rate fluctuates around 70% in the early period of our sample and drops to approximately 50% in the late period of the sample. This drop over time suggests a decrease in the premium on cost of capital for private firms. If we focus on VC/PE-backed firms, we find very similar patterns over time, though the post IPO increase in capital is on average 5-10% higher as compared to all public firms.

Second, we examine changes in firms' profitability around the IPO date. We measure firms' profitability as a ratio of operating income before depreciation (*oibdp*) and total book assets (*at*). Similarly to Pástor, Taylor, and Veronesi (2008), we find that firms' profitability drops after an IPO. This finding is in line with firms operating decreasing returns to scale technology and scaling up their capital after going public. Further, we find that this drop in profitability disappears in the recent two decades (see Panel B of Figure 9). For VC/PE-financed firms, we find no drop in profitability around the IPO date in the early period of sample and an increase in the late period of the sample.

3 Model

In this section we describe the model setup and derive valuations for private and public firms. We then characterize the distributions of public and private firms and the stationary equilibrium.

Time is continuous and the horizon is infinite. The economy is populated with a continuum of firms, consisting of two types: public and private. All firms initially enter as private and can subsequently choose to become public by paying a fixed cost. We focus on two main features that drive the decision to go public. First, we assume that public firms have a lower cost of capital than private firms. Investors in our model are risk-neutral but this difference in the discount rate can be thought of as an illiquidity premium for private firms. Second, there are operational costs associated with being publicly listed. We model these as consisting of both a one-time sunk cost, incurred at the time the firm decides to go public, as well as an ongoing fixed cost of operations. These costs are intended to capture the additional regulatory, disclosure, and compliance costs associated with being a publicly listed firm.

3.1 Firm cash flows

Firms produce using capital, k, which is rented and can be flexibly adjusted and are subject to idiosyncratic productivity shocks, x. All firms face a common corporate tax rate τ and a fixed operating cost c_f. Investors are risk-neutral and apply a premium, θ, to the discount rate for private firms. A private firm's after-tax profits are given by

$$\pi_{priv}(x;\theta) = \max_{k} \ (1-\tau)(xk^{\alpha} - \delta k - c_f) - (r+\theta)k, \tag{1}$$

A firm's productivity, x, evolves as

$$\frac{dx_t}{x_t} = \mu dt + \sigma dw_t - dJ_t, \tag{2}$$

where w_t is a standard Brownian motion and J_t is a Poisson process with arrival intensity λ. The optimal investment rule satisfies,

$$(1-\tau)(\alpha x k^{\alpha-1} - \delta) = r + \theta \tag{3}$$

which gives

$$k^*_{priv}(x;\theta) = \left(\frac{\alpha x}{\frac{r+\theta}{1-\tau}+\delta}\right)^{\frac{1}{1-\alpha}}. \tag{4}$$

Plugging this back in, we can write after-tax private firm profits as

$$\pi_{priv}(x) = (1-\tau)(\mathcal{A}_{priv}(\theta)x^{\frac{1}{1-\alpha}} - c_f), \tag{5}$$

where

$$\mathcal{A}_{priv}(\theta) = (1-\alpha)\left(\frac{\alpha}{\frac{r+\theta}{1-\tau}+\delta}\right)^{\frac{\alpha}{1-\alpha}}. \tag{6}$$

Given the presence of the fixed operating cost, c_f, a private firm will choose to optimally shut down when productivity falls to a sufficiently low value. We assume a zero recovery rate in the event of exit. We will use T_{Dpriv}, to denote the private firm's optimal stopping time that it chooses to shut down. This optimal stopping decision can be expressed a lower threshold on the private firm productivity, which we will denote by $x_{D,priv}$.

A private firm can also decide to undertake an IPO to become a public firm. To become public, a firm must pay a one-time cost of $\mathcal{I}_{IPO}$. The benefit to becoming public is that a firm faces a lower cost of capital. Specifically, public firms avoid the illiquidity premium, θ, that investors apply to private firms. However, public firms are also subject to additional costs, both in the form of a one-time fixed cost at the time of IPO, $\mathcal{I}_{IPO}$, as well as an ongoing flow cost, $\mathcal{C}_{pub}$.

Public firm cash flows are similar to those of private firms, however public firms face a lower opportunity cost of capital (r instead of $r+\theta$) and an additional cost to being public, C_{pub}. Public firm after-tax profits are given by

$$\pi_{pub}(x) = \max_k \ (1-\tau)(xk^\alpha - \delta k - c_f) - rk - \mathcal{C}_{pub}. \tag{7}$$

Public firms' optimal capital choice is

$$k^*_{pub}(x) = \left(\frac{\alpha x}{\frac{r}{1-\tau}+\delta}\right)^{\frac{1}{1-\alpha}} \tag{8}$$

Plugging in, we can write public firm profits as

$$\pi_{pub} = (1-\tau)\left(\mathcal{A}_{pub}x^{\frac{1}{1-\alpha}} - c_f - \frac{\mathcal{C}_{pub}}{1-\tau}\right), \tag{9}$$

where

$$\mathcal{A}_{pub} = (1-\alpha)\left(\frac{\alpha}{\frac{r}{1-\tau}+\delta}\right)^{\frac{\alpha}{1-\alpha}}. \tag{10}$$

3.2 Firm valuation

The private firm's problem amounts to choosing capital, k, a stopping time for exit, T_{Dpriv}, and a stopping time for the IPO, T_{IPO}. For a private firm with current productivity, x, its value can be expressed as

$$\begin{aligned} v_{priv}(x;\theta) = \sup_{\{k_t\}_{t\geq 0}, T_{Dpriv}, T_{IPO}} \mathbb{E} \int_0^{T_{Dpriv}\wedge T_{IPO}} e^{-(r+\lambda+\theta)t}\pi_{priv}(x_t;\theta)dt \\ + e^{-(r+\lambda+\theta)T_{IPO}}\mathbb{1}_{[T_{IPO}<T_{Dpriv}]}\Big(v_{pub}(x_{T_{IPO}}) - \mathcal{I}_{IPO}\Big), \end{aligned} \tag{11}$$

where $T_{Dpriv} \wedge T_{IPO} \equiv \inf\{T_{Dpriv}, T_{IPO}\}$. The first integral reflects the present discounted value of the private firm's cash flows until the time that it chooses to exit (T_{Dpriv}) or go public (T_{IPO}). In the event of exit, the firm receives a zero payoff. The second term reflects the payoff at IPO.

The public firm's problem is to choose optimal capital, k, and a stopping time, T_{Dpub}, at which it optimally shuts down. In the event of shut down, we assume that a public firm receives a final payoff of zero. The public firm chooses capital, k, and a stopping time at which it optimally exits, T_{Dpub}. A public firm's value, for a given level of current productivity x, is given by

$$v_{pub}(x) = \sup_{\{k_t\}_{t\geq 0}, T_{Dpub}} \mathbb{E} \int_0^{T_{Dpub}} e^{-(r+\lambda)t}\pi_{pub}(x_t)dt \tag{12}$$

The public firm value is the expected discounted value of the future after-tax cash flows until the time of exit, which occurs either because the firm's productivity falls sufficiently low or because the firm is hit with an obsolescence shock.

Proposition 1. *Define* $b \equiv \frac{1}{1-\alpha}$ *and assume*

$$r + \lambda - \mu b - \frac{\sigma^2}{2} b(b-1) > 0.$$

The value of a private firm with current productivity x *is given by*

$$v_{priv}(x;\theta) = A_1 x^{\gamma_1} + A_2 x^{\gamma_2} + (1-\tau)\left(\frac{\mathcal{A}_{priv}(\theta)x^b}{r+\theta+\lambda-\mu b - \frac{\sigma^2}{2}b(b-1)} - \frac{c_f}{r+\theta+\lambda}\right), \tag{13}$$

where the coefficients A_1 *and* A_2 *are solved for by imposing the boundary conditions and* $\mathcal{A}_{priv}$ *is defined in Equation* (6)*. The value of a public firm value is given by*

$$v_{pub}(x) = B_2 x^{\xi_2} + (1-\tau)\left(\frac{\mathcal{A}_{pub}x^b}{r+\lambda-\mu b - \frac{\sigma^2}{2}b(b-1)} - \frac{c_f}{r+\lambda} - \frac{C_{pub}}{(1-\tau)(r+\lambda)}\right), \tag{14}$$

where the B_2 *coefficient is solved for by imposing the boundary conditions and* $\mathcal{A}_{pub}$ *is defined in Equation* (10)*.*

3.3 Private firm entry

There is an exogenous flow M of new entrepreneurs that draw a startup cost c_e from the cumulative distribution function $F(c_e)$. We assume this entry cost is lognormally distributed:

$$\log(c_e) \sim \mathcal{N}\left(\log(\bar{c}_e) - \frac{1}{2}\sigma_{ce}^2,\ \ \sigma_{ce}^2\right). \tag{15}$$

As noted in Gourio and Roys (2014), the variance of the entry cost, σ_{ce}^2, parameterizes the inverse elasticity of the supply of private entrants. Having observed their drawn entry cost, c_e, an entrepreneur can then choose whether to pay this cost and begin operating as a private firm. Otherwise, the entrepreneur simply exits at zero cost. We assume the entry decision must be made immediately and cannot be delayed. The initial productivity at entry, x_0, is drawn from a uniform distribution with support over the interval $[x_A, x_B]$. Given θ, a firm will choose to enter if their expected value upon entering is greater than or equal to the startup cost drawn:

$$\int_{x_A}^{x_B} \frac{v_{priv}(x;\theta)}{x_B - x_A} dx \geq c_e. \tag{16}$$

Let $c_e^*(\theta)$ denote the maximum drawn entry cost such that an entrepreneur would pay the cost and enter. That is, $c_e^*(\theta)$ is such that Equation (16) holds with equality. The endogenous flow of new private firms entering, $N(\theta)$, is given by

$$N(\theta) = F(c_e^*(\theta))M, \tag{17}$$

In what follows, we will write the flow of new private entering firms simply as N, suppressing the dependence on θ. For a given level of productivity x, the value of a private firm is decreasing in θ. Intuitively, for a higher level of θ, a private firm's future cash flows are subject to a higher discount rate and therefore have a lower valuation. Thus, $c_e^*(\theta)$ and the flow of new private firms, N, are both decreasing in θ.

3.4 Distribution of private firms

We now characterize the stationary distribution of private firms. In the stationary equilibrium, the masses and aggregate variables for public and private firms are constant, though individual firms enter, exit, and experience heterogeneous productivity shocks.

Private firms choose to optimally shut down when the productivity falls to $x_{D,priv}$ and optimally choose to go public when productivity reaches $\overline{x}_{IPO}$. As a result, the distribution of private firm productivity, x, has support over the interval $(x_{D,priv}, \overline{x}_{IPO})$. There is an endogenous flow N of new private firms that enter with productivity uniformly distributed over the interval $[x_A, x_B]$. Private firms exit the distribution for one of three reasons: they reach the optimal exit threshold $x_{D,priv}$, the IPO threshold $\overline{x}_{IPO}$, or are hit with an exogenous death shock. In the stationary distribution, the total entry and exit flows are equal.

We divide the private firm distribution into three regions: $(x_{D,priv}, x_A), [x_A, x_B], (x_B, \overline{x}_{IPO})$. In the first and third region, there is no firm entry, while in the middle region there is a flow N of new private firm entrants.

Proposition 2. *The stationary distribution of private firm productivity is* $N \times \varphi(x)$*, where*

N is defined in Equation (17) *and*

$$\varphi(x) = \begin{cases} C_1 x^{\beta_1 - 1} + C_2 x^{\beta_2 - 1}, & \text{if } x_{D,priv} < x < x_A \\ D_1 x^{\beta_1 - 1} + D_2 x^{\beta_2 - 1} + \frac{1}{(x_B - x_A)(\lambda + \mu - \sigma^2)}, & \text{if } x_A \leq x \leq x_B \\ H_1 x^{\beta_1 - 1} + H_2 x^{\beta_2 - 1}, & \text{if } x_B < x < \overline{x}_{IPO}. \end{cases} \tag{18}$$

The coefficients $C_1, C_2, D_1, D_2, H_1, H_2$ are solved by imposing boundary conditions and where

$$\beta_1 = \frac{\mu}{\sigma^2} - \frac{1}{2} + \frac{\sqrt{2\lambda\sigma^2 + (\mu - \sigma^2/2)^2}}{\sigma^2}, \qquad \beta_2 = \frac{\mu}{\sigma^2} - \frac{1}{2} - \frac{\sqrt{2\lambda\sigma^2 + (\mu - \sigma^2/2)^2}}{\sigma^2}. \tag{19}$$

3.5 Distribution of public firms

Given the distribution of private firms, we can determine the flow of IPOs, which will effectively act as a scaling factor on the public firm distribution. Let Υ_{IPO} denote the steady state flow of IPOs. Given the distribution of private firms, the flow rate of IPOs can be computed as

$$\Upsilon_{IPO} = -\frac{1}{2}\sigma^2 N\Big(\beta_1 H_1 \overline{x}_{IPO}^{\beta_1} + \beta_2 H_2 \overline{x}_{IPO}^{\beta_2}\Big). \tag{20}$$

In steady state, there is a flow Υ_{IPO} of firms becoming public, each entering the public firm distribution with productivity $\overline{x}_{IPO}$. Upon becoming public, the firm's cash flows then evolve according to the previously specified cash flow dynamics for a public firm. Public firms exit for two reasons: they optimally shut down when their cash flows drop to $x_{D,pub}$ or they are hit by an obsolescence shock. Thus, the distribution of public firms has support $(x_{D,pub}, \infty)$. We divide the support into two regions: $(x_{D,pub}, \overline{x}_{IPO})$ and $[\overline{x}_{IPO}, \infty)$.

Proposition 3. *Assume $\lambda + \mu - \sigma^2 > 0$ and $\zeta_2 + \frac{}{1-\alpha} > 0$. Then the distribution of public firm productivity is given by $\Upsilon_{IPO} \times \Psi(x)$, where*

$$\Psi(x) = \begin{cases} J_1 x^{\zeta_1 - 1} + J_2 x^{\zeta_2 - 1}, & \text{if } x_{D,pub} < x < \overline{x}_{IPO} \\ K_2 x^{\zeta_2 - 1}, & \text{if } x \geq \overline{x}_{IPO}. \end{cases} \tag{21}$$

The coefficients J_1, J_2, K_2 are solved by imposing the boundary conditions and

$$\zeta_1 = \frac{\mu}{\sigma^2} - \frac{1}{2} + \frac{\sqrt{2\lambda\sigma^2 + (\mu - \sigma^2/2)^2}}{\sigma^2}, \qquad \zeta_2 = \frac{\mu}{\sigma^2} - \frac{1}{2} - \frac{\sqrt{2\lambda\sigma^2 + (\mu - \sigma^2/2)^2}}{\sigma^2}. \tag{22}$$

Figure 10 displays the stationary distributions of private (blue line) and public (red line) firm productivity. Equation (21) shows that the right tail of public firm productivity exhibits a power law.

3.6 Private capital market

We assume that there is a perfectly elastic supply of private capital, which has an illiquidity premium θ relative to public firm capital. For a given θ, the aggregate private capital is given by

$$K_{priv} = N \int_{x_{D,priv}}^{\overline{x}_{IPO}} k^*_{priv}(x;\theta)\varphi(x)dx. \tag{23}$$

In Figure 11, we plot the supply and demand curves for private firm capital. The solid red and blue lines show the supply and demand curves, respectively, for private capital. The dashed red line represents a case of a reduction in θ, which leads to a larger quantity of aggregate private capital in equilibrium. The blue dashed line represents an increase in the demand for private capital, resulting from an increase in the costs to public firms ($\mathcal{I}_{IPO}$ or C_{pub}).

4 Model mechanisms

In this section we illustrate the effects of three different changes in model parameters: the cost of being public (C_{pub}), the IPO cost ($\mathcal{I}_{IPO}$), and the premium on private firm financing (θ).

4.1 Costs of being public ($\mathcal{C}_{pub}$)

In Figure 12 we show comparative statics for the effect of a change in C_{pub}, a public firm's ongoing operating costs. From Equation (8) we see that C_{pub} does not affect a public firm's optimal investment decision. An increase in C_{pub} does reduce public firm profits and value for a given level of productivity, x. This reduction in value makes it less attractive to be public firm, which increases $\overline{x}_{IPO}$, the productivity threshold at which a private firm decides to go public. It also has the effect of increasing $x_{D,pub}$, the threshold at which a public firm optimally chooses to shut down. These increases effectively shift the public firm distribution to the right. Similarly, the profits and value of a firm at IPO are larger for higher levels of the cost of being public. Due to this selection effect, the average productivity, capital, and market value of public firms actually increase with an increase in C_{pub}. The increase in public firm operating costs reduces the average profitability among public firms. While this is somewhat offset by the increase in average public firm size, which has a positive effect on average profitability, the net effect is that a higher C_{pub} results in a lower average public firm profitability.

An increase in the operating costs for public firms also impacts the private firm distribution. The increase in the IPO threshold, $\overline{x}_{IPO}$, results in private firms delaying their IPO and becoming larger. That is, it extends the right tail of the private firm distribution and reduces the frequency of IPOs. Effectively, an increase in C_{pub} produces an outward shift in the demand for private firm capital. This increases the aggregate private capital in equilibrium. The higher premium on private capital results in private firms choosing to shut down sooner. That is, the minimum private productivity, $x_{D,priv}$, increases.

The increase in C_{pub} also results in less private firm entry. The value of a private firm incorporates the option to become a public firm, as shown in the private firm's problem in Equation (11). Thus, the reduction in the value to being public also reduces a private firm's value. For a potential entrant, this makes the value of entering lower, all else equal.

4.2 Cost of IPO ($\mathcal{I}_{IPO}$)

In Figure 13, we show the effects of changes in the IPO cost, $\mathcal{I}_{IPO}$. An increase in $\mathcal{I}_{IPO}$ makes it more costly for a firm to become public, however this cost is sunk once a firm is public and therefore has no effect on a public firm's ongoing operations. That is, $\mathcal{I}_{IPO}$ doesn't change a public firm's profits, value, or investment, for a given level of productivity x. It also has no effect on the threshold at which a public firm exits. However, an increase in the IPO cost will push up the threshold for the going public decision, $\overline{x}_{IPO}$, which reduces the frequency of IPOs. Additionally, the higher IPO threshold results in a selection effect that impacts the distribution of public firms. With the higher IPO threshold, firms are larger at the time of their IPO. This results in a larger average firm size and a higher average profitability among public firms.

An increase in the cost of becoming public also impacts the distribution of private firms. Firms stay private longer and this extends the right tail of the private firm distribution, increasing the demand for private firm capital.

