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Abstract

This paper extends a model of firm dynamics to incorporate heterogeneous privately held and publicly traded firms facing different financial frictions, and the decision to become publicly traded (Initial Public Offering, or IPO) is endogenous. This allows changes in the economic environment to affect these firms differently, impacting the selection into becoming publicly traded, and its macroeconomic outcomes. Firms are born privately held and small due to financial frictions. They finance investment with internal resources and debt and have the choice to go public (IPO). The main trade-off is access to external equity financing, at a one-off cost of IPO and an increased cost of operation. The calibrated model is successful in capturing the size distribution of firms, the share of publicly traded firms, and the dynamics around the IPO date. The decrease in corporate and dividend taxes experienced from the 1970s to the 1990s benefited more publicly traded firms financing with equity at the margin. This helps explaining the stock market boom, and the observed changes in the characteristics of firms going public, their investment and payout behavior. I perform some counterfactual exercises to understand what could be the reasons behind the decrease in publicly traded firms since the 2000s: increased cost of being public, increased access to debt, or changes in the idiosyncratic shock process. I find these changes are consistent with part (though not all) of the changes in IPO choice, payout and investment behavior of publicly traded firms in this period.

Keywords: firm life cycle, macroeconomics, fiscal policy, corporate finance, IPO.

JEL classification: D25, E23, G32, G35, H25, H32.

Resumen

Este artículo aplica un modelo de dinámica empresarial para incorporar empresas cotizadas en bolsa y empresas no cotizadas, que se enfrentan a distintas fricciones financieras, donde la decisión de hacer una oferta pública inicial (OPI) es una decisión endógena de la empresa. Esto permite que los cambios en el entorno económico afecten de forma distinta a estos dos tipos de empresas, a la decisión de hacer una OPI y a los agregados macroeconómicos. Las empresas nacen como no cotizadas y pequeñas, debido a problemas de financiación. Crecen reinvertiendo beneficios y con deuda, y en cada período tienen la opción de hacer una OPI. El principal beneficio de hacer una OPI es la posibilidad de financiación a través de la emisión de acciones, mientras que la desventaja es el coste de hacer la OPI, además de un coste de operación más elevado el resto de su vida. El modelo calibrado a Estados Unidos consigue reproducir la distribución del tamaño empresarial, la fracción de empresas cotizadas y las dinámicas alrededor de la fecha de la OPI. La bajada del impuesto sobre sociedades y del impuesto a los dividendos de los años setenta a los noventa benefició más a las empresas cotizadas que se estaban financiando a través de la emisión de acciones. Esto ayuda a explicar el *stock market boom* de los noventa, y algunos de los cambios observados en las características de las empresas que hacen OPI, sus decisiones de inversión y de distribución de dividendos, y la emisión de acciones. Finalmente, se llevan a cabo unos ejercicios para intentar entender las razones existentes detrás de la bajada en el número de empresas cotizadas durante los años 2000: un aumento en el coste de ser cotizadas, un incremento en el acceso a deuda o cambios en los *shocks* idiosincrásicos de productividad que reciben las empresas. Aunque alguno de estos cambios puede explicar parte de las modificaciones observadas en los datos relativos a las OPI y en el comportamiento de empresas cotizadas, ninguno es capaz de dar una respuesta unificada a todas las variaciones observadas en el período.

Palabras clave: ciclo de vida empresarial, macroeconomía, política fiscal, finanzas corporativas, OPI.

Códigos JEL: D25, E23, G32, G35, H25, H32.

1 Introduction

Firms' decisions are irredeemably affected by changes in taxes or in the economic environment. However, how these firms react to these changes might vary depending on their individual characteristics. Because of this, it is nowadays more and more common to find economists using heterogeneous agents' model to understand the impact of changes in the economic environment on the size distribution of firms, and ultimately on aggregate output and TFP. Most papers in the firm dynamics' literature focus on publicly traded firms in the US. There are two main reasons for this: these large firms are the ones that influence the most macroeconomic aggregates, since they account for nearly one third of the overall employment in the US; and most readily available firm-level data sources comprise only publicly traded firms, such as Compustat. However, becoming publicly traded is an endogenous choice, since firms decide to list their shares in a stock exchange via an initial public offering (IPO). Furthermore, privately held firms and publicly traded firms have different characteristics, so they might be affected differently by changes in the economy. One of the main differences between these two types of firms is the financial frictions they face. Most private firms finance investment by issuing debt and/or reinvesting internal funds. Very few private firms issue equity, and those that do, equity is generally financed by the firm's owner/manager, since it is hard to raise external equity financing due to informational frictions.¹ Meanwhile, there is around 26% of public firms financing with equity.