4.3 Private cost of capital premium (θ)

In Figure 14, we show the effects of a change in the premium on private capital, θ. A decrease in θ increases the aggregate private capital in equilibrium. With a lower θ, the optimal abandonment threshold for private firms, $x_{D,priv}$ decreases, resulting in a longer left tail of the private firm distribution. Firms also optimally choose to stay private longer, corresponding to a higher IPO threshold $\overline{x}_{IPO}$. This increase in the IPO threshold has the effect of reducing the number of IPOs and public firms. However, the lower θ also incentivizes more entry by private firms, creating a greater pool of private firms that could potentially go public. The higher flow of private entrants, N, scales up the number of private firms, number of IPOs, and number of public firms. The net effect of a decline in θ on the number of public firms depends on the relative elasticities of the private entry and IPO flows with respect to the private capital illiquidity premium θ. Given our parameterization, the net effect is that a decrease in θ results in a decrease in the number of public firms and IPOs, as shown in Figure 14.

A reduction in the private capital premium θ also has the effect of increasing the average size, productivity, and profitability of both incumbent public firms and firms at the time of their IPO. However, θ has no effect on an existing public firm's decision to shut down and so in effect this increases the dispersion in the productivity of public firms.

5 Quantitative results

To quantify the effect of changes in the premium on private capital and costs of becoming and remaining public, we calibrate the model separately to match moments from the early period (1980–1998) and late period (2001–2015) of our sample. We use the model to infer the extent to which an increase in the cost being public (C_{pub}), an increase in the cost of an IPO ($\mathcal{I}_{IPO}$), or a decrease in the premium on private capital (θ), can explain the changes observed in the data.

In Table 2, we list the model parameters and their values under our baseline setting. We set $\alpha = 0.5$, which is consistent with the estimates of Caballero and Engel (1999), as discussed by Miao (2005). We set $\mu = 0.0048$ and $\sigma = 0.1725$ to match the mean and volatility of the growth rate of public firm earnings. We set the public discount rate to $r = 0.05$, the depreciation rate $\delta = 0.1$ and tax rate $\tau = 0.3$, consistent with values used in the investment literature. We normalize the initial productivity of private entrants, x_0, to a value of one. The private firm fixed costs, c_f are set to a value of 0.5 to match the fraction of private firms that exit within 10 years of entry. In the version of the model where θ is an exogenous parameter, the average entry cost shock scales the total mass of firms and therefore can simply be normalized. The variance of the entry cost shock parameterizes the elasticity of entry and does influence how the entry flow N, responds to a change in model parameters. We calibrate this entry elasticity to match the elasticity of private firm entry on average Tobin's Q in public markets.

For the remaining four parameters— $\lambda, C_{pub}, \mathcal{I}_{IPO}, \theta$ — we allow these to differ between the early and late periods of our sample. We calibrate these parameters to match four moments in the data, separately for the two periods. Table 3 presents the moments targeted in the calibration as well as the parameter values for both the early and late periods. The first moment used is the slope of the Pareto tail of public firm assets. As shown in the model, the right tail of public firms in the model follows a power law and this slope coefficient depends on μ, σ, and λ. So we set λ to match the Pareto tail coefficient in the data. The ratio of public to private firms is informative about multiple model parameters, but we use this primarily to target the cost of being public, C_{pub}. The ratio of the IPO cost to the value at IPO is informative about the $\mathcal{I}_{IPO}$ parameter. In the data, we measure this IPO cost as the ratio of the cost of underwriting fees and underpricing relative to the firm's market value at IPO. Finally, we use the ratio of a firm's post-IPO capital to its pre-IPO capital. This ratio is informative about θ. For a larger θ, there is a larger reduction in a firm's cost of capital once it becomes public. This lower cost of capital corresponds to a larger optimal scale post-IPO relative to pre-IPO. Since the optimal capital choice does not depend on C_{pub} or $\mathcal{I}_{IPO}$, the change in firm size around IPO is informative about the private capital premium θ.

Panel B of Table 3 shows the calibrated parameter values for the early and late period. The model implies a decline in λ and increases in the costs of being public (C_{pub}) and IPO ($\mathcal{I}_{IPO}$). Finally, the model suggests a significant decrease in the premium on private capital, going from 2% in the early period to 1.2% in the late period.

Next, we examine changes in additional model moments between the early and late periods and compare these to the changes observed in the data. In Table 4 we compare moments from the model under the calibrated parameters of the early period to those of the late period, which were not explicitly targeted in the calibration. The third column of Table 4 shows the moment change in percentage terms from the model. We see that for many of these moments, the model does a good job of matching the empirical changes, although these were not directly targeted in the calibration. As in the data, the model generates a significant reduction in the number of public firms and IPOs but an increase in the average public firm size and size at IPO. Overall, the model does relatively well in matching these observables. Given the parameter changes reported in Panel B of Table 3, this suggests that a significant reduction in private firms' cost of capital, combined with increases in the costs of being public and the IPO can replicate many of the empirical changes seen for the public firm distribution over the last two decades.

6 Alternative Explanations

Composition Shift: A contributing factor for the decline in the number of public listings could be a composition change: there might have been a drop in the type of firms for which doing an initial public offering is beneficial. For example, some of the decline in public firms could be driven by a relative increase in the types of companies that require less financing at a large scale, such as those in the technology sector. To assess these compositional effects, we examine the trends in the number of publicly listed across major industries. Appendix Figure B.3 depicts the counts of both all publicly listed firms and VC/PE-financed firms for eight SIC industry divisions. Admittedly, we find very robust secular trends in the number of public firms — a steady increase from 1980 until 1996 followed and a dramatic decline thereafter — for the majority of industry divisions, including construction manufacturing, utilities, trade, finance, and services.

We further investigate whether the downward trend in the number of public listings is also germane for the high-technology industries. Following the study by Hecker (2005), we classify an industry to be high tech if the share of jobs in that industry that are held by STEM (Science, Technology, Engineering, and Mathematics) workers is at least twice as high as the average level for all industries. More details are provided in Appendix A.3. We document that both in high-technology and non high-technology industries the number of publicly listed has declined by more than 50% from 1996 until 2018 (see Appendix Figure B.4). This evidence suggest sthat the decline in the number of public firms is a widespread phenomenon and can not be attributed to a decline in the type of firms for which conducting an IPO is beneficial.

M&A Activity. Another potential driver behind the decline in the firm's propensity to go public is that in the recent years private firms have been entering the public markets by being acquired by publicly traded firms rather than by conducting an IPO themselves. To this end, we investigate the trends in the number of acquisitions with a public acquirer and non-public target using the SDC M&A database. Appendix A.2 provides more details on how we identify whether an acquirer/target is a public or non-public firm. We find that the number of private firms entering the public markets through an acquisition has dropped significantly starting from 1998, as shown Panel A of Appendix Figure B.6. This secular trend is robust to whether we consider deals which resulted in 100% ownership for an acquirer or deals with both U.S. public and non-public targets. Moreover, we continue to find a similar decline in the number of M&A deals when we restrict our attention to public acquirers which have been PE/VE-financed (see Panel B of Appendix Figure B.6). These findings lead us to conclude that the changes in the M&A activity are unlikely to drive the decline in the number of U.S. public listings.

We further investigate the exit rates across different cohorts of VC/PE-financed private firms classified by the year of their first round of financing. The exit state is measured ten years after the first financing round, i.e. if a firm received its first funding in 1996 we measure its exit as of 2006. We consider three exit types of interest: going public, being acquired by a public firm, and being acquired by a private firm. As shown in Appendix Figure B.7, the private firms' propensity to enter the public markets through an acquisition is quantitatively similar for 1996 and 2007 cohorts, while the private firms' propensity to IPO has steadily declined over time. Moreover, the combined entry rates of the private firms into the public market – through an IPO and an acquisition by a public firm – has declined from about 30% in 1996 to 17% in 2007, further suggesting the decline in the number of public firms in the U.S. cannot be explained by the increased M&A activity.

7 Conclusion

Since 1996, the number of publicly listed firms in the US has declined by 50%. There are currently as many publicly listed firms as there were 40 years ago. We collect a set of facts on the change in the distribution of public and private firms that relate to this decline in public listing. We then develop a model of a firm's choice to become public and use the model to evaluate the extent to which two prominent explanations — an increase in the costs of operating as a public company or a decrease in the cost of capital for private firms — can explain these changes observed over the last two decades.

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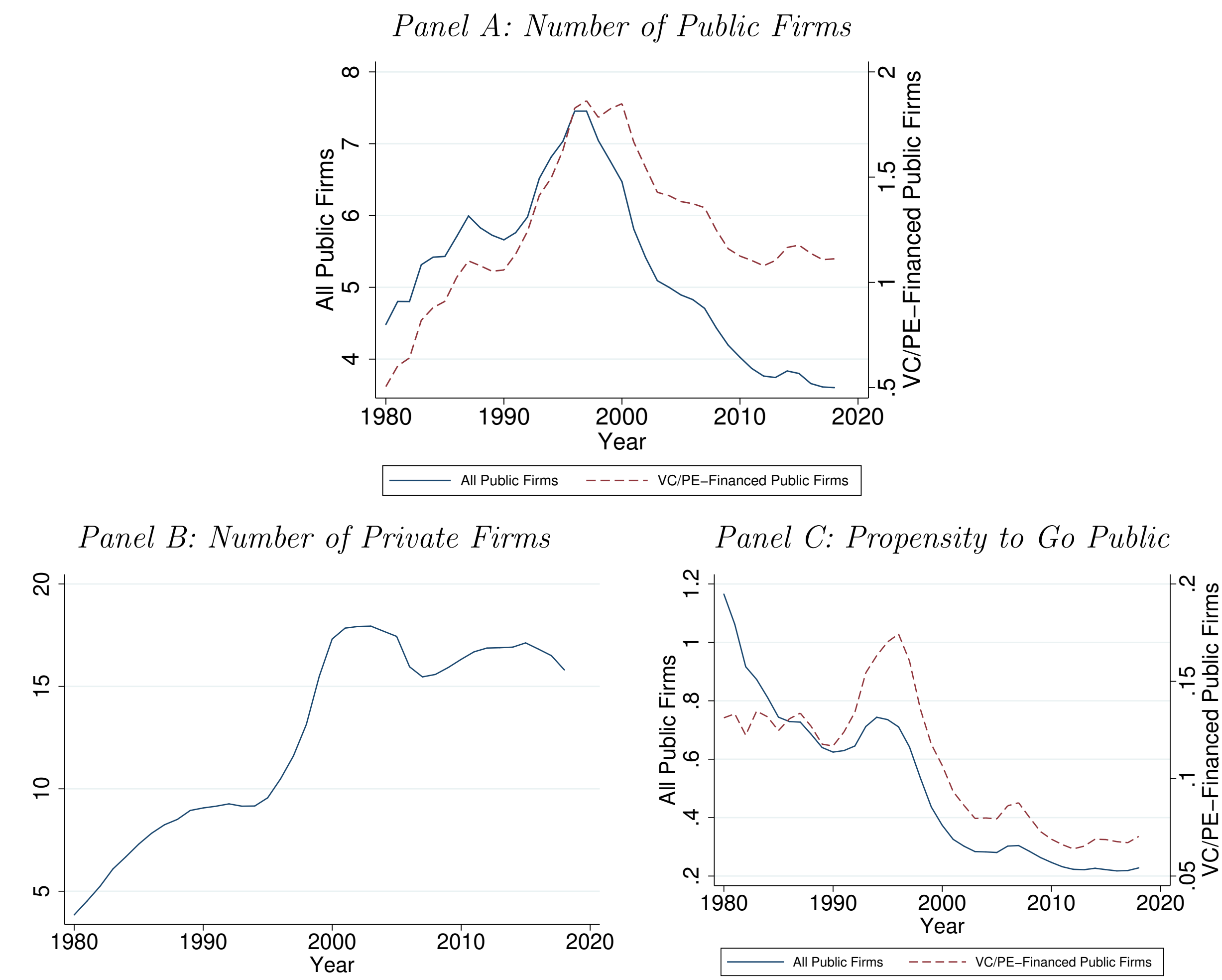


Fig. 1. Publicly Listed and Private Firms

Panel A shows the count of all publicly listed U.S. firms (solid blue line) and VC/PE-financed publicly listed firms (dashed red line). Panel B displays the number of VC/PE-financed private firms in the U.S. Panel C shows the ratio of the number of all publicly listed firms to the number of VC/PE-financed private firms (solid blue line) and the ratio of the number of VC/PE-financed publicly listed firms to the number of VC/PE-financed private firms (dashed red line). The data are annual observations from 1980 to 2018. The firm counts are expressed in thousands. The ratios are expressed in percentages.

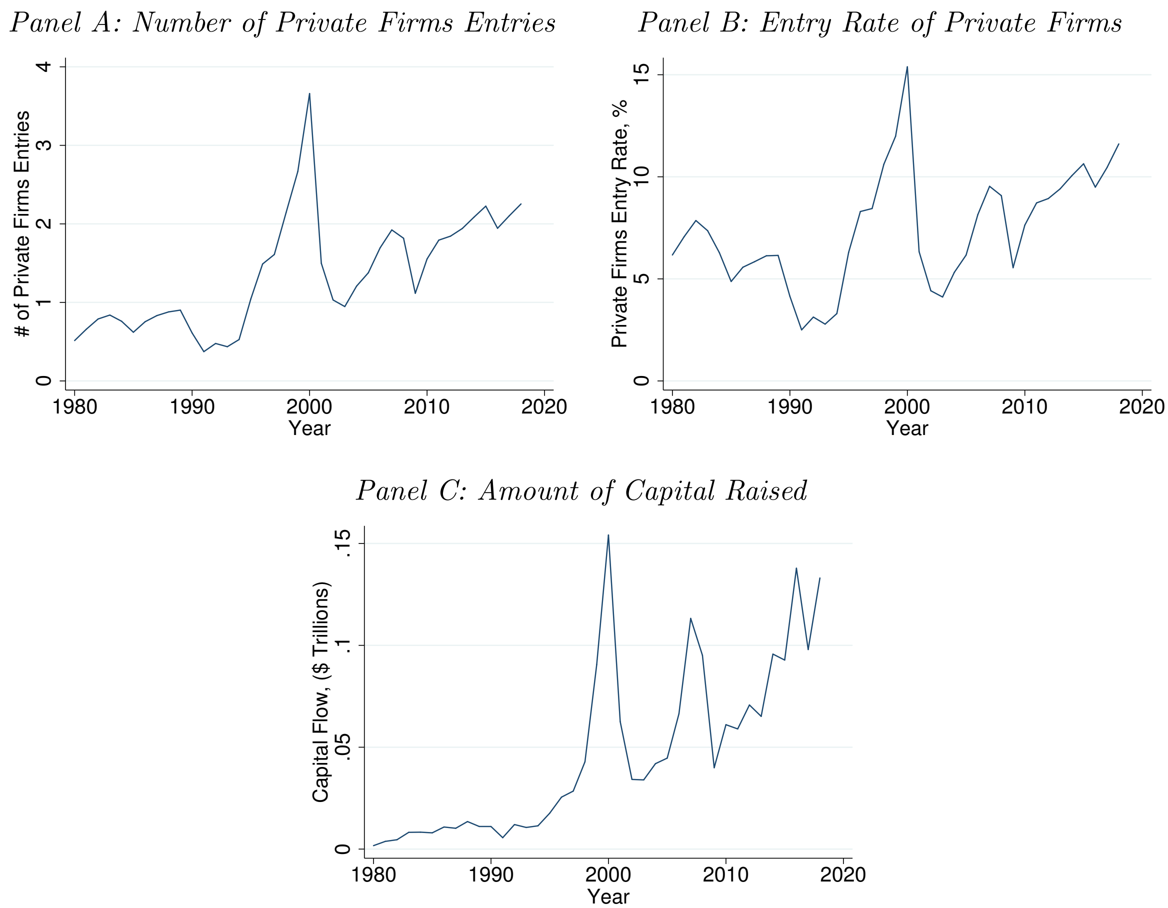
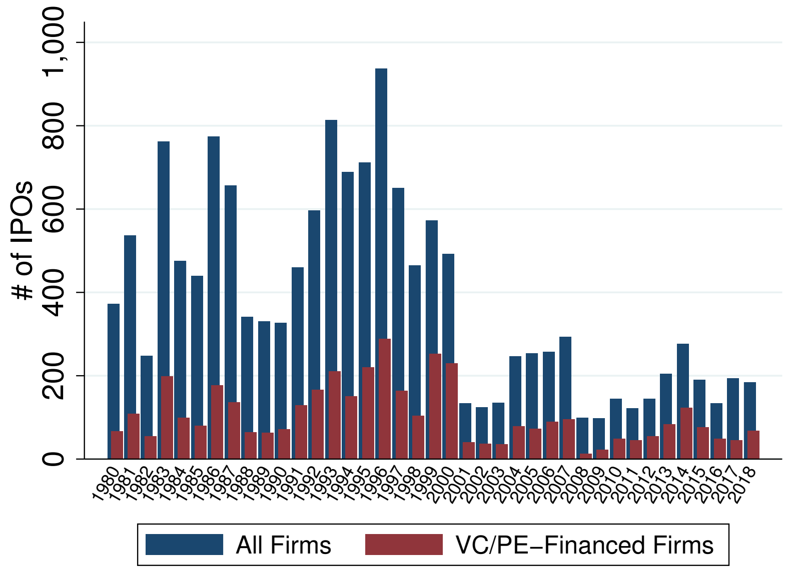


Fig. 2. Entry of Private Firms

Panel A shows the number of private firms receiving their first round of financing from VC/PE funds in each year. The firm counts are expressed in thousands. Panel B shows the the number of private firms receiving their first round of financing from VC/PE funds scaled by the number of VC/PE-financed private firms and all publicly listed firms in each year. The entry rate is expressed in percentages. Panel C shows the aggregate amount of capital received by private firms from VC/PE funds in each year. The data are annual observations from 1980 to 2018, and are expressed in trillions of dollars.

Panel A: Number of IPOs



Panel B: IPO Rate

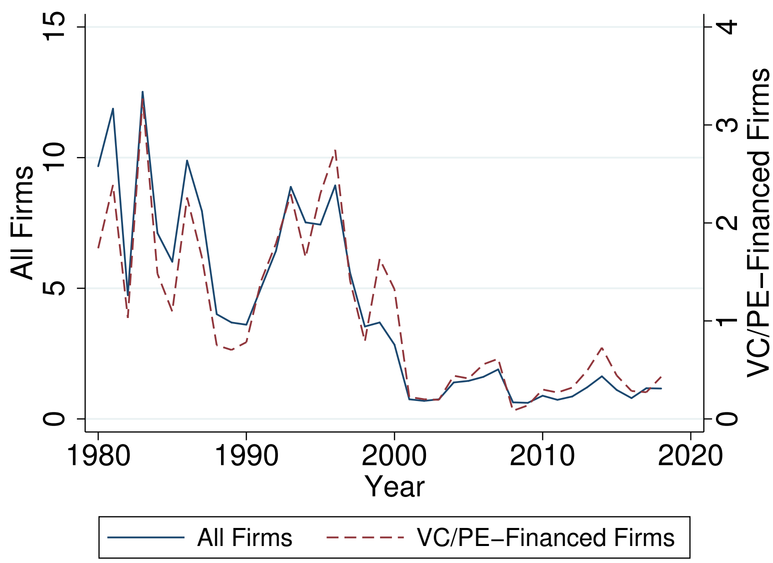


Fig. 3. Entry Rate of Public Firms

The Panel A shows the number of all IPOs (blue bars) and the number of IPOs among VC/PE-financed firms (red bars). Panel B shows the IPO rate, which is calculated as the ratio of the number of IPOs to the number of VC/PE financed private firms. The data are annual observations from 1980 to 2018. The IPO rates are expressed in percentages.