In this paper, I introduce an explicit IPO choice in an otherwise standard firm dynamics model, focusing on the different financial frictions privately held and publicly traded firms face.² In this framework, the focus is to understand how different changes in the economic environment (financial costs, costs of being public, idiosyncratic productivity shocks, and especially taxes) might impact differently privately held and publicly traded firms, which then might lead to a reallocation of resources and have important macroeconomic implications. Furthermore, by endogenizing this decision to become publicly traded (IPO), we can better understand the changes in selection into becoming publicly traded, and hence the changes in behaviour (payout, investment and savings policy) of this pool of publicly traded firms. In this way, this paper is able to bridge the gap between the macroeconomics literature studying the aggregate impact of individual firms' decision, and the corporate finance literature studying the motives and consequences of the IPO choice at the firm level.

First, I document several facts about the changes in selection (firms becoming publicly traded) and the characteristics and behaviour of publicly traded firms from 1970 to 2010 in the US. From the 1970s to the end of the 1990s, the US witnessed a stock market boom: the number of IPOs and the number of publicly traded firms nearly doubled, and the stock market value to GDP more than doubled. Average size of public firms and the median size at IPO decreased, while the dispersion of size at IPO increased. However, from the end of the 1990s on, the number of publicly traded firms and IPOs decreased significantly, and the average size of public firms and the median size at IPO increased. This points at differences in the selection of firms becoming publicly traded. However, the behaviour of these publicly traded firms followed the same pattern in these two periods compared to the 1970s: firms were issuing more equity (and more frequently), they increased distributions, investment and the stock of savings. Although these empirical patterns have been studied separately in the literature, to the best of my knowledge this is the first paper developing a model that attempts to rationalize *both* the changes in selection *and* changes in corporate behaviour, and aims to understand its reallocation and aggregate implications.³ Indeed, the aim of the paper is to understand whether some of the important changes in the economic environment witnessed in this period (changes in

¹See C.1 for more details on the differences between publicly traded and privately held firms, and the IPO choice.

²Throughout the paper, I use the terms 'privately held' and 'private'; and 'publicly traded' and 'public' indistinctively.

³Changes in selection were studied empirically for instance in Davis et al. (2006) or Comin and Philippon (2005). Changes in the behaviour of corporate firms have been studied in Armenter and Hnatkovska (2017) or Macnamara (2019), among others.

taxes, financial development, costs of being public, idiosyncratic shocks faced by firms)⁴ can reconcile or not the trends presented here regarding the selection of firms into publicly traded and their behaviour, in order to ultimately assess what their macroeconomic consequences are.

Next, I develop a general equilibrium model with heterogeneous private and public firms, where the decision to become publicly traded is endogenous. In the model there is a fixed mass of firms that are heterogeneous in net worth and productivity. They begin their lives as privately held. Production technology features decreasing returns to scale, and firms feature a life-cycle: they are created small due to financial frictions, grow, and eventually exit. They can finance operations either with debt subject to a collateral constraint, or with retained earnings. Each period, they can decide whether to do an IPO or not. At this decision point, they face a trade-off, as access to (costly) equity markets comes at the expense of a one-off fixed cost of IPO and a higher on-going cost of operation. This higher cost of operation captures the costs of being public, such as higher auditing cost, corporate governance regulations or principal-agent problems, that this paper abstracts from modelling. Both private and public firms suffer the so-called double taxation of profits: they pay corporate taxes and distribution taxes.⁵ Firms deciding to do an IPO are generally those that are constrained since they can benefit from the extra financing they obtain when they are public. When firms have accumulated enough assets, the costs of going public outweigh the benefits, and firms remain private. Thus, as in the real world, the rich dynamics of the model give rise to the existence of large privately held firms (such as Cargill). The publicly traded status is therefore history-dependent since it depends on the stream of shocks the firm received during its life cycle. I calibrate the model to match key moments of the distribution of public and private firms between 1970-1980. Despite its simplicity, the model is able to capture the skewness of the firm distribution, and some key moments for private and publicly traded firms, as well as the age at IPO. Furthermore, the model matches reasonably well the size distribution of firms and other non-targeted moments, and it replicates well the dynamics of firms around the IPO date found in the data by Chemmanur et al. (2009).

With the calibrated model in hand, I perform several counterfactual exercises. First, I focus on the drop in corporate and distribution taxes witnessed from the 1970s to the 1990s in the US, which was one of the largest drops of the last century: distribution taxes decreases 15pp, and corporate taxes decreased nearly 7pp⁶. The impact of changes in taxes is particularly interesting because there is theoretical (Auerbach (2002)) and empirical evidence (Becker et al. (2013)) pointing at the differential impact of taxes on firms financing with external equity or internal resources, meaning these changes might impact differently private and publicly traded firms. I find that a decrease in distribution taxes acts as if external equity financing was cheaper, hence benefiting mostly publicly traded firms financing with equity at the margin. This makes doing an IPO more attractive, so the share of publicly traded firms and the size dispersion at IPO increase, while the median size at IPO and average size of public firms decreases. Publicly traded firms act as if external equity financing was cheaper, so there is a higher fraction of firms issuing equity, and equity to sales increases significantly. Furthermore, the decrease in corporate taxes leaves firms with more after-tax profits to reinvest in their firm or to distribute, so that distributions and investment increase. On top of

⁴Evidence regarding changes in the economic environment (taxes, equity issuance costs, access to debt) is presented in Appendix A.

⁵Taxes on distributions estimated from the data encompass taxes on both dividend and shares repurchases (see Appendix B.1)

⁶I focus only on changes in distribution taxes and corporate taxes, and set aside capital gains tax and income taxes. The first reason is that they did not suffer major changes: according to TAXSIM, capital gains tax increased 4pp from the 70s to the 90s, and then decrease 5pp from the 90s to the 00s; while taxes paid on interest decreased 4pp in the first subperiod, and remained fairly constant in the second subperiod. The second reason is related to the problem studied here. Since there is no organizational choice here (pass-through vs c-corp), income taxes only affect firms through the stochastic discount rate of the household, hence they are not as interesting for the firm dynamics patterns. Capital gains taxes might have important effects on the payout policy and investment decisions of firms. Modelling it correctly, i.e. capital gains being taxed at realization, involves a great deal of complexity, and it is out of the scope of this paper. A simpler way of modelling it into a firm dynamics framework is assuming this tax paid every period: i.e. every period all firms are sold and bought, and capital gains on this sale are taxed every period. Although more technically convenient, this gives rise to the question of its comparability to the real world, even more when we are studying privately held firms, which hardly ever sell the shares of their company.

that, the tax advantage of debt is lower, which makes firms want to store a higher stock of savings for ‘precautionary’ reasons. These changes in selection into public and behaviour of publicly traded firms are all in line with the changes observed in the data. At the aggregate, this differential impact of taxes on public and constrained firms makes concentration of employment to increase. Since firms are less constrained, misallocation decreases, increasing output by 2.5% and TFP by 0.7%. Modelling private and publicly traded firms is key for the increase in concentration: if we only had publicly traded firms in our economy, the increase in the employment share of the top 1% of firms would be one tenth of that of the baseline, and 70% of the increase in stock market capitalization to GDP of the baseline, since it would be missing the selection channel.

In the last section of the paper, I test some of the theories explaining why the share of publicly traded firms decreased in the 2000s within the lens of my model. Taxes decreased slightly further in this period, so although they can still explain most of the patterns in behaviour of publicly traded firms compared to the 1970s, they alone cannot account for the differences in selection into publicly traded. Hence, I explore how the interaction of changes in taxes with other changes in the economic environment (namely the increase in the cost of being public, increased access to debt, or changes in the idiosyncratic shock process) affect firms’ payout, investment policies and IPO choice. An increase in the cost of being public, one of the most common explanations behind the decrease in the number of IPOs since the 2000s, is consistent with some trends in selection (it brings a decrease in the share publicly traded firms and an increase in the size as compared to the 1990s), but it is at odds with others, since it would predict a lower increase in concentration and a much lower increase in stock market capitalization to GDP. Greater access to credit predicts less firms becoming publicly traded and a higher average size as compared to the experiment changing only taxes. This would predict a larger increase in concentration, and a significant increase in output and TFP thanks to the lower misallocation.