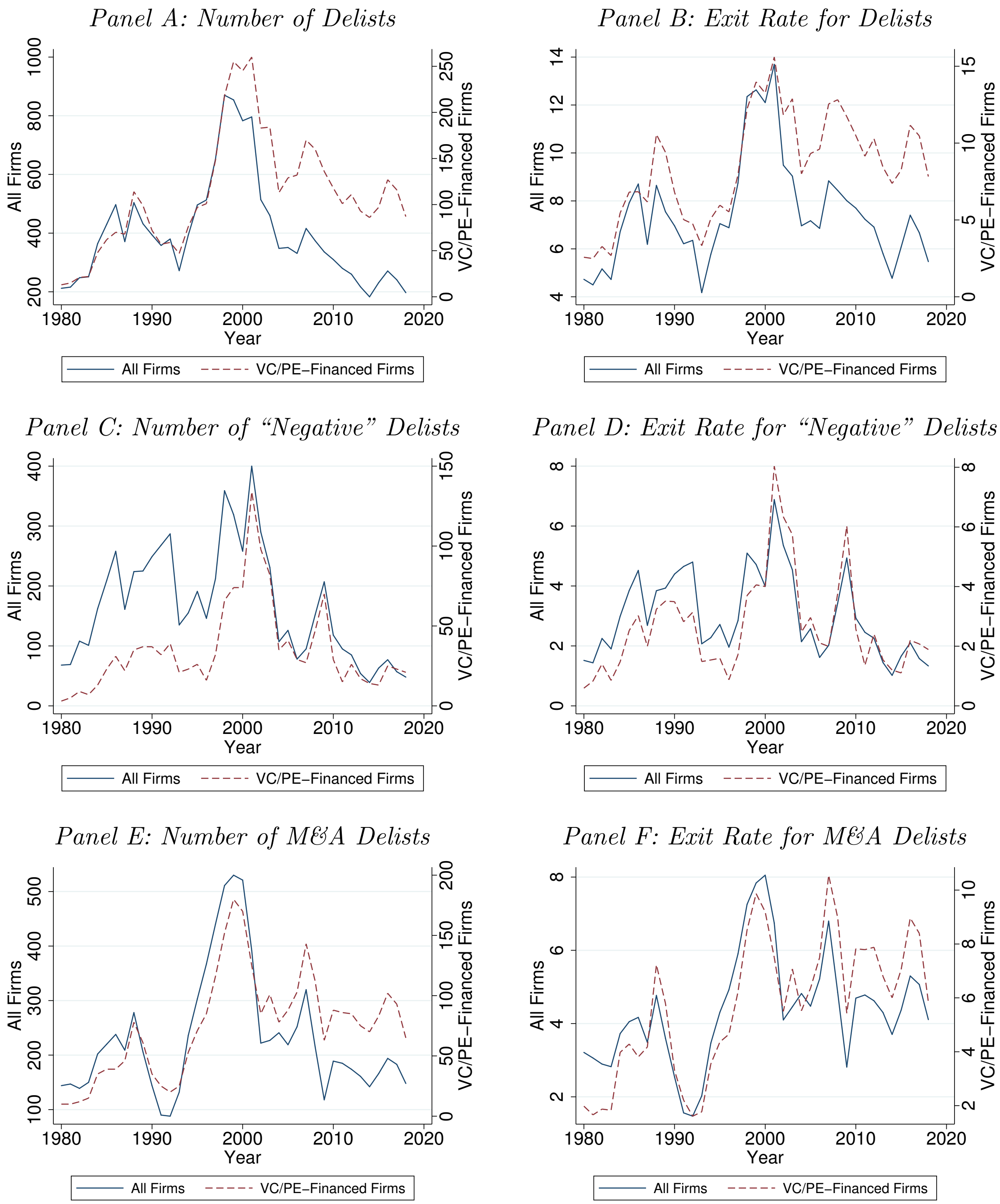


Fig. 4. Exit Rate of Public Firms

Panels A, C, and E show the number of exits among all public firms (solid blue line) and among VC/PE - financed public firms (red dashed line). Panels B, D, and F show the exit rate, defined as the ratio of firms exits to the number of publicly traded firms. Panels C and D include only exits for “negative” reasons, defined as securities with delisting codes $4xx$ and $5xx$ (excluding 573). Panels E and F include only exits through mergers and acquisitions are defined as securities with delisting codes $2xx$ and $3xx$. The data are annual observations from 1980 to 2018. The exit rates are expressed in percentages.

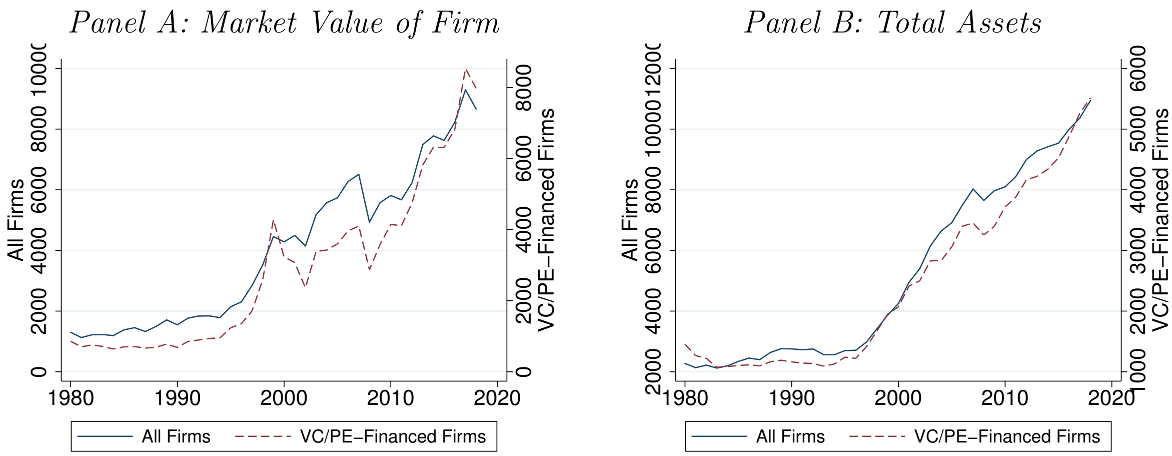


Fig. 5. Average Size of Public Firms

Figure plots the cross-sectional mean size of all publicly listed U.S. firms (solid blue line) and of VC/PE-financed firms (dashed red line). In Panel A, the firm's size is measured with market value of firm, which is defined as the sum of market value of equity and book value of debt. In Panel B, the firm's size is measured with total assets. The data are real annual observations from 1980 to 2018, and are expressed in millions of December 2009 dollars.

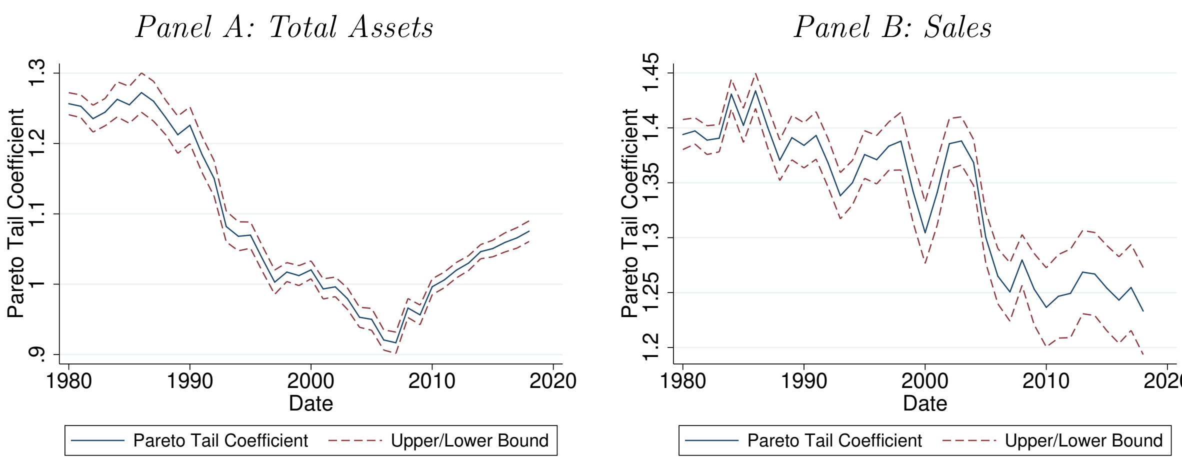


Fig. 6. Power Law Coefficient of Public Firm Size

Figure plots the power law exponent given by $Pr\left(size > X\right) = kX^{-\gamma}$ along with the 5% and 95% confidence intervals over time. The firm's size is measured with total assets (Panel A) and total revenues (Panel B). γ is estimated by running the following cross-sectional regression

$$log\left(rank_{i,t}\right) = \alpha_t + \beta_t log\left(size_{i,t}\right) + \varepsilon_{i,t}$$

for each year t using the top n largest firms, where n is defined by the 95th percentile of firm size in the year.

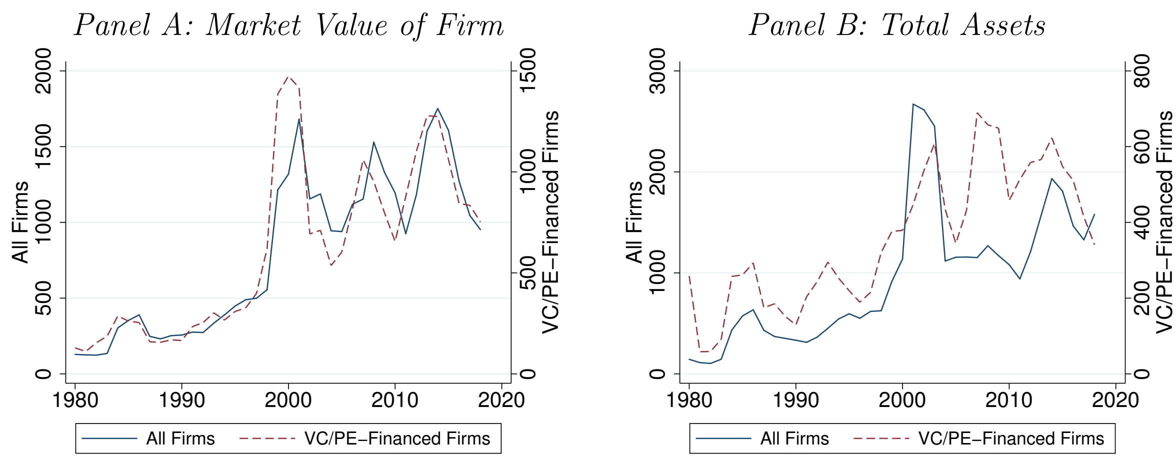


Fig. 7. Average Size of Firms at IPO

The Figure plots the cross-sectional mean size of all firms at IPO (solid blue line) and of VC/PE-financed firms at IPO (dashed red line). The means are smoothed using the three-year moving average. In Panel A, the firm's size is measured with market value of firm, which is defined as the sum of market value of equity and book value of debt. In Panel B, the firm's size is measured with total assets. The data are real annual observations from 1980 to 2018, and are expressed in millions of December 2009 dollars.

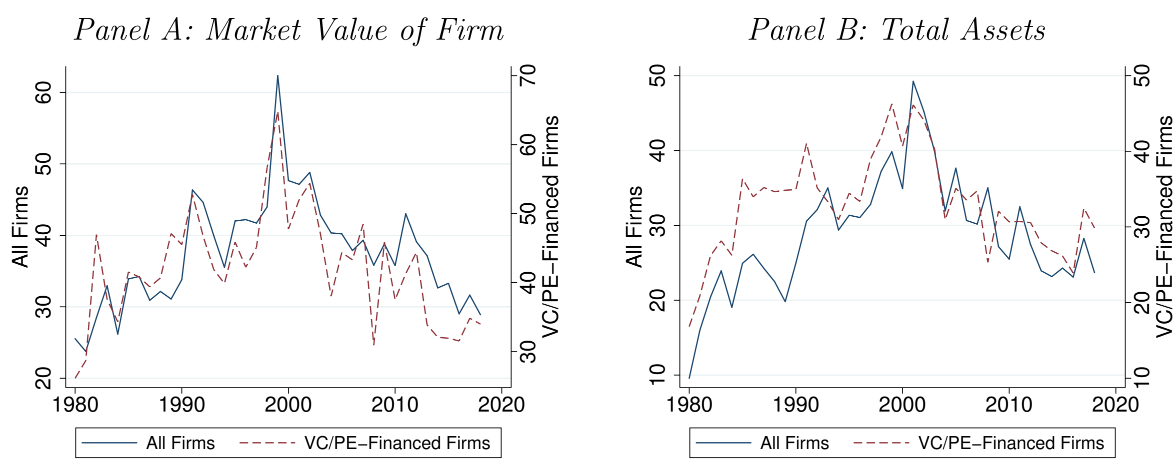


Fig. 8. Share of Public Firms Below Median Firm Size at IPO

The Figure plots the share of public firms below the median firm's size at IPO. In Panel A, the firm's size is measured with market value of firm. In Panel B, the firm's size is measured with total assets. The data are annual observations from 1980 to 2018, and are expressed in percentages.

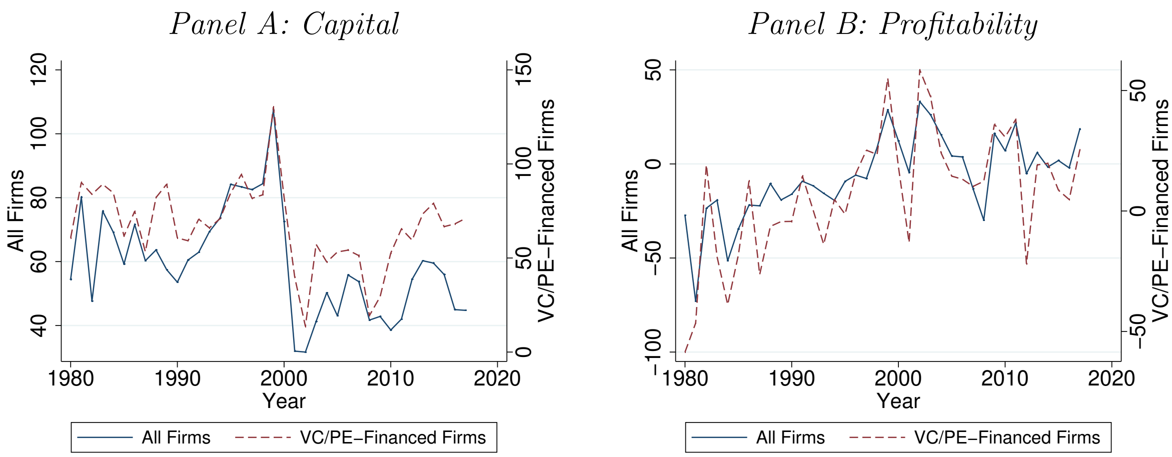


Fig. 9. Changes in Firms' Capital and Profitability around IPO

The Figure plots the cross-sectional average growth rates in firms' capital and profitability over one year before an IPO and one year after an IPO. The growth rates are calculated as

$$\Delta x_{j,t} = \frac{x_{j,t+1} - x_{j,t-1}}{0.5(|x_{j,t+1}| + |x_{j,t-1}|)},$$

where t is the year of an IPO. Panel A show changes in firms' capital, measured with net property, plant, and equipment. Panel A show changes in firms' profitability, calculated as the ratio of operating income before depreciation and total assets. The data are annual observations from 1980 to 2018, and are expressed in percentages.

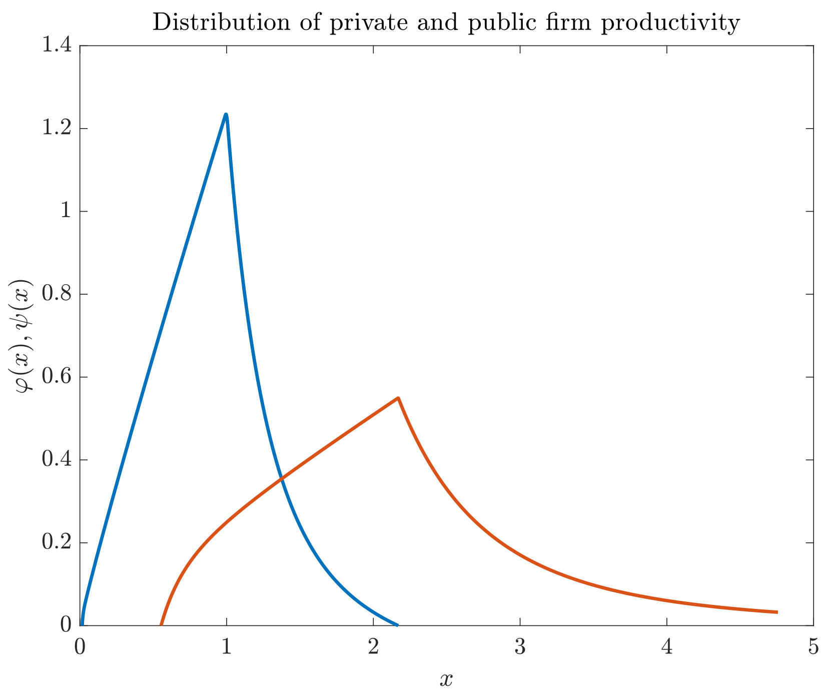


Fig. 10. **Distributions of firm productivity**. The figure displays the stationary distributions of private (blue) and public (red) firm productivity.

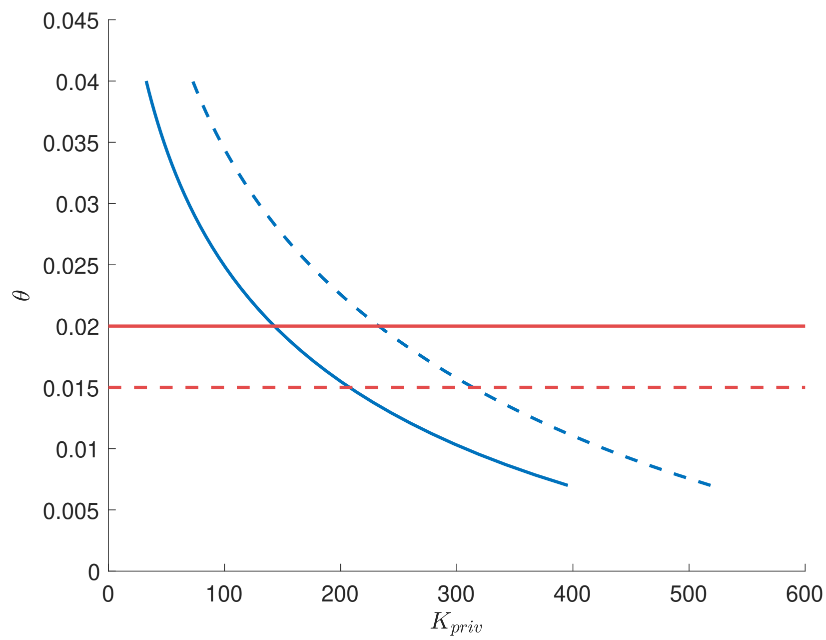


Fig. 11. **Supply and demand for private capital**. The figure shows the supply (blue) and demand (red) curves for private capital for different cases. The solid lines show the supply and demand for a benchmark parameter case. The dashed red line is the outward shift in demand for either an increase in $\mathcal{C}_{pub}$ or $\mathcal{I}_{IPO}$. The dashed blue line shows a reduction in the private capital premium θ.