Regarding changes in the idiosyncratic shock process, I first assume the changes in the persistence of the shock process of privately held firms were the same as that measured from publicly traded firms in Compustat, which means it increased from 0.82 to 0.85. Second, firm-level volatility has decreased, as shown by Davis et al. (2006) and Bloom et al. (2017), so I qualitatively assess what would be the implications of a decrease in the volatility of 20%, within the range of that found by Bloom et al. (2017). This can rationalize the decrease in the number of IPOs and the number of public firms, together with an increase in the size of public firms, but predicts a decrease in investment and a decrease in stock market capitalization to GDP, at odds with the data. Summing up, none of these changes can account for the full story, but it is likely to be the mix of them that is driving the overall results, together with two other important changes that happened in this period and that this simple model cannot account for: the increase in mergers and acquisitions (M&As) and the increase in private capital financing.

Related Literature. This paper is related to a vast literature studying the role of financial frictions and taxes on heterogeneous firms’ decisions. Hennessy and Whited (2007), building on the model of Gomes (2001), use a dynamic model with endogenous choice of debt, costly equity issuance, distributions, and real investment in the presence taxes to infer the magnitude of financing costs. They find these frictions are important to understand firms’ behaviour in the data. Jermann and Quadrini (2007) use a model with heterogeneous firms featuring financing frictions to demonstrate that the mere prospect of high future productivity growth experienced during the 1990s can generate sizable gains in current productivity, as well as a stock market boom. Gourio and Miao (2010) and Gourio and Miao (2011) study the long run and transitional effects of dividend and capital gains taxation on aggregate capital with a continuum of firms subject to idiosyncratic productivity shocks, finding that changes in these taxes matter for the financing and investment decision of firms. Anagnostopoulos et al. (2017) study the aggregate and distributional effects of reforms that replace corporate profit taxes with dividend taxes in a model that features both household and firm heterogeneity, finding that this reform yields distributional gains with a large majority

of households benefiting. Some papers have also highlighted the role of the life cycle of firms within the firm dynamics framework. Cooley and Quadrini (2001) show that a firm dynamic model featuring financial frictions and persistent shocks can account for the simultaneous dependence of the firm dynamics on size and age found in the data. Furthermore, Erosa and González (2019) study the aggregate effects of a full set of capital income taxes (corporate tax, dividend tax, capital gains tax and personal tax) in a model with heterogeneous firms featuring endogenous entry and life cycle, and find that each tax has different asymmetric effects throughout the firms' life cycle (young vs old), affecting investment, entry choices, and macroeconomic aggregates. This paper builds on all of them by introducing financial frictions and taxes when modelling the life cycle of firms. However, a common feature of all these papers is that they focus on publicly traded firms: all firms can finance via equity issuance, and in most of them data from publicly traded firms (Compustat) is used to discipline their models. Hence, introducing privately held firms and an endogenous IPO is the main contribution on this literature. There is also a vast literature studying the dynamics of small producers, or entrepreneurs', who face financial frictions. These papers usually try to explain wealth inequality (e.g., Quadrini (2000), Cagetti and De Nardi (2006)) or to understand how financial frictions affects firms' choices and economic aggregates in developing countries, where most firms are small (e.g. Erosa and Hidalgo Cabrillana (2008)). However, these papers usually overlook heterogeneity in the *corporate* sector. Very few papers model heterogeneity of private firms *and* publicly traded firms in the same model. Zetlin-Jones and Shourideh (2017) study how financial shocks affect private (risk averse) firms and public (risk neutral) firms asymmetrically, and how this can affect the macroeconomic implications of financial shocks. Thesmar and Thoenig (2011) explain the divergence in volatility trends of public and private firms by an increase in the stock market participation and better risk sharing. Although these papers model private and public firms, neither of them have endogenous IPO choice, i.e. the mass of private and public firms is fixed, so private and publicly traded firms only interact through general equilibrium forces, hence by construction they cannot talk about selection into publicly traded. My paper is most related to Clementi (2002), one of the very few examples introducing the IPO choice in a firm dynamics setting. He uses a dynamic stochastic model of firm behavior where a risk-averse entrepreneur can take his firm public. Unlike this paper, he has a partial equilibrium framework where he seeks to explain why operating performance of the firm is increasing before IPO and it decreases afterwards, but he abstracts from understanding the different impact of changes in the economic environment on public and private firms, and how this can impact the IPO choice and macroeconomic aggregates.

The rest of the paper is organized as follows. Section 2 documents the changes in selection and behaviour of public firms. Section 3 presents the model. Section 4 explains the estimation strategy, and describes the fit of the baseline model. Section 5 shows the counterfactual experiments, where Section 5.1 presents the effect of changes in taxes from the 1970s to the 1990s and explores its implications, and Section 5.2 explores the effects of changes in taxes, costs of being public, access to debt, and the idiosyncratic shock process from the 1970s to the 2000s. Section 6 concludes.

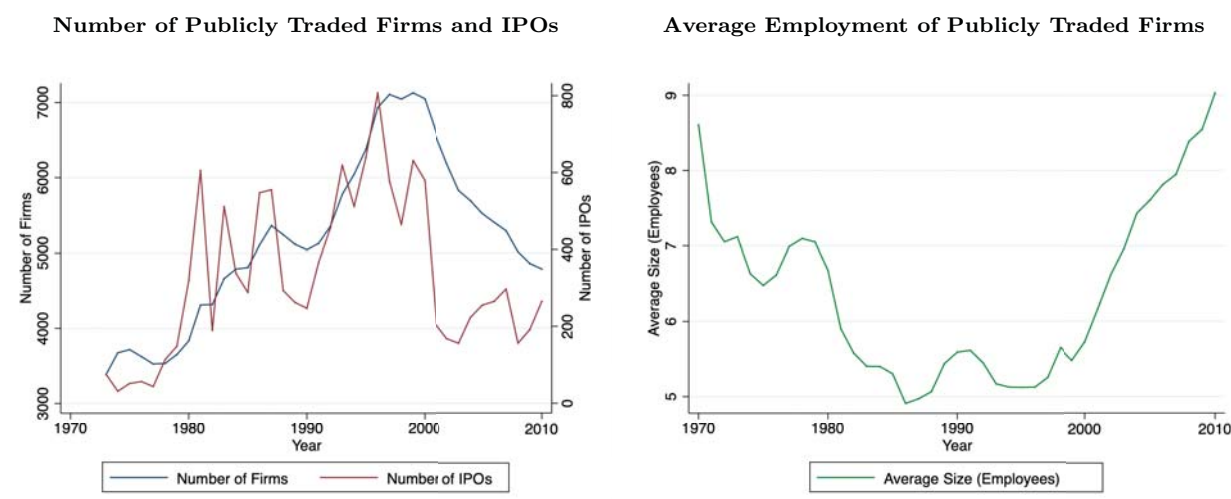
2 Empirical Evidence

This section reviews the main changes in *selection* (IPO choice) and *behaviour* of publicly traded firms' from the decade of the 1970s to the 2000s in the US; and it briefly summarizes the main empirical patterns of the IPO decision that motivate the modelling choices later on, which are developed further in Appendix C.1. The main data source is Compustat, as explained in Appendix A. Since I am interested in the long term effect of changes in the economic environment, and in order to avoid capturing business cycle movements, I separate the data in three periods: 1970-1980, 1990-2000, and 2000-2010.

Selection. There have been several changes in the characteristics of firms doing IPOs in this period. More concretely:

- 1.- *Increase in the number of IPOs and publicly traded firms until end of the 1990s, decrease afterwards.*

Figure 1: Changes in Selection into Publicly Traded



Source: Authors' calculations using Compustat, following the description of Appendix A. Average size (employment) measured in thousands of employees.

On the left Panel of Figure 1, we can observe the ‘*stock market boom*’ witnessed in the US since the 1970s until the 1990s. There were more firms becoming publicly traded, and the number of publicly traded firms increased significantly.⁷ However, since the end of the 1990s, there seems to be a ‘reversal’ in this trend: the number of IPOs and the number of publicly traded firms decreases.