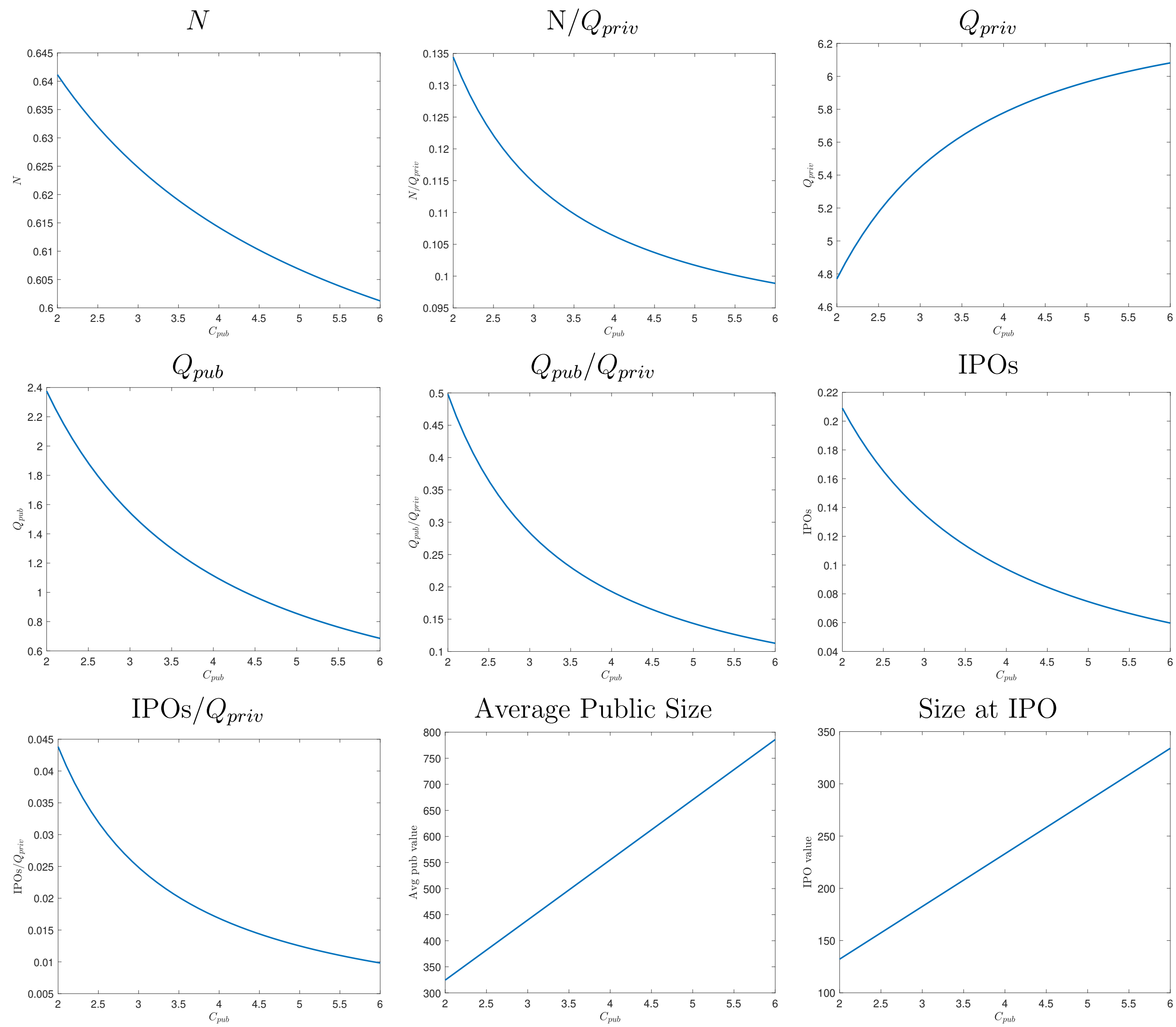


Fig. 12. **Comparative statics for C_{pub}.** The figure plots model statistics as a function of the cost of being public, C_{pub}. Q_{priv} and Q_{pub} are the masses of private and public firms. N is the flow of new private entrants and IPOs refers to the flow of firms going public.

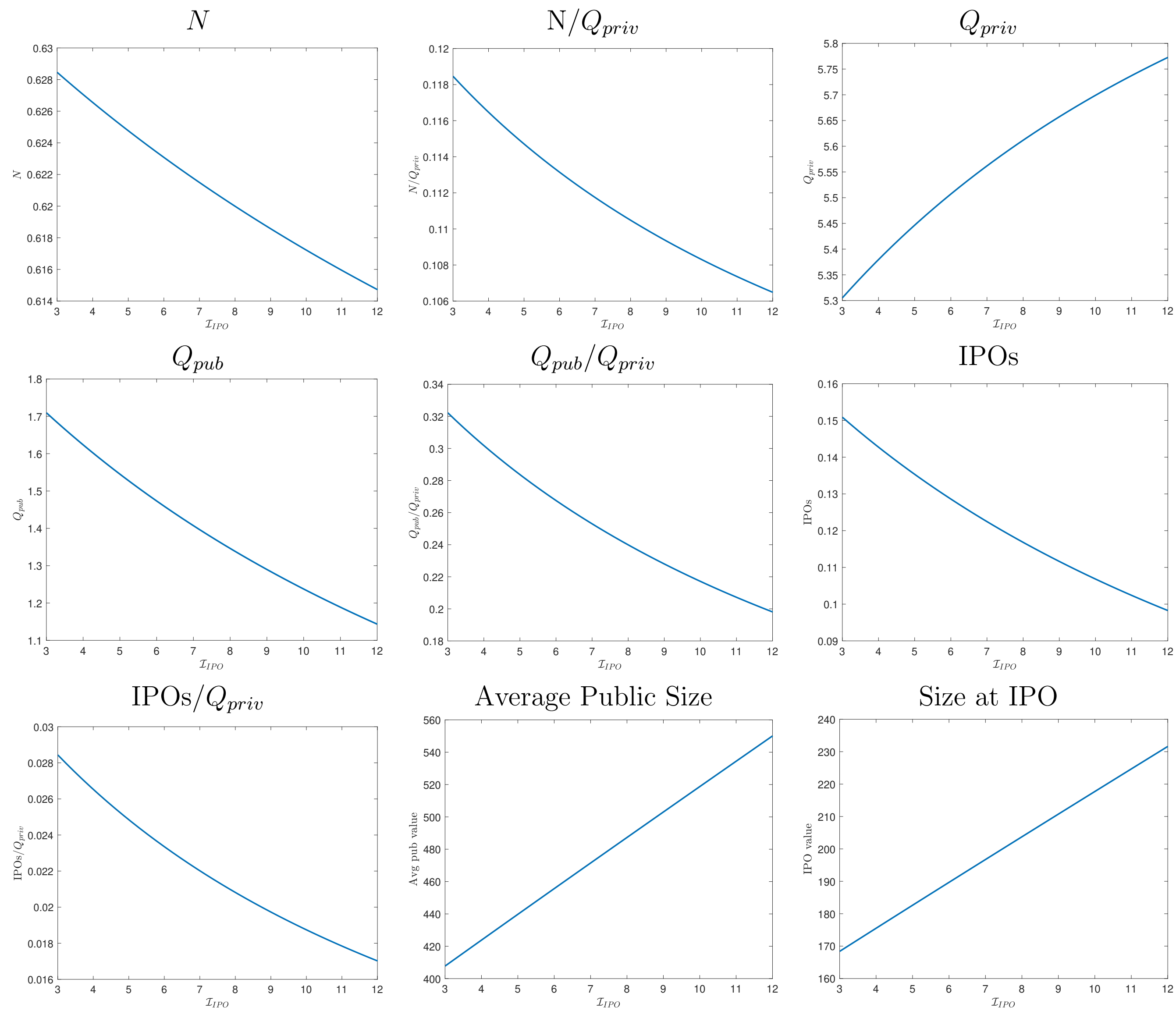


Fig. 13. **Comparative statics for $\mathcal{I}_{IPO}$.** The figure plots model statistics as a function of the IPO cost, $\mathcal{I}_{IPO}$. Q_{priv} and Q_{pub} are the masses of private and public firms. N is the flow of new private entrants and IPOs refers to the flow of firms going public.

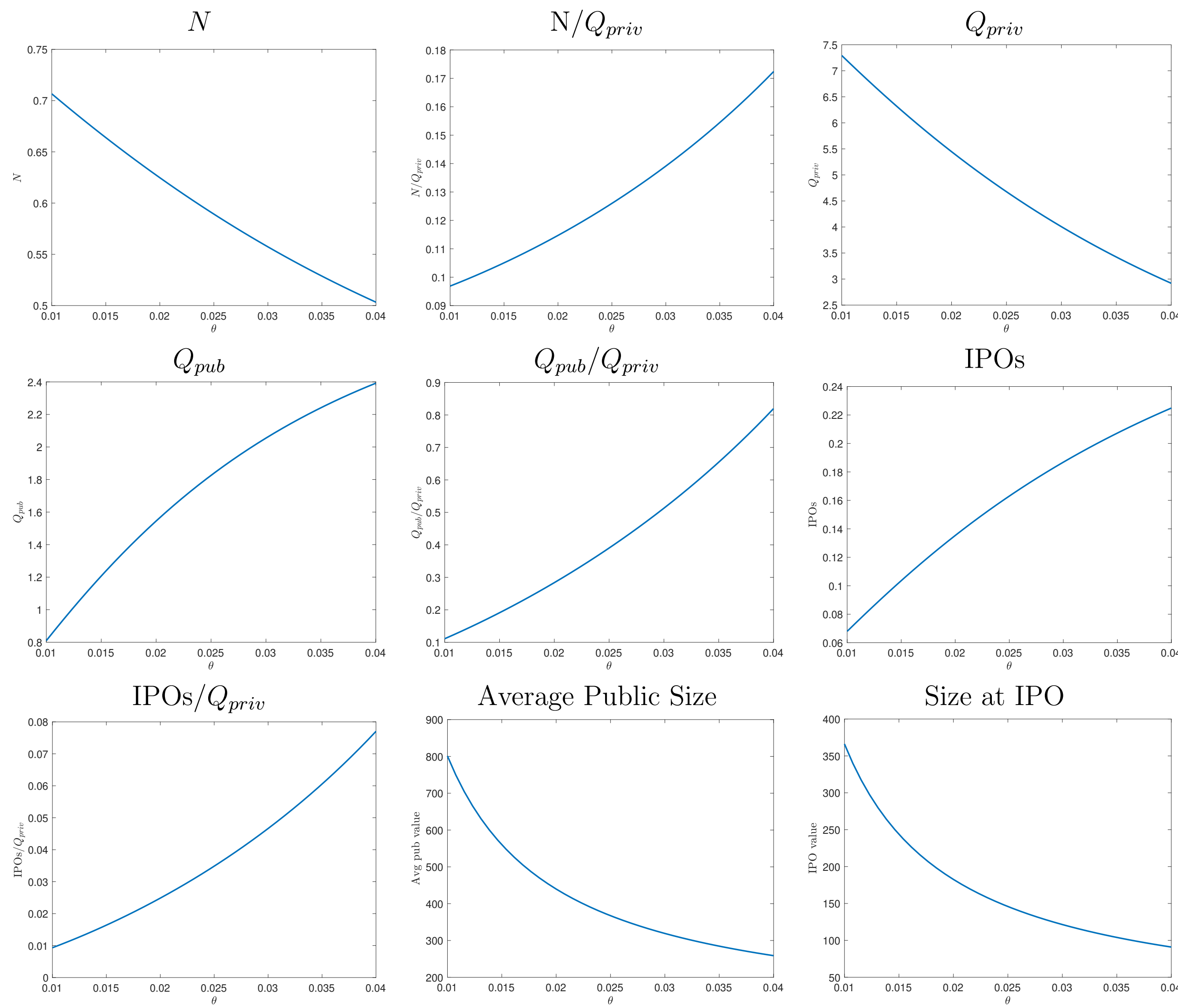


Fig. 14. **Comparative statics for** θ. The figure plots model statistics as a function of the premium on private capital, θ. Q_{priv} and Q_{pub} are the masses of private and public firms. N is the flow of new private entrants and IPOs refers to the flow of firms going public.

Table 1: Empirical Facts: Early vs. Late Period

	All Firms			VC/PE-Financed Firms		
	Early	Late	% Change	Early	Late	% Change
Firms' counts						
Number of public firms†	7.16	3.80	−46.89	1.72	1.13	−34.52
Number of private firms†	10.79	16.90	56.57	10.79	16.90	56.57
Propensity to go public, %†	67.36	22.51	−66.59	16.08	6.66	−58.56
Entry & exit of public firms						
Number of IPOs	0.56	0.18	−67.41	0.13	0.06	−54.80
IPO rate, %	7.08	1.08	−84.71	1.66	0.36	−78.24
Number of exits	0.41	0.36	−12.77	0.07	0.14	86.62
Negative delists	0.19	0.15	−23.35	0.03	0.05	81.56
M&A delists	0.22	0.21	−3.78	0.05	0.09	89.25
Exit rate, %	6.81	7.80	14.59	5.94	10.55	77.63
Negative delists	3.16	3.08	−2.54	2.11	3.37	59.75
M&A delists	3.64	4.72	29.46	3.83	7.18	87.48
Size of public firms						
Log(Total assets)†	5.31	6.60	24.12***	5.01	6.14	22.38***
	(2.11)	(2.15)		(1.89)	(2.06)	
Log(Market value of firm)†	5.40	6.63	22.87***	5.43	6.55	20.67***
	(2.03)	(2.10)		(1.80)	(1.97)	
Size of public firms at IPO						
Log(Total assets)	3.91	5.43	38.87***	4.03	5.02	24.52***
	(1.78)	(1.74)		(1.42)	(1.37)	
Log(Market value of firm)	4.40	5.83	32.46***	4.78	5.87	22.69***
	(1.51)	(1.50)		(1.31)	(1.29)	
Power law coefficient of public firms size						
Total assets	1.18	1.02	−13.45***	1.31	1.20	−8.66***
Revenues	1.44	1.33	−7.45***	1.59	1.29	−18.63***
Changes in firms' characteristics around IPO						
Capital	72.34	48.96	−23.38***	77.59	57.50	−20.09***
	(69.58)	(67.18)		(66.65)	(67.68)	
Profitability	−16.30	4.73	21.03***	0.07	17.95	17.87***
	(108.94)	(95.68)		(112.09)	(106.12)	

The table reports the changes in firms' counts, entry and exit rates, size, and power law coefficient between the early and late periods. The table shows the changes both for all public firms and VC/PE-financed public firms. The early-period averages and standard deviations are calculated over the period from 1980 to 1998 (from 1994 to 1998 for moments marked with †). The late-period moments are calculated over the period from 2001 to 2015 (from 2011 to 2015 for moments marked with †). Standard deviations are reported in the parentheses. The firms' counts are expressed in thousands. The data on total assets, market value of firm, and revenues are real annual observations, and are expressed in millions of December 2009 dollars. The changes between the early and late periods, as well as rates, are expressed in percentages. For the changes in the cross-sectional moments, ***, **, and * indicate significance at the 1%, 5%, and 10% level.

Table 2: Model Parameters

Parameter	Definition	Value
μ	Productivity drift	0.0048
σ	Productivity volatility	0.1725
α	Curvature of profit function	0.5
c_f	Fixed operating cost	0.5
r	Public firm discount rate	0.05
τ	Corporate tax rate	0.30
δ	Capital depreciation rate	0.1
x_0	Initial productivity of private entrant	1
$\log(\overline{c}_e)$	Mean entry cost	4
σ_{ce}	Volatility of entry cost	1.2

The table reports the parameter values used in the baseline specification of the model. Values are annualized where applicable.

Table 3: Model moments and parameters, early and late periods

Panel A: Targeted moments				
	Early		Late	
	Model	Data	Model	Data
Pareto tail, public assets	1.305	1.307	1.22	1.20
# Public / # Private	0.161	0.161	0.066	0.066
IPO cost / IPO value	0.020	0.020	0.0193	0.023
Post-/Pre- IPO capital	1.918	1.926	1.70	1.678

Panel B: Parameters			
	Early	Late	Change (%)
λ	0.075	0.064	-14.7
C_{pub}	0.74	0.96	30.6
$\mathcal{I}_{IPO}$	0.9	2.3	155.5
θ	0.020	0.012	-41.6

Panel A reports the moments targeted in the calibration, both data and model, for the early period (1980–1998) and late period (2001–2015). Panel B shows the calibrated parameter values for the early and late periods. See Table 2 for the other parameter values.

Table 4: Moment changes, model and data

	Model Early	Model Late	Model Change, %
# Public firms	0.953	0.603	-36.7
# Public/#Private	0.158	0.067	-57.8
IPOs	0.079	0.041	-47.8
IPOs/ # Private firms	0.013	0.005	-65.2
Average capital , public	89.0	230.1	158.6
Average firm value, public	116.3	358.8	208.5
Capital at IPO	38.5	82.8	115.4
Firm value at IPO	44.4	119.5	169.0
Median age at IPO	8.9	14.6	64.8
Capital growth around IPO(%)	91.8	70.7	-23.0
Private entrants	0.569	0.667	17.3
# Private firms	6.034	9.054	50.0
Private entry rate	0.094	0.074	-21.8

The table compares moments for the early (1980–1998) and late (2001–2015) periods. The first two columns report moments computed from the model, for the parameters listed in Tables 2 and 3. The third column gives the percentage change of the model moment from the early to late period value.

A Data Appendix

A.1 Identifying VC/PE-financed Firms in the CRSP/Compustat Dataset

We merge the VenturExpert dataset to the CRSP/Compustat Merged dataset in order to identify which VC/PE-financed firms exited private markets via an IPO and when. This merge also allows us to split the universe of the CRSP/Compustat firms into two groups – firms that were at some point of their life cycle VC/PE-backed and firms that did not receive any funding from venture capital and private equity funds.

We start with the VenturExpert database which allows us to identify a set of the U.S. companies that received VC/PE financing.[9] All firms that raised at least one round of financing, except for leveraged buyout financing, between 1980 and 2018 are included. The sample consists of 52,941 unique portfolio companies. Among these 52,941 companies, 5,101 have potentially exited private markets via an IPO. We identify these candidates for public firms in the following way. First, the VenturExpert collects data on firms' exit events: IPOs, buybacks, secondary and trade sales, reverse takeovers, and write offs. Such exit information is available for 14,565 firms, 3,605 of which have been recorded with an IPO exit and 3,100 have been listed on NYSE, AMEX or NASDAQ. Second, the VenturExpert provides information on a company's current status (e.g.,"Went Public" , "Active", "Merger") and public status (e.g., "Public", "Private", "Subsidiary"). We only have this information recorded as of 2019 year end. This means that a set of companies with the status "Went Public" does not necessarily capture all VC/PE-financed firms that exited private markets via an IPO. For example, a company with the status "Acquisition" as of 2019 could have gone public in 2015 and a few years thereafter got acquired by another firm. Hence, our set of potential candidates for public firms is a union of (i) 3,605 firms with exit type "IPO", (ii) 4,357 firms with status "Went Public", and (iii) 4,490 firms with public status "Public". To minimize the classification error, we conduct the merge for a full universe of VC/PE-financed compa-

[9] Another database which covers venture capital deals in the U.S. is the VentureSource dataset. However, the majority of companies in the VentureSource are also in the VenturExpert. Puri and Zarutskie (2012) document that only 10% of the companies present in the two databases are exclusively in the VentureSource.

nies, but we use the information on a company's exit type and current status provided in the VenturExpert to assess the quality of our matches.

To match the VenturExpert to the CRSP/Compustat dataset, we rely on a company's name and full address, that is, city, state and zipcode. Overall, we identify that 4,605 companies out of 52,941 conducted an IPO and satisfy the criteria of Doidge et al. (2017) (see Section 2 for additional details). We first attempt to match on a company's full name and full address. This step delivers 52% of all the matches (see Panel A of Table A.1). Next, we merge firms using their full name and partial address (e.g. city and state, but not zipcode). This step allows us to match another 23%. Another 14% of matches are obtained by matching only a full name. Finally, we repeat the above three steps but this time using the partial name of a company. To assess the quality of our matches, we check what fraction of our matches has been identified as a potential public firm in the VenturExpert, as well as compare the IPO year reported in the two databases for companies with exit type "IPO" (see Panel B of Table A.1). Overall, we find that around 60%-90% of the matched companies (depending on a matching criterion) have been among potential public candidates as identified in the VenturExpert. However, if we were only to rely on the IPO dates reported in the VenturExpert, we would have nontrivially underestimated the number of VC/PE-financed firms exiting private markets via an IPO.

Table A.1: Matching Results between VenturExpert and CRSP/Compustat

Panel A: Number of Matches by Matching Rounds

	# of Matched Firms (4605 firms)	% of Matched Firms
Full Name, City, Zip, State	2390	51.90
Full Name, City, State	370	8.03
Full Name, Zip, State	96	2.08
Full Name, State	590	12.81
Full Name	630	13.68
Total	4076	88.51
Partial Name, City, Zip, State	331	7.19
Partial Name, City, State	64	1.39
Partial Name, Zip, State	13	0.28
Partial Name, State	101	2.19
Partial Name	20	0.43
Total	529	11.49

Panel B: Match Quality by Matching Rounds

	# of Matched Firms (4605 firms)	% with Public Status "Public"	% with Status "Went Public"	% with Exit Type "IPO"	% with Public Flag	Average Difference in IPO Year
Full Name, City, Zip, State	2390	73.56	71.17	67.41	85.94	−0.04
Full Name, City, State	370	73.24	71.89	59.19	80.81	−0.01
Full Name, Zip, State	96	81.25	81.25	72.92	91.67	−0.77
Full Name, State	590	78.14	77.29	67.46	86.78	−0.11
Full Name	630	54.29	52.70	43.33	61.59	0.26
Total	4076	71.39	69.50	63.08	81.97	
Partial Name, City, Zip, State	331	68.88	66.77	61.63	79.15	0.02
Partial Name, City, State	64	65.62	64.06	56.25	75.00	−0.56
Partial Name, Zip, State	13	53.85	46.15	38.46	61.54	0.00
Partial Name, State	101	59.41	58.42	43.56	64.36	1.07
Partial Name	20	85.00	80.00	65.00	100.00	−7.77
Total	529	66.92	64.84	57.09	76.18	

Panel A reports the number and percent of matches between the VenturExpert and CRSP/Compustat databases by a matching round. Panel B shows the percent of companies among matches, which have either public status "Public", or status "Went Public", or exit type "IPO", or any of the above by a matching round. Panel B also reports the average difference between the IPO year reported in the VenturExpert and CRPS/Compustat databases for firms with exit type "IPO".

A.2 Matching the CRSP/Compustat Dataset with the Thomson Reuters SDC Platinum M&A Dataset

We merge the Thomson Reuters SDC Platinum Mergers and Acquisitions database to the CRSP/Compustat database in order to identify firms which (i) enter public market via an acquisition by a public firm, and (ii) exit public market via an acquisition by a private firm. To merge the two databases, we rely on the securities' identifier – the CUSIP number.

Admittedly, we underestimate the number of conducted M&A deals, since SDC M&A dataset typically covers larger acquisitions and acquisitions by public acquirers. However, comparing the number of M&A deals covered in the SDC database with the number of deals reported by the Institute for Mergers, Acquisitions and Alliances (IMMA) suggests that underreporting is relatively small. The SDC database provides information for over 85% of merger and acquisition deals in each year over our sample period (see Appendix Figure B.5). Note that we focus only on the U.S. M&A deals, i.e. deals in which either an acquirer or a target is a U.S. firm as identified by *anation* and *tnation*, respectively.

Identifying Non-Public Firms Acquired by Public Firms in the SDC Platinum M&A Dataset. To identify deals in which the acquirer is a public firm, we merge the set of firms in the CRSP/Compustat dataset to firms listed as an acquirer in the deals from the SDC database using the acquirer's CUSIP number (*acusip*). An acquirer is classified as a public firm if its CUSIP number is matched to the CRSP securities' numbers. Importantly, we also require that it satisfies the criteria of Doidge et al. (2017). Similarly, we identify deals in which the target is a public firm. But rather than matching firms in the CRSP/Compustat dataset to firms in the SDC database listed as an acquirer, we match them to firms listed as a target using the target's CUSIP number (*master_cusip*).

Note that this definition of a public firm implies that non-public firms include foreign firms (either privately held or publicly listed), U.S. privately held firms, and U.S. publicly listed firms that do not meet the criteria of Doidge et al. (2017) (e.g., publicly listed firms that have never been listed NYSE, AMEX, or NASDAQ stock exchanges).

Identifying Public Firms Acquired by Non-Public Firms in the CRSP/Compustat

Dataset. These firms are a subset of the CRSP/Compustat firms satisfying the Doidge et al. (2017) criteria and exiting though mergers and acquisitions. We therefore restrict our sample to securities with delisting codes $2xx$ and $3xx$. Then, we match this set to firms to firms listed as targets in the acquisition deals from the SDC database using the target's CUSIP number (*master_cusip*). We only keep deals which have been completed and become effective in a two year window from the CRSP delisting year and which have resulted in more than 50% ownership for an acquirer. These restriction are on the conservative side, allowing us to avoid underreporting of acquisitions. Alternatively, we could have required the effective year of an acquisition being the same as the CRSP delisting year, as well as 100% ownership for an acquirer.

A.3 Identifying High-Technology Industries

To identify high-technology industries, we follow the study by Hecker (2005) which relies on the Bureau of Labor Statistics (BLS) definition of high-technology industries — those that have high concentrations of workers in STEM (Science, Technology, Engineering, and Mathematics) occupations. More specifically, an industry is considered to be high tech if the share of jobs in that industry that are held by STEM workers is at least twice as high as the average level for all industries. Technology-oriented occupations include the following occupational groups: computer and mathematical scientists (SOC code 15–0000); engineers (SOC code 17–2000); drafters, engineering, and mapping technicians (SOC code 17–3000); life scientists (SOC code 19–1000); physical scientists (SOC code 19–2000); life, physical, and social science technicians (SOC code 19–4000); computer and information systems managers, (SOC code 11–3020); engineering managers (SOC code 11–9040); and natural sciences managers (SOC code 11–9120). To calculate industries' shares of STEM employment, Hecker (2005) relies on the 2002 National Employment Matrix from the BLS which reports occupational employment by NAICS industry groups. As of 2002, a typical four digit NAICS industry had 4.9% of employment in high-technology oriented occupations. Therefore, only industries with the share of STEM employment above 9.8% were classified as high tech. These high-technology industries were further classified into three groups: Level I consists of industries with the share of STEM workers at least 5 times above the average level for all industries, Level II — at least 3 but less than 5 times above the average level, Level III — at least 2 but less than 3 times above the average level. The full list of high-technology industries, along with the shares of employment in technology-oriented occupations as of 2002, is reported in Table 4 of Hecker (2005). For our analysis, we classify a firm to be part of a high-technology industry if its NAICS code from the S&P Compustat (*naics*) is among the NAICS codes of high-technology industries as identified by Hecker (2005).

B Additional Figures and Tables

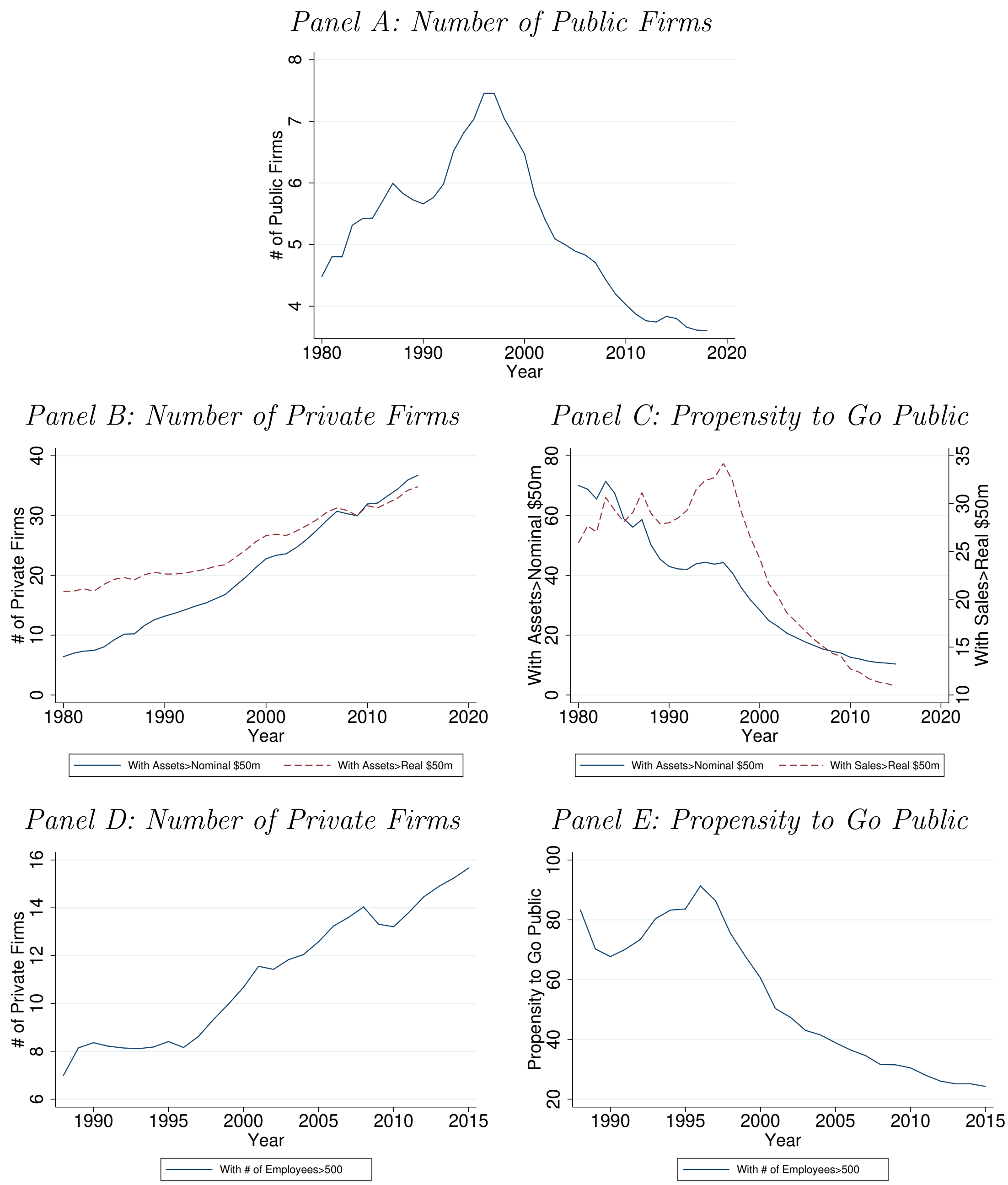


Fig. B.1. Publicly Listed and Private Firms

Panel A shows the count of publicly listed U.S. firms. Panel B and D display the number of U.S. private firms with assets above $50m and with more than 500 employees, respectively. Panel C and E shows the ratio of the number of publicly listed firms to the number of private firms with assets above $50m and with more than 500 employees, respectively. The firm counts are expressed in thousands, and the ratios are expressed in percentages.

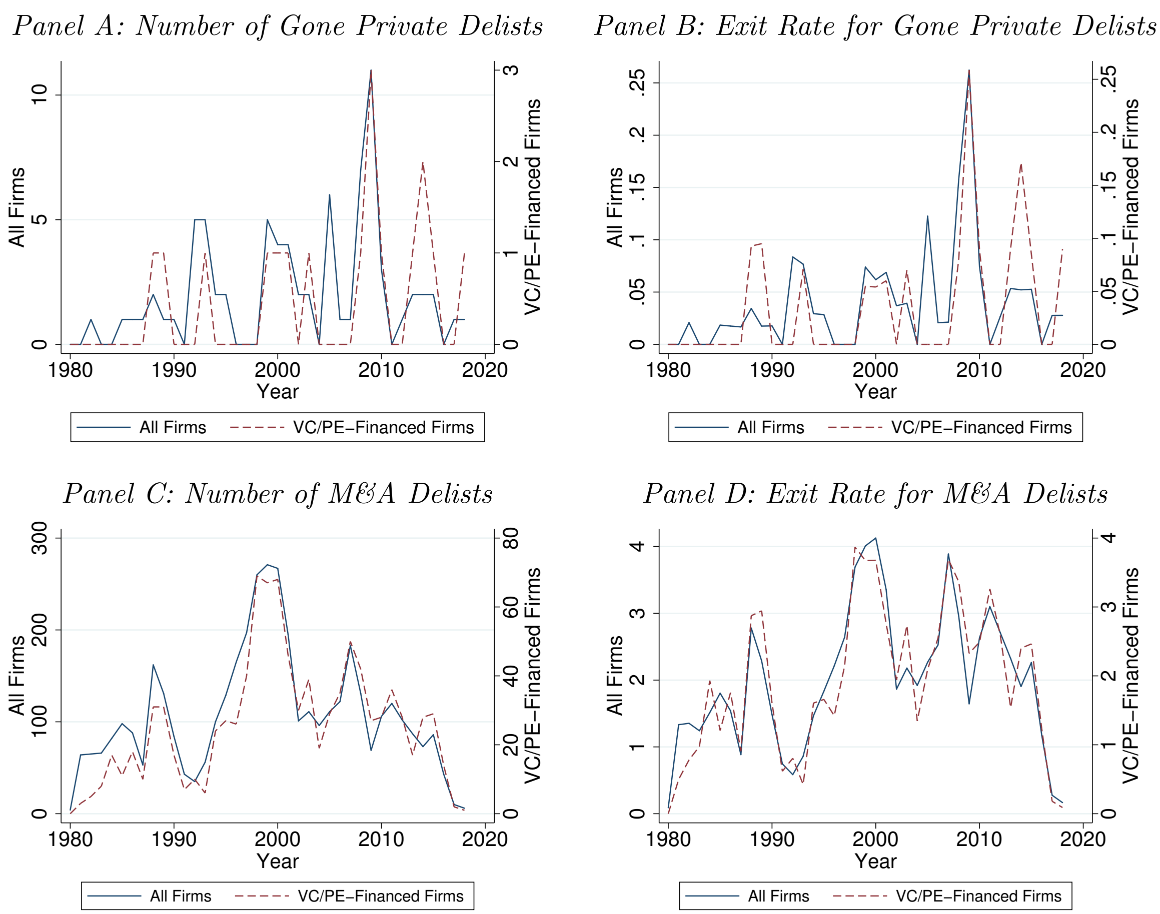


Fig. B.2. Exit Rate of Public Firms

Panels A and C show the number of exits among all public firms (solid blue line) and among VC/PE -financed public firms (red dashed line). Panels B and D show the exit rate, defined as the ratio of firms exits to the number of publicly traded firms. Panels A and B include only exits with a reason "gone private", defined as securities with the delisting code 573. Panels C and D include only exits through mergers and acquisitions by a non-public acquirer are defined as securities with delisting codes $2xx$ and $3xx$. More details are provided in Appendix A.2. The data are annual observations from 1980 to 2018. The exit rates are expressed in percentages.