2.- *Average size of publicly traded firms decreases until the 1990s, but it increases afterwards.* The average size of publicly traded firms follows also a U-shaped relationship, as can be observed in the right Panel of Figure 1. From the 1970s up to 1990s, the average size of publicly traded firms was decreasing: it went from 6,999 employees in the 1970s to 5,389 employees on average in the 1990s. However, average size in the 2000s is 7,556, which means an increase in size as compared to the two previous periods.

3.- *Median size at IPO decreases until the end of the 1990s but increases afterwards. However, the dispersion of size at IPO increases during all the period.* As shown in Table 1, the median size at IPO decreases until the 1990s, and then it increases to 310 employees. All the previous facts seem to point at a reversal in the selection pattern: something happened in the 1990s that is reverted back in the 2000s. However, this is not the case along other dimensions: the dispersion of employment at IPO increased significantly during all the period studied, meaning there were smaller *and* larger firms becoming publicly traded.

4.- *Stock market capitalization to GDP increases.* The stock market capitalization as a ratio to US GDP does not follow either the expected U-shaped pattern: even though the number of publicly traded firms decreases in the 2000s, their market valuation increases so much that the stock market capitalization to GDP increases.

Behaviour of publicly traded firms. Firms that are publicly traded have exhibited changes in their corporate behaviour: payout policy, investment and savings policies, as described in the lower Panel of Table 1⁸. Unlike the changes in selection, none of this patterns is reverted in the 2000s, pointing at the interaction of different forces of the economic environment affecting selection and behaviour of public firms differently.

⁷Firms publicly traded as a share of all the firms in the economy follows the same pattern as the number of publicly traded firms, so it is not the extensive margin (changes in the number of firms operating in the economy) the one driving the results. See a more detailed description of entry and exit rates into publicly traded in Appendix A.2

⁸Although these changes in selection might be partly due to changes in composition (entrants vs incumbents), in Appendix A.2 I show these patterns are followed by both entrants *and* incumbents.

Table 1: Main statistics

	1970s	1990s	2000s
<i>Selection & Composition</i>			
Avg. Size Public	7.00	5.39	7.56
Median Size at IPO	0.54	0.22	0.31
p75 to p25 Size at IPO	7.90	12.13	41.37
Stock Market Capitalization to GDP	0.42	1.01	1.22
<i>Behaviour Publicly Traded</i>			
Fraction firms eq>0	0.12	0.30	0.30
Equity to Sales	0.007	0.024	0.018
Distributions to Sales	0.018	0.031	0.043
Investment to Sales	0.046	0.066	0.66
Financial Assets to Total Assets	0.32	0.39	0.41

Source: Compustat. Averages over a ten year window. Average size is measured in employees (thousands). Equity to sales, and distribution to sales are employment weighted. Variables are winsorized at 2%. For more information about data construction, see Appendix A.

1.- *Increase in the extensive and intensive margin of equity.* The fraction of firms issuing equity increased significantly, from a 12% in the 1970s to around a 30% in the 1990s. Not only there were more firms issuing equity, but they were issuing larger amounts of equity, increasing nearly 10 times the average equity to sales. During the 2000s, these patterns did not revert: there were more firms issuing equity, and issuing larger quantities.

2.- *Increase in distributions, investment.* Firms in the 1990s period also increased distributions to their shareholders, and increased their investment in capital.⁹ Furthermore, firms are investing more in capital as a share of their sales.¹⁰

3.- *Increase in the stock of corporate savings.* Since the 1990s, firms have been increasing the amount of financial assets they hold inside the firm, from being around 32% of the overall assets to 41%. Also, net financial assets, defined as financial assets minus financial liabilities, have been increasing during this period turning the corporate sector in the US into a net lender.