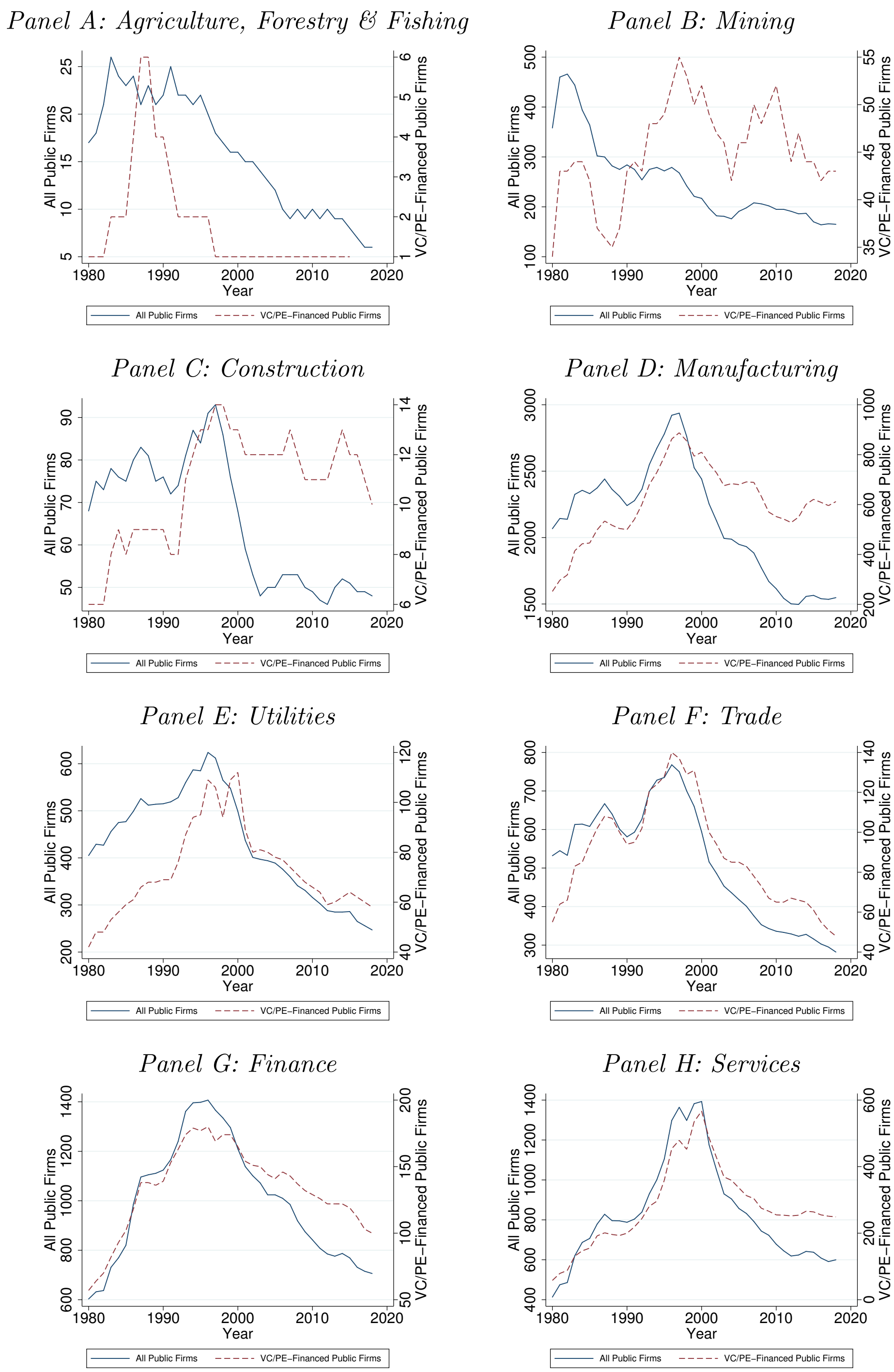


Fig. B.3. Number of Public Firms - Industry Decomposition

Figure shows the count of all publicly listed U.S. firms (solid blue line) and VC/PE-financed publicly listed firms (dashed red line) across different industries: (a) agriculture, forestry and fishing (SIC codes 100-999), (b) mining (SIC codes 1000-1499) (c) construction (SIC codes 1500-1799), (d) manufacturing (SIC codes 2000-3999), (e) transportation, communications, electric, gas and sanitary service (SIC codes 4000-4999), (f) wholesale and retail trade (SIC codes 5000-5999), (g) finance, insurance and real estate (SIC codes 6000-6799), and (h) services (SIC codes 7000-8999). The data are annual observations from 1980 to 2018.

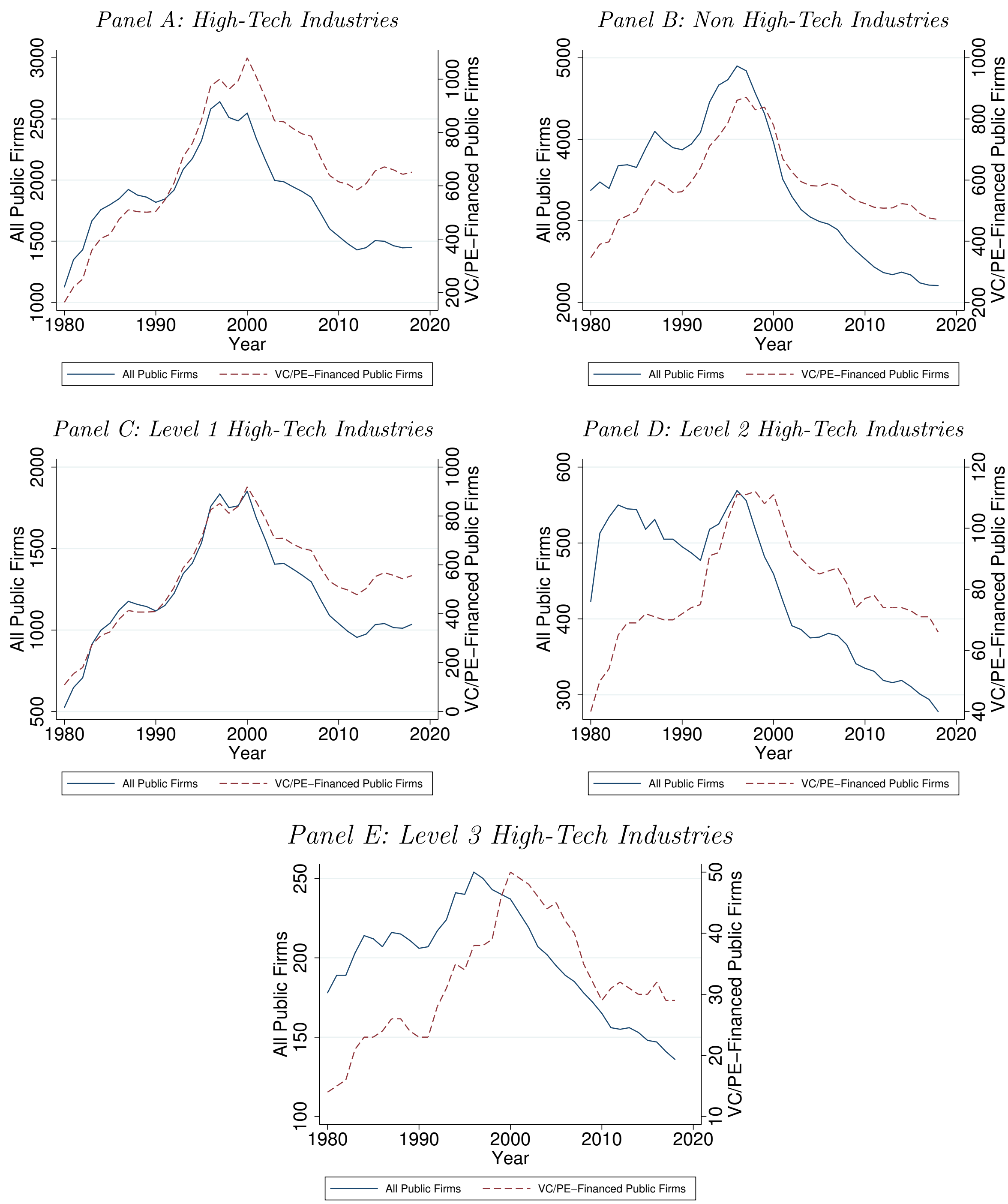


Fig. B.4. Number of Public Firms - High-Technology Industries

Figure shows the count of all publicly listed U.S. firms (solid blue line) and VC/PE-financed publicly listed firms (dashed red line) across high-technology and non high-technology industries. An industry is considered to be high tech if the share of jobs in that industry that are held by STEM workers is at least twice as high as the average level for all industries as of 2002. More details are provided in Appendix A.3. The data are annual observations from 1980 to 2018.

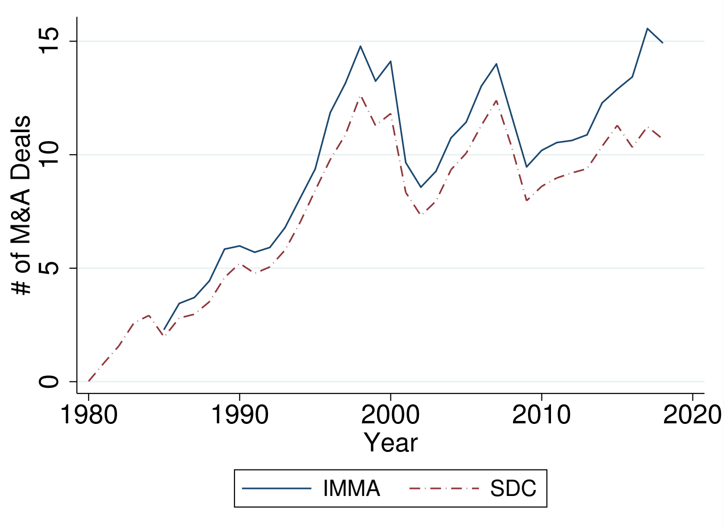
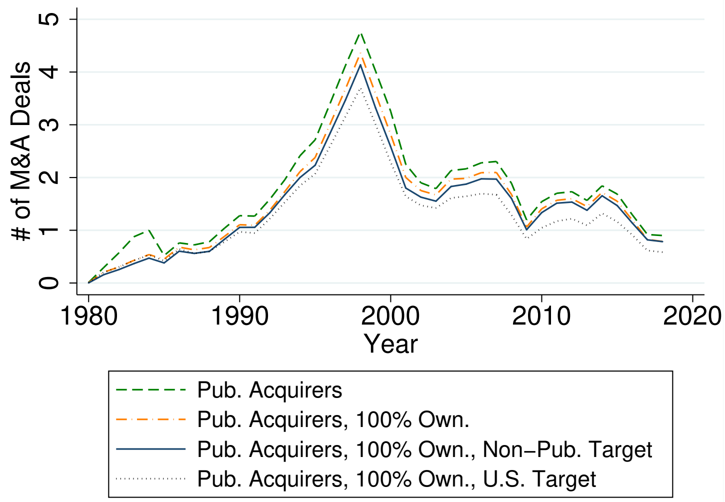


Fig. B.5. Number of M&A Deals

Figure shows the number of M&A deals in the U.S. as reported by the Institute for Mergers, Acquisitions and Alliances and the number of deals covered by the SDC Platinum M&A database over time. The data are annual observations from 1980 to 2018. The deals counts are expressed in thousands.

Panel A: Number of M&A Deals by Public Acquirers



Panel B: Number of M&A Deals by VC/PE-Financed Public Acquirers

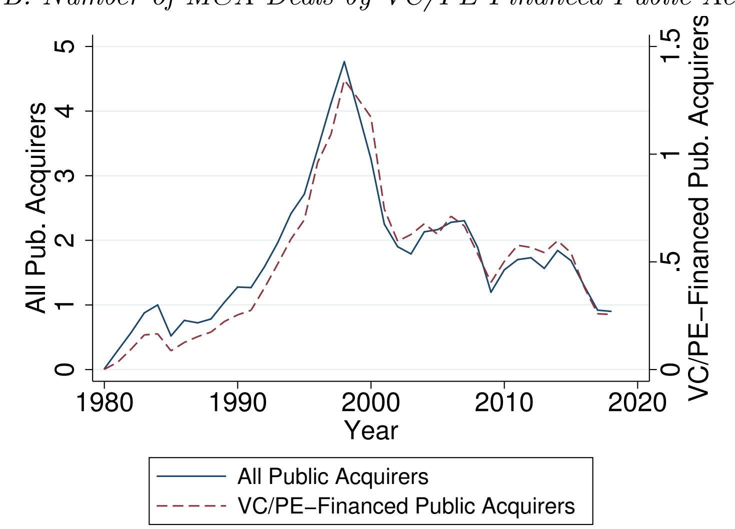


Fig. B.6. Number of M&A Deals by Public Acquirers

Figure shows the number of M&A deals with a public acquirer from the SDC Platinum M&A database over time. Panel B depicts the number of M&A deals with a public acquirer versus the number of M&A deals with a VC/PE-financed public acquirer. More details are provided in Appendix A.2. The data are annual observations from 1980 to 2018. The deals counts are expressed in thousands.

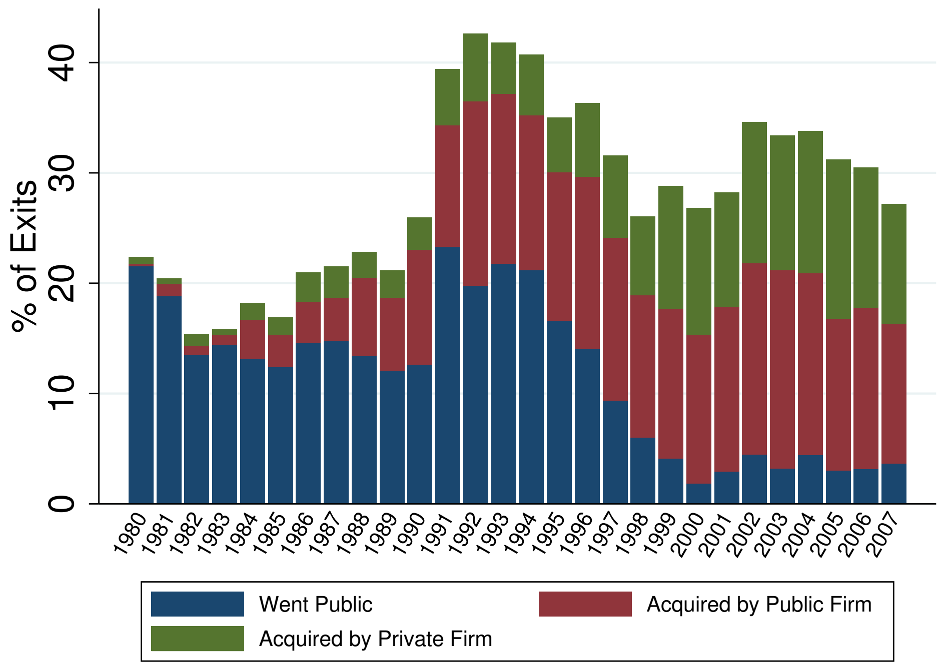


Fig. B.7. Exit Rate of VC/PE-Financed Private Firms

Figure shows the exit rates of VC/PE-financed private firms for each first financing year cohort. The exit state – went public, acquired by a public firm or acquired by a private firm – is measured ten years after the firm's first round of financing for each cohort. The data are annual observations from 1980 to 2018. The exit rates are expressed in percentages.

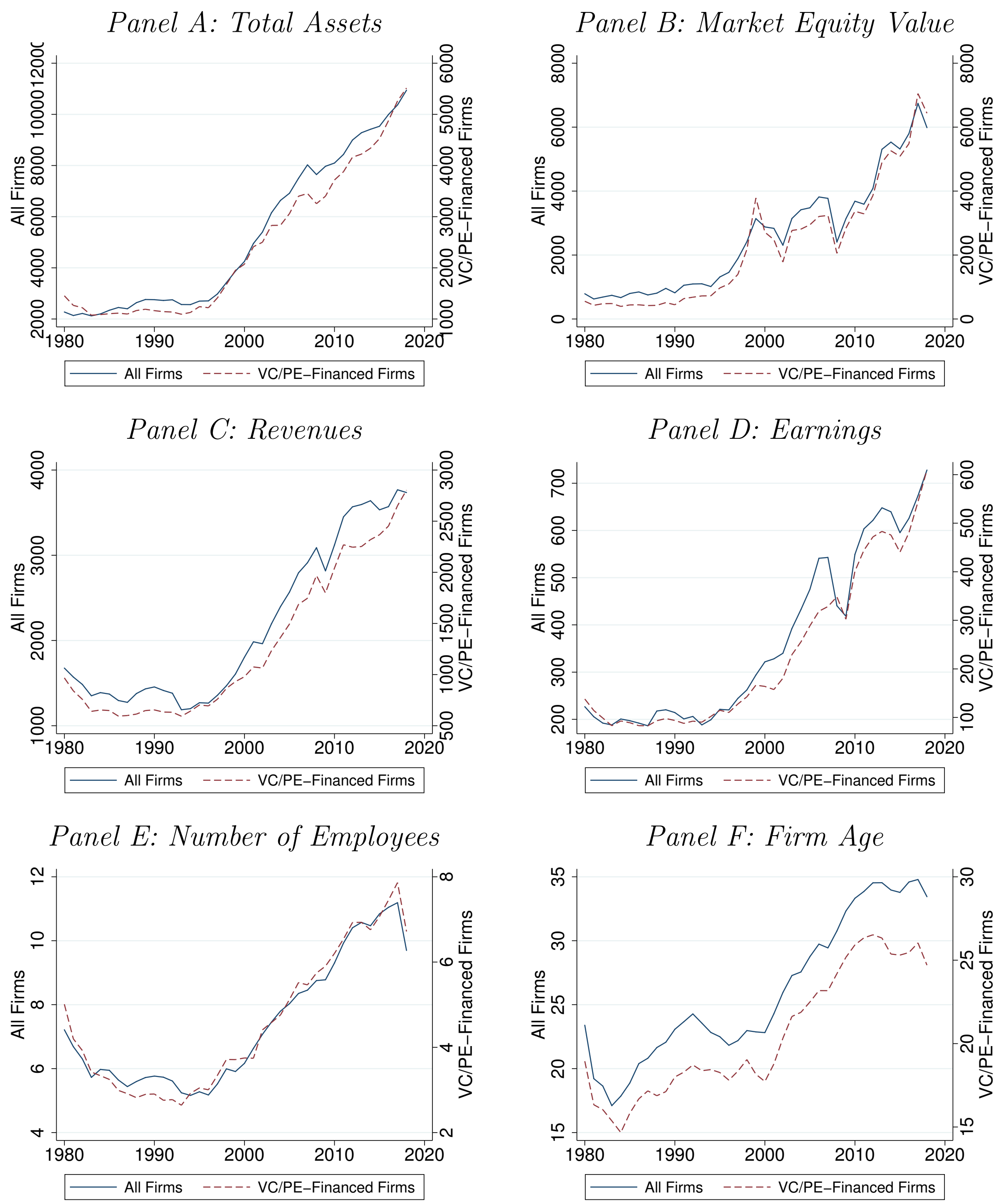


Fig. B.8. Average Size of Public Firms

Figure shows the cross-sectional mean size of all publicly listed U.S. firms (solid blue line) and of VC/PE-financed firms (dashed red line). The firm's size is measured with total assets, market value of equity, market value of firm, revenues, earnings, number of employees, and age. In Panels A - D, the data are real annual observations from 1980 to 2018, and are expressed in millions of December 2009 dollars. In Panel E, the data are annual observations, expressed in thousands. In Panel F, the data are annual observations, expressed in years.

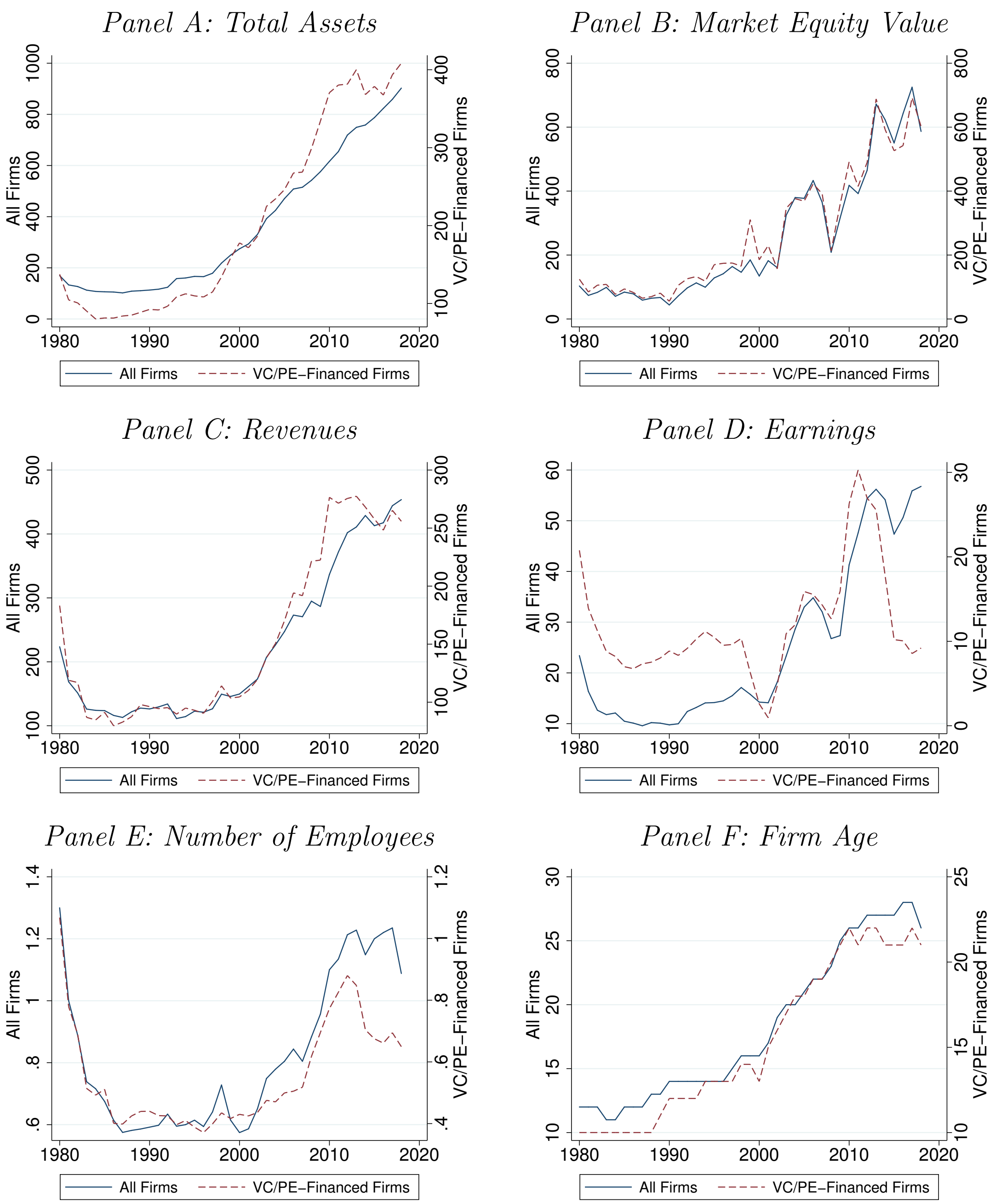


Fig. B.9. Median Size of Public Firms

Figure shows the cross-sectional median size of all publicly listed U.S. firms (solid blue line) and of VC/PE-financed firms (dashed red line). The firm's size is measured with total assets, market value of equity, market value of firm, revenues, earnings, number of employees, and age. In Panels A - D, the data are real annual observations from 1980 to 2018, and are expressed in millions of December 2009 dollars. In Panel E, the data are annual observations, expressed in thousands. In Panel F, the data are annual observations, expressed in years.

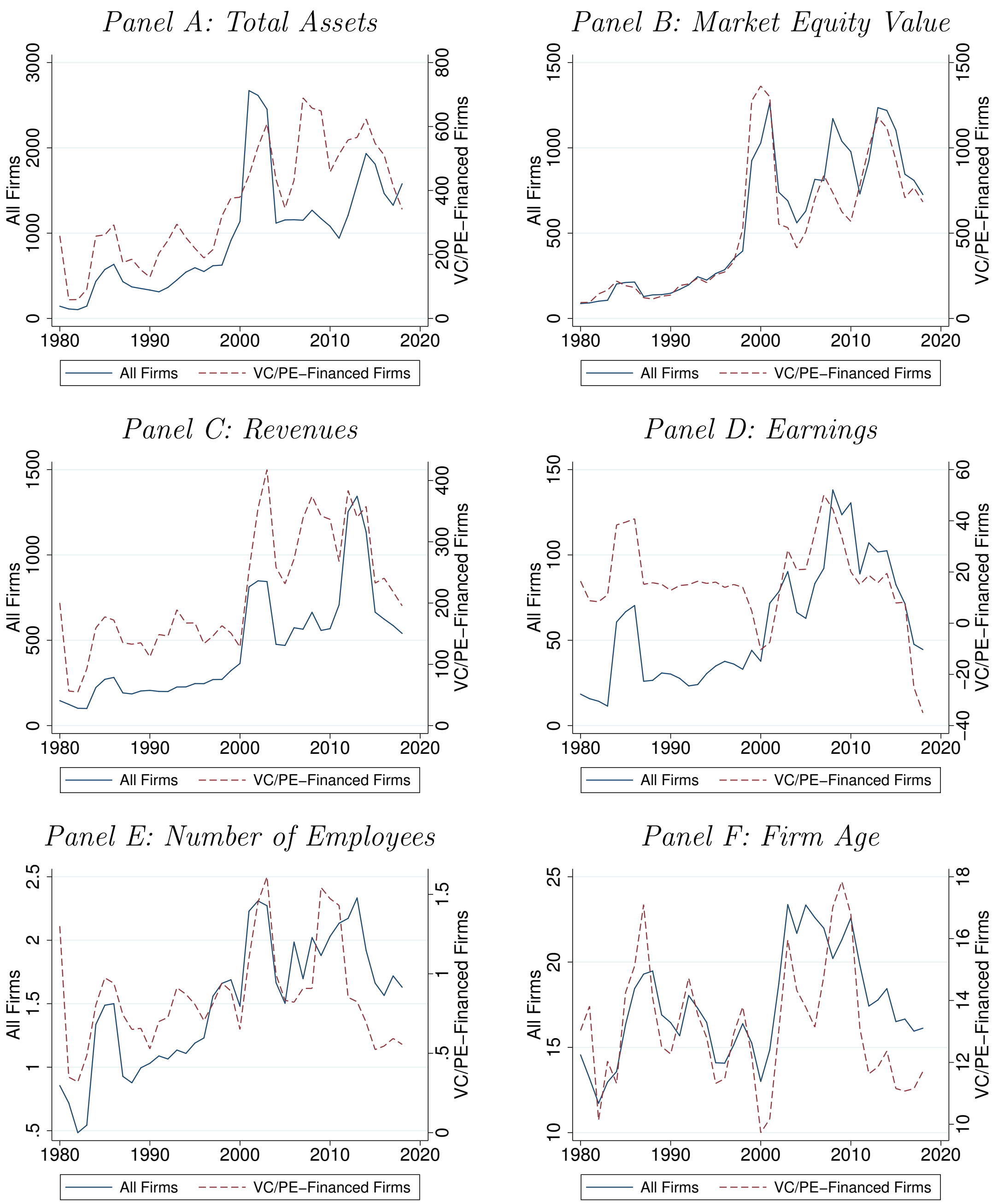


Fig. B.10. Average Size of Firms at IPO

The Figure shows the cross-sectional mean size of all firms at IPO (solid blue line) and of VC/PE-financed firms (dashed red line). The means are smoothed using the three-year moving average. The firm's size is measured with total assets, market value of equity, revenues, earnings, number of employees, and age. In Panels A - D, the data are real annual observations from 1980 to 2018, and are expressed in millions of December 2009 dollars. In Panel E, the data are annual observations, and are expressed in thousands. In Panel F, the data are annual observations, and are expressed in years.

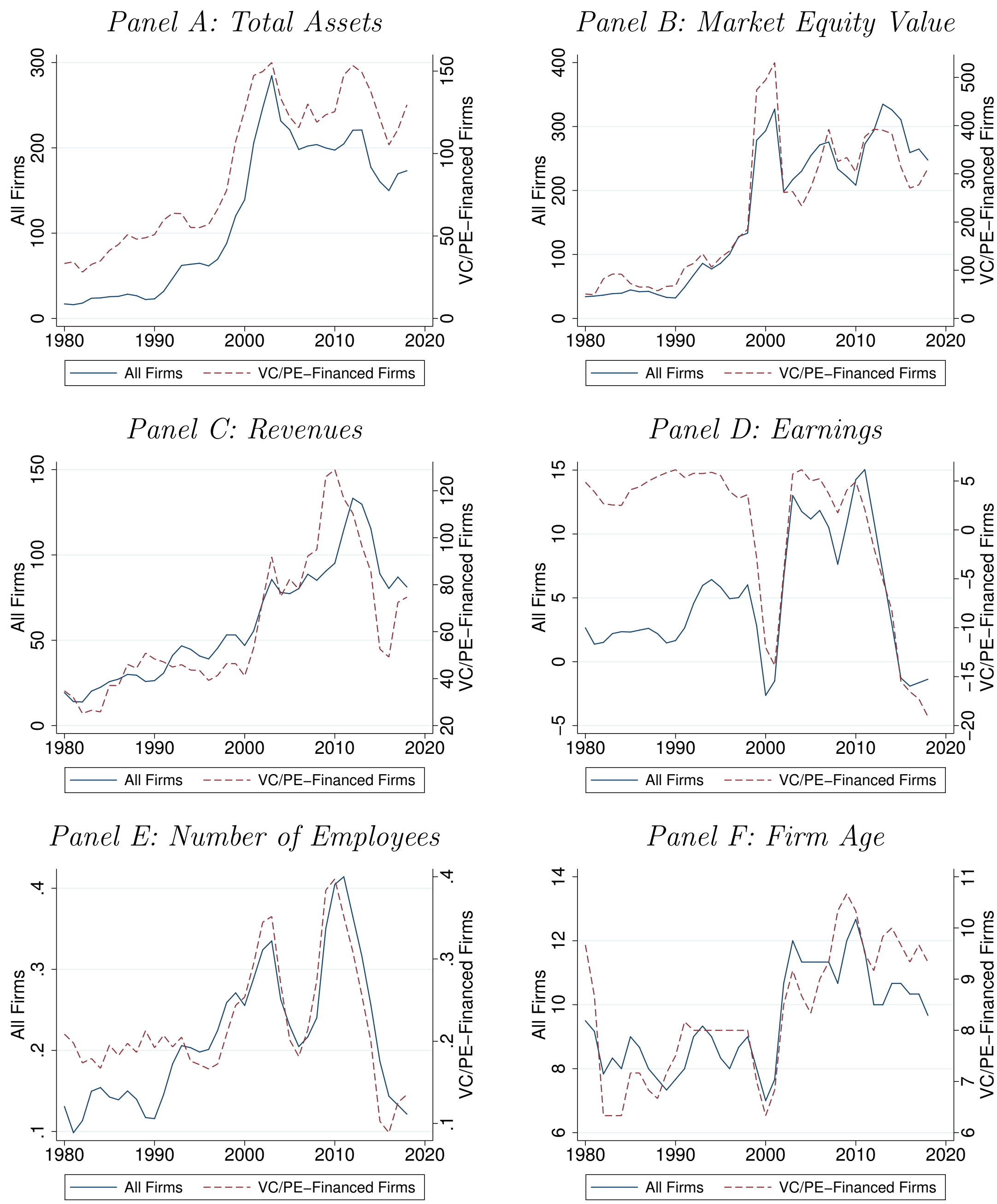


Fig. B.11. Median Size of Firms at IPO

The Figure shows the cross-sectional median size of all firms at IPO (solid blue line) and of VC/PE-financed firms (dashed red line). The medians are smoothed using the three-year moving average. The firm's size is measured with total assets, market value of equity, revenues, earnings, number of employees, and age. In Panels A - D, the data are real annual observations from 1980 to 2018, and are expressed in millions of December 2009 dollars. In Panel E, the data are annual observations, and are expressed in thousands. In Panel F, the data are annual observations, and are expressed in years.

Table B.1: Propensity to Go Public

		Early Period	Late Period	% Change
Number of public firms		7.16	3.80	−46.89
Number of private firms				
VenturExpert	VC/PE-financed firms			
	Failure 3 years after last financing round	10.11	14.90	47.36
	Failure 4 years after last financing round	10.40	15.92	53.02
	Failure 5 years after last financing round	10.79	16.90	56.57
	Failure 6 years after last financing round	11.25	17.82	58.36
	Failure 7 years after last financing round	11.78	18.71	58.83
Census	Firms with > 500 employees	8.54	14.81	73.37
IRS	C & S firms with assets>nominal $50m	19.82	35.02	76.70
IRS	C & S firms with assets>real $50m	24.51	33.61	37.15
IRS	C & S firms with assets>nominal $100m	12.15	23.52	93.50
IRS	C & S firms with assets>real $100m	15.19	22.53	48.33
IRS	C & S firms with revenues>nominal $50m	17.43	33.56	92.50
IRS	C & S firms with revenues>real $50m	25.25	31.09	23.14
Propensity to go public, %				
VenturExpert	VC/PE-financed firms			
	Failure 3 years after last financing round	72.47	25.53	−64.77
	Failure 4 years after last financing round	70.22	23.89	−65.98
	Failure 5 years after last financing round	67.36	22.51	−66.59
	Failure 6 years after last financing round	64.34	21.35	−66.82
	Failure 7 years after last financing round	61.25	20.34	−66.79
Census	Firms with > 500 employees	84.02	25.73	−69.38
IRS	C & S firms with assets>nominal $50m	36.27	10.88	−69.99
IRS	C & S firms with assets>real $50m	29.26	11.33	−61.27
IRS	C & S firms with assets>nominal $100m	59.41	16.21	−72.72
IRS	C & S firms with assets>real $100m	47.30	16.91	−64.26
IRS	C & S firms with revenues>nominal $50m	41.33	11.37	−72.49
IRS	C & S firms with revenues>real $50m	28.39	12.25	−56.85

The table reports the average counts of private U.S. firms and propensity to go public for the early period 1994-1998 and for the late period 2011-2015. The number of VC/PE-financed firms is calculated when the failure date is set to 3,4,5,6, and 7 years from the last financing round if a firm has not exited earlier via an IPO or acquisition (for additional information see Section 2). The number of private firms with more than 500 employees is calculated as the difference between the number of all firms with more than 500 employees reported by the Census Bureau and the number of all publicly listed firms. The number of private firms with assets/revenues above the certain threshold is calculated as the difference between the number of all firms assets/revenues above that threshold reported by the IRS and the number of publicly listed firms above that threshold. The firm counts are expressed in thousands, the propensity to go public and the changes between the early and late periods are expressed in percentages.

Table B.2: Propensity to Go Public — Adjusted for M&A

		Early Period	Late Period	% Change
Number of public firms		11.51	11.32	−1.66
Number of private firms				
VenturExpert	VC/PE-financed firms			
	Failure 3 years after last financing round	10.11	14.90	47.36
	Failure 4 years after last financing round	10.40	15.92	53.02
	Failure 5 years after last financing round	10.79	16.90	56.57
	Failure 6 years after last financing round	11.25	17.82	58.36
	Failure 7 years after last financing round	11.78	18.71	58.83
Census	Firms with > 500 employees	8.54	14.81	73.37
IRS	C & S firms with assets>nominal $50m	19.82	35.02	76.70
IRS	C & S firms with assets>real $50m	24.51	33.61	37.15
IRS	C & S firms with assets>nominal $100m	12.15	23.52	93.50
IRS	C & S firms with assets>real $100m	15.19	22.53	48.33
IRS	C & S firms with revenues>nominal $50m	17.43	33.56	92.50
IRS	C & S firms with revenues>real $50m	25.25	31.09	23.14
Propensity to go public, %				
VenturExpert	VC/PE-financed firms			
	Failure 3 years after last financing round	115.18	75.99	−34.03
	Failure 4 years after last financing round	111.69	71.11	−36.33
	Failure 5 years after last financing round	107.29	66.99	−37.56
	Failure 6 years after last financing round	102.62	63.55	−38.08
	Failure 7 years after last financing round	97.80	60.53	−38.11
Census	Firms with > 500 employees	134.66	76.56	−43.15
IRS	C & S firms with assets>nominal $50m	58.02	32.39	−44.18
IRS	C & S firms with assets>real $50m	46.89	33.72	−28.09
IRS	C & S firms with assets>nominal $100m	94.83	48.23	−49.14
IRS	C & S firms with assets>real $100m	75.69	50.31	−33.54
IRS	C & S firms with revenues>nominal $50m	66.03	33.83	−48.77
IRS	C & S firms with revenues>real $50m	45.50	36.46	−19.87

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Table B.3: Size of Public Firms and Firms at IPO

	All Firms			VC/PE-Financed Firms		
	Early	Late	% Change	Early	Late	% Change
Size of public firms						
Log(Total assets)†	5.31	6.60	24.12***	5.01	6.14	22.38***
	(2.11)	(2.15)		(1.89)	(2.06)	
Log(Market value of firm)†	5.40	6.63	22.87***	5.43	6.55	20.67***
	(2.03)	(2.10)		(1.80)	(1.97)	
Log(Market equity value)†	5.07	6.28	24.03***	5.20	6.33	21.60***
	(2.00)	(2.11)		(1.76)	(1.96)	
Log(Revenues)†	4.88	5.88	20.40***	4.59	5.47	19.21***
	(2.22)	(2.38)		(2.13)	(2.38)	
Log(Earnings)†	3.40	4.58	34.58***	3.29	4.50	37.04***
	(2.07)	(2.12)		(1.90)	(2.10)	
Number of employees†	5.43	10.44	92.44***	3.22	6.85	112.64***
	(24.05)	(49.37)		(11.01)	(24.30)	
Age†	22.44	34.13	52.06***	18.38	25.94	41.17***
	(22.44)	(26.70)		(18.04)	(19.37)	
Size of public firms at IPO						
Log(Total assets)	3.91	5.43	38.87***	4.03	5.02	24.52***
	(1.78)	(1.74)		(1.42)	(1.37)	
Log(Market value of firm)	4.40	5.83	32.46***	4.78	5.87	22.69***
	(1.51)	(1.50)		(1.31)	(1.29)	
Log(Market equity value)	4.19	5.58	33.11***	4.64	5.76	24.15***
	(1.47)	(1.46)		(1.30)	(1.29)	
Log(Revenues)	3.31	4.43	34.01***	3.39	3.98	17.23***
	(2.26)	(2.31)		(2.05)	(2.19)	
Log(Earnings)	2.23	3.52	57.61***	2.31	3.25	40.66***
	(1.75)	(1.75)		(1.42)	(1.64)	
Number of employees	1.17	1.90	61.77***	0.77	0.87	13.26
	(6.66)	(6.47)		(2.76)	(2.63)	
Age	16.24	19.41	19.51***	13.27	12.90	−2.76
	(20.57)	(25.06)		(17.02)	(16.06)	

The table reports the changes in (i) the average size of all public firms and VC/PE-financed public firms for the early period 1994-1998 and for the late period 2011-2015 (marked with †); (ii) the average of size of all and VC/PE-financed firms at the IPO date for the early period 1980-1998 and for the late period 2001-2015. Standard deviations are reported in the parentheses. The firm's size is measured with total assets, market value of firm, market value of equity, market value of firm, revenues, earnings, number of employees, and age. The data are real annual observations, and are expressed in millions of December 2009 dollars, except for the number of employees and age. The number of employees is expressed in thousands, and age is expressed in years. The changes in firm's size between the early and late periods are expressed in percentages. ***, **, and * indicate significance at the 1%, 5%, and 10% level.

C Proofs of Propositions

In this Appendix, we provide proofs for the propositions in the main text.

C.1 Private and Public Firm Values (Proposition 1)

C.1.1 Private Firm Value

The value of a private firm, $v_{priv}(x;\theta)$, satisfies the ODE:

$$(r+\theta+\lambda)v_{priv}(x;\theta) = \mu x\frac{\partial v_{priv}(x;\theta)}{\partial x} + \frac{\sigma^2}{2}x^2\frac{\partial^2 v_{priv}(x;\theta)}{\partial x^2} + (1-\tau)(\mathcal{A}_{priv}(\theta)x^b - c_f), \quad (24)$$

where $b = \frac{}{1-\alpha}$ and

$$\mathcal{A}_{priv}(\theta) = (1-\alpha)\left(\frac{\alpha}{\frac{r+\theta}{1-\tau}+\delta}\right)^{\frac{\alpha}{1-\alpha}}. \quad (25)$$

The solution to the associated homogeneous ODE has the general form:

$$v_{priv}(x;\theta) = A_1 x^{\gamma_1} + A_2 x^{\gamma_2} \quad (26)$$

where γ_1 and γ_2 are roots of the fundamental quadratic, given by

$$\gamma_1 = \frac{1}{2} - \frac{\mu}{\sigma^2} + \sqrt{\left(\frac{\mu}{\sigma^2}-\frac{1}{2}\right)^2 + \frac{2(r+\theta+\lambda)}{\sigma^2}}, \quad \gamma_2 = \frac{1}{2} - \frac{\mu}{\sigma^2} - \sqrt{\left(\frac{\mu}{\sigma^2}-\frac{1}{2}\right)^2 + \frac{2(r+\theta+\lambda)}{\sigma^2}}, \quad (27)$$

with $\gamma_1 > 1$ and $\gamma_2 < 0$. The inhomogeneous portion has a particular solution of the form

$$\frac{(1-\tau)\mathcal{A}_{priv}(\theta)x^b}{r+\theta+\lambda-\mu b-\frac{\sigma^2}{2}b(b-1)} - \frac{(1-\tau)c_f}{r+\theta+\lambda}. \quad (28)$$

Combining, we have a solution of the form

$$v_{priv}(x;\theta) = A_1 x^{\gamma_1} + A_2 x^{\gamma_2} + (1-\tau)\left(\frac{\mathcal{A}_{priv}(\theta)x^b}{r+\theta+\lambda-\mu b-\frac{\sigma^2}{2}b(b-1)} - \frac{c_f}{r+\theta+\lambda}\right) \quad (29)$$

where A_1 and A_2 are solved for by imposing the boundary conditions. We assume that when a private firm exits, it receives zero recovery. Optimal exercise of the exit and IPO options implies the following four boundary conditions:

$$v_{priv}(x_{D,priv};\theta) = 0 \tag{30}$$

$$\frac{\partial v_{priv}(x_{D,priv};\theta)}{\partial x} = 0 \tag{31}$$

$$v_{priv}(\overline{x}_{IPO};\theta) = v_{pub}(\overline{x}_{IPO}) - \mathcal{I}_{IPO} \tag{32}$$

$$\frac{\partial v_{priv}(\overline{x}_{IPO};\theta)}{\partial x} = \frac{\partial v_{pub}(\overline{x}_{IPO})}{\partial x} \tag{33}$$

Equations (30) and (31) are the value matching and smooth pasting conditions for the optimal abandonment threshold, $x_{D,priv}$. Equations (32) and (33) are the value matching and smooth pasting conditions for the optimal IPO threshold, $\overline{x}_{IPO}$. These four equations are solved for the four unknowns: $x_{D,priv}, \overline{x}_{IPO}, A_1$, and A_2.

C.1.2 Public Firm Value

Public firm value satisfies the ODE:

$$(r+\lambda)v_{pub}(x) = \mu x \frac{\partial v_{pub}(x)}{\partial x} + \frac{\sigma^2}{2}x^2\frac{\partial^2 v_{pub}(x)}{\partial x^2} + (1-\tau)(\mathcal{A}_{pub}x^b - c_f) - \mathcal{C}_{pub}, \tag{34}$$

The public firm value has solution of the form

$$v_{pub}(x) = B_1 x^{\xi_1} + B_2 x^{\xi_2} + (1-\tau)\left(\frac{\mathcal{A}_{pub}x^b}{r_{pub}+\lambda-\mu b-\frac{\sigma^2}{2}b(b-1)} - \frac{c_f}{r_{pub}+\lambda} - \frac{C_{pub}}{(1-\tau)(r_{pub}+\lambda)}\right), \tag{35}$$

where ξ_1 and ξ_2 are roots of the fundamental quadratic, given by

$$\xi_1 = \frac{1}{2} - \frac{\mu}{\sigma^2} + \sqrt{\left(\frac{\mu}{\sigma^2}-\frac{1}{2}\right)^2 + \frac{2(r+\lambda)}{\sigma^2}}, \quad \xi_2 = \frac{1}{2} - \frac{\mu}{\sigma^2} - \sqrt{\left(\frac{\mu}{\sigma^2}-\frac{1}{2}\right)^2 + \frac{2(r+\lambda)}{\sigma^2}}, \tag{36}$$

with $\xi_1 > 1$ and $\xi_2 < 0$. The B coefficients and exit threshold $x_{D,pub}$ are determined by the boundary conditions. To ensure the valuation is bounded, we require the coefficient on the positive root, B_1, to be set to zero. Public firm value is then given by

$$v_{pub}(x) = B_2 x^{\xi_2} + (1-\tau)\left(\frac{\mathcal{A}_{pub}x^b}{r+\lambda-\mu b-\frac{\sigma^2}{2}b(b-1)} - \frac{c_f}{r_{pub}+\lambda} - \frac{C_{pub}}{(1-\tau)(r+\lambda)}\right). \tag{37}$$

We assume that a public firm can choose to exit public markets, in which case it receives a fraction of the future cash flows. The following two boundary conditions determine B_2 and $x_{D,pub}$:

$$v_{pub}(x_{D,pub}) = \varrho \frac{(1-\tau)\mathcal{A}_{pub} x_{D,pub}^{b}}{r+\lambda-\mu b-\frac{\sigma^2}{2}b(b-1)}, \tag{38}$$

$$\frac{\partial v_{pub}(x_{D,pub})}{\partial x} = b\varrho \frac{(1-\tau)\mathcal{A}_{pub} x_{D,pub}^{b-1}}{r+\lambda-\mu b-\frac{\sigma^2}{2}b(b-1)}. \tag{39}$$

Plugging in and rearranging gives

$$B_2 x_{D,pub}^{\xi_2} + (1-\tau)\left(\frac{(1-\varrho)\mathcal{A}_{pub} x_{D,pub}^{b}}{r+\lambda-\mu b-\frac{\sigma^2}{2}b(b-1)} - \frac{c_f}{r+\lambda} - \frac{\mathcal{C}_{pub}}{(1-\tau)(r+\lambda)}\right) = 0, \tag{40}$$

$$\xi_2 B_2 x_{D,pub}^{\xi_2-1} + (1-\tau)\frac{(1-\varrho)b\mathcal{A}_{pub} x_{D,pub}^{b-1}}{r+\lambda-\mu b-\frac{\sigma^2}{2}b(b-1)} = 0. \tag{41}$$

These two nonlinear equations can be solved for the two unknowns, B_2 and $x_{D,pub}$.

C.2 Derivation of Private Firm Distribution (Proposition 2)

Define $z \equiv \log(x)$. By applying Itô's Lemma, z evolves as an arithmetic Brownian motion given by

$$dz_t = \left(\mu - \frac{1}{2}\sigma^2\right)dt + \sigma dW_t. \tag{42}$$

Let $\phi(z)$ denote the stationary distribution of log productivity for private firms. Firms exogenously exit at rate λ. A new private firm can choose to enter by paying a cost c_{entry} and draws its initial log cash flow from a distribution denoted $g(x)$. We assume that the distribution of initial cash flows of private firms entrants is uniform: $x_0 \sim U[x_A, x_B]$, where $x_{D,priv} < x_B < \overline{x}_{IPO}$. This implies that the log cash flow distribution of private firm entrants is exponentially distributed over the interval $[x_A, x_B]$:

$$h(x) = e^{z-\hat{z}}, \tag{43}$$

where $\hat{z} = \log(x_B - x_A)$. To solve for the stationary distribution of log productivity, $\phi(z)$, we consider three regions: $z \in (z_{D,priv}, z_A)$; $z \in (z_A, z_B)$; $z \in (z_B, \overline{z}_{IPO})$.

Region 1: $z \in (z_{D,priv}, z_A)$

Over this interval, firms exit at rate λ, however there is no flow of new entrants. The Kolmogorov forward equation (KFE) characterizing the steady state distribution for this region satisfies

$$\frac{1}{2}\sigma^2\phi_{zz}(z) - \left(\mu - \frac{1}{2}\sigma^2\right)\phi_z(z) - \lambda\phi(z) = 0. \tag{44}$$

This has the general solution

$$\phi(z) = C_1 e^{\beta_1 z} + C_2 e^{\beta_2 z}, \tag{45}$$

where β_1 and β_2 are the roots of the fundamental quadratic,

$$\beta = \frac{\mu}{\sigma^2} - \frac{1}{2} \pm \frac{\sqrt{2\lambda\sigma^2 + (\mu - \sigma^2/2)^2}}{\sigma^2} \tag{46}$$

and where $\beta_1 > 0 > \beta_2$. The coefficients C_1 and C_2 are solved below.

Region 2: $z \in (z_A, z_B)$

In this region, firms exit at rate λ due to the death shock and a flow of new firms enter with initial log cash flows given by the distribution $h(z)$. Over this region, the stationary distribution $\phi(z)$ satisfies the KFE:

$$\frac{1}{2}\sigma^2\phi_{zz}(z) - \left(\mu - \frac{1}{2}\sigma^2\right)\phi_z(z) - \lambda\phi(z) + h(z) = 0. \tag{47}$$

This has the general solution

$$\phi(z) = D_1 e^{\beta_1 z} + D_2 e^{\beta_2 z} + D_3 e^{z}, \tag{48}$$

where β_1 and β_2 are the same roots of the fundamental quadratic given in Equation (46) of region 1 above. We can solve for D_3, the coefficient on the particular solution of the KFE, by plugging in:

$$\frac{1}{2}\sigma^2 D_3 e^z - (\mu - \frac{1}{2}\sigma^2) D_3 e^z - \lambda D_3 e^z + e^{z-\hat{z}} = 0. \tag{49}$$

This can be rearranged as

$$D_3 = \frac{e^{-\hat{x}}}{\lambda + (\mu - \frac{1}{2}\sigma^2) - \frac{1}{2}\sigma^2}, \tag{50}$$

which gives a general solution in this case of

$$\phi(z) = D_1 e^{\beta_1 z} + D_2 e^{\beta_2 z} + \frac{e^{z-\hat{z}}}{\lambda + (\mu - \frac{1}{2}\sigma^2) - \frac{1}{2}\sigma^2}. \tag{51}$$

The coefficients D_1 and D_2 are solved by imposing the boundary conditions given below.

Region 3: $z \in (z_B, \overline{z}_{IPO})$

As in region 1, firms in this region exit at rate λ and there is no new entry in this region, so we have the same ODE characterizing the KFE. That is, the KFE satisfies

$$\frac{1}{2}\sigma^2 \phi_{zz}(z) - \left(\mu - \frac{1}{2}\sigma^2\right) \phi_z(z) - \lambda \phi(z) = 0, \tag{52}$$

and the general solution is given by

$$\phi(z) = H_1 e^{\beta_1 z} + H_2 e^{\beta_2 z}, \tag{53}$$

where again the coefficients H_1 and H_2 are solved for by imposing the appropriate boundary conditions.

We have a total of six boundary conditions for the stationary distribution of log productivity of private firms, $\phi(z)$:

$$\phi(z_D) = 0 \tag{54}$$

$$\phi(\overline{z}_{IPO}) = 0 \tag{55}$$

$$\lim_{z \uparrow z_A} \phi(z) = \lim_{z \downarrow z_A} \phi(z) \tag{56}$$

$$\lim_{z \uparrow z_A} \phi_z(z) = \lim_{z \downarrow z_A} \phi_z(z) \tag{57}$$

$$\lim_{z \uparrow z_B} \phi(z) = \lim_{z \downarrow z_B} \phi(z) \tag{58}$$

$$\lim_{z \uparrow z_B} \phi_z(z) = \lim_{z \downarrow z_B} \phi_z(z). \tag{59}$$

Equations (54) and (55) follow from the fact that private firms exit when their log productivity falls to $z_{D,priv}$ and choose to go public when their log productivity reaches the IPO threshold $\overline{z}_{IPO}$. Equations (56)–(59) ensure sufficient smoothness for $\phi(z)$. These six boundary conditions determine the six coefficients, $C_1, C_2, D_1, D_2, H_1, H_2$.

The stationary distribution of private firm log productivity, $\phi(z)$, is given by

$$\phi(z) = \begin{cases} C_1 e^{\beta_1 z} + C_2 e^{\beta_2 z}, & \text{if } z_{D,priv} < z < z_A \\ D_1 e^{\beta_1 z} + D_2 e^{\beta_2 x} + \frac{e^{z-\hat{z}}}{\lambda + (\mu - \frac{1}{2}\sigma^2) - \frac{1}{2}\sigma^2}, & \text{if } z_A \leq z \leq z_B \\ H_1 e^{\beta_1 z} + H_2 e^{\beta_2 z}, & \text{if } z_B < z < \overline{z}_{IPO}. \end{cases} \tag{60}$$

For the level of productivity, x, the stationary distribution of private firms, $\varphi(x)$, can be expressed as

$$\varphi(x) = \begin{cases} C_1 x^{\beta_1 - 1} + C_2 x^{\beta_2 - 1}, & \text{if } x_{D,priv} < x < x_A \\ D_1 x^{\beta_1 - 1} + D_2 x^{\beta_2 - 1} + \frac{1}{(x_B - x_A)(\lambda + (\mu - \frac{1}{2}\sigma^2) - \frac{1}{2}\sigma^2)}, & \text{if } x_A \leq x \leq x_B \\ H_1 x^{\beta_1 - 1} + H_2 x^{\beta_2 - 1}, & \text{if } x_B < x < \overline{x}_{IPO}, \end{cases} \tag{61}$$

C.3 Derivation of Public Firm Distribution (Proposition 3)

As with the private firm distribution, it is easier to work with the log productivity. Again, let $z \equiv \log(x)$ and let $\psi(z)$ denote the stationary distribution of log productivity of public firms. This distribution satisfies the KFE

$$\frac{1}{2}\sigma^2 \psi_{zz}(z) - \left(\mu - \frac{1}{2}\sigma^2\right)\psi_z(z) - \lambda\psi(z) = 0, \tag{62}$$

for $z \neq \overline{z}_{IPO}$. The general solution is given by

$$\psi(z) = \begin{cases} J_1 e^{\zeta_1 z} + J_2 e^{\zeta_2 z}, & \text{if } z_{D,pub} < z < \overline{z}_{IPO} \\ K_1 e^{\zeta_1 z} + K_2 e^{\zeta_2 z}, & \text{if } z > \overline{z}_{IPO}, \end{cases} \tag{63}$$

where ζ_1 and ζ_2 are the roots of the fundamental quadratic,

$$\zeta = \frac{\mu}{\sigma^2} - \frac{1}{2} \pm \frac{\sqrt{2\lambda\sigma^2 + (\mu - \sigma^2/2)^2}}{\sigma^2}, \tag{64}$$

with $\zeta_1 > 0 > \zeta_2$. The coefficients J_1, J_2, K_1, and K_2 are determined by imposing the following conditions:

$$\int_{\overline{x}}^{\infty} \psi(x) < \infty \tag{65}$$

$$J_1 e^{\zeta_1 z_{D,pub}} + J_2 e^{\zeta_2 z_{D,pub}} = 0 \tag{66}$$

$$J_1 e^{\zeta_1 \overline{z}_{IPO}} + J_2 e^{\zeta_2 \overline{z}_{IPO}} = K_2 e^{\zeta_2 \overline{z}_{IPO}} \tag{67}$$

$$\lambda \Upsilon_{IPO} \left(\int_{z_{D,pub}}^{\infty} \psi(z) dz \right) - \frac{1}{2}\sigma^2 \Upsilon_{IPO} \psi'(z_{D,pub}) = \Upsilon_{IPO} \tag{68}$$

Equation (65) ensures that $\psi(z)$ is integrable as $z \to \infty$, which implies $K_1 = 0$. Equation (66) states that there is zero mass of public firms at the optimal exit boundary, $z_{D,pub}$ and equation (67) ensures continuity of $\psi(z)$ at the IPO entry point, $\overline{z}_{IPO}$.

Equation (68) follows from the definition of a steady state distribution of public firms. In steady state, the flow of exit is equal to the flow of entry. The mass of public firms, Q_{public}, can be expressed as

$$Q_{public} = \Upsilon_{IPO} \left(\int_{z_{D,pub}}^{\infty} \psi(z) dz \right). \tag{69}$$

Of the existing mass of public firms, a fraction λ exit due to the Poisson shock. Additionally, some public firms exit by hitting the lower bound of cash flows, $z_{D,pub}$, at which they optimally abandon. The flow of firms hitting this lower threshold $z_{D,pub}$ is given by

$$-\frac{1}{2}\sigma^2 \Upsilon_{IPO} \psi'(z_{D,pub}). \tag{70}$$

Together, these two forms of exit account for the left hand side of Equation (68). This flow of exit must be equal to the inflow of public firms, which is the flow of private firms exercising their IPO option, Υ_{IPO}.

So the stationary distribution of public firm log cash flows is given by $\Upsilon_{IPO} \times \psi(z)$, where

$$\psi(z) = \begin{cases} J_1 e^{\zeta_1 z} + J_2 e^{\zeta_2 z}, & \text{if } z_{D,pub} < z < \overline{z}_{IPO} \\ K_2 e^{\zeta_2 z}, & \text{if } z > \overline{z}_{IPO} \end{cases} \tag{71}$$

The distribution of the level of productivity x for public firms is given by $\Upsilon_{IPO} \times \Psi(x)$, where

$$\Psi(x) = \begin{cases} J_1 x^{\zeta_1 - 1} + J_2 x^{\zeta_2 - 1}, & \text{if } x_{D,pub} < x < \overline{x}_{IPO} \\ K_2 x^{\zeta_2 - 1}, & \text{if } x > \overline{x}_{IPO} \end{cases} \tag{72}$$