The IPO choice. In this section, I review some regularities surrounding the IPO decision and the financing of private and public firms, on which I base some of the modelling choices in the next section. An Initial Public Offering is the first time a privately held firm offers its stock publicly. Going public is usually thought of as a 'one-way' process¹¹, and the cost of going back to being privately held are large, so firms carefully weigh in the pros and cons of doing an IPO. According to Ritter and Welch (2002), the main reason for going public is '*...the desire to raise equity capital for the firm and to create a public market in which the founders and other shareholders can convert some of their wealth into cash at a future date*', and they argue that '*nonfinancial reasons, such as increased publicity, play only a minor role for most firms*'. Because of this, in this paper I explicitly focus on the financial friction motive for going public.¹² *Becoming public is costly*: transaction costs include the compensation to underwriters plus all the legal, accounting, and other fees, that imply a spread on equity issued at IPO that range between 14% in the 1970s to 11%

⁹I refer to distributions as the total amount of funds distributed to shareholders, i.e. dividends and share repurchases.

¹⁰Gutiérrez and Philippon (2016) find a decreasing pattern for investment intensity. One of the differences with the analysis conducted here is that they study gross investment (in capital and R&D) to operating income, instead of investment in capital to sales.

¹¹Although in practice there are firms that delist and go back to being private, usually through acquisition or leveraged buyout, it can be a difficult and costly process for most firms.

¹²By doing so, I abstract from other reasons for becoming public (for instance, owners' risk aversion) and other IPO-related phenomena caused by information asymmetries or owners' shares dilution.

in the 2000s.¹³ Not all firms are qualified to list in a stock exchange: firms need to meet certain size and profitability criteria¹⁴. Being publicly traded is also costly, since they are required by the SEC under the Securities 1934 Act to file certain periodic reports to keep the investing public informed (annual and quarterly reports, information in the corporate webpage, etc.). Because of this, the *cost of being public* is high: according to a survey performed by PWC (PWC, 2012), on average companies incur \$1.5 million of recurring costs as a result of being public.

3 Model

I consider an infinite horizon model in discrete time, $t=0,1,2,\dots$. Each period is a year, and there is no aggregate uncertainty. The economy is populated by a representative household, who supplies labor inelastically, a fixed mass Υ of heterogeneous privately held and publicly traded firms, and a government. Firms are characterized by its permanent component of productivity θ , the level of transitory productivity z , its capital k and its level of debt b . To simplify notation, call the vector of idiosyncratic states $x \equiv \{\theta, z, k, b\}$. There are two main differences between privately held and publicly traded firms. First, publicly traded firms can access the equity markets, while privately held cannot. This feature captures that private firms do most of their financing with retained earnings or debt, since accessing the equity markets is very costly due mainly to information asymmetries¹⁵. Second, publicly traded firms need to pay a fixed cost of operation, whereas privately traded firms do not. This cost captures the higher ongoing costs of publicly traded firms, such as annual reports, auditing, SEC filings, etc. The household is the final owner of all firms, since she owns two funds: the *private capital fund*¹⁶, which is comprised of all private firms; and the *mutual fund*, comprised of all public firms.

Firms start as privately held. They draw the permanent component of productivity θ and the transitory component of productivity z . Before taking the productivity draw, the household, through the private capital fund, finances its initial operation. Because of information asymmetries, the private capital fund does not observe the type of the firm, and faces a high cost of external financing, so the firm is not funded optimally. Every period, they operate, decide how much to reinvest and how much to distribute as dividends, but they cannot issue external equity again. At the end of the period, the exit shock and the productivity shock are realized. After this, at the beginning of the next period, the firm decides whether to remain private, or to begin the following period as a public firm by doing an IPO. If it decides to do an IPO, the private capital obtains the proceeds of the IPO, and the company is acquired by the mutual fund. The trade-off faced at the IPO decision is access to (costly) equity markets, at the expense of a fixed cost of IPO and a higher on-going cost of operation. In Appendix C.1 I show evidence supporting this trade-off in the data.

Publicly traded firms produce, decide how much to invest, how much to distribute as dividends, and how much equity to issue at the beginning of the period. At the end of the period, the exit shock and the productivity shock are realized, and after this, they can decide whether to exit or not before next period

¹³Own calculations using SDC data.

¹⁴Firms that want to trade their shares in stock exchanges need to meet a set of minimum requirements. For instance, to trade in NASDAQ Global Markets firms need to have income from continuing operations before income taxes (in latest fiscal year or in two of last three fiscal years) of at least \$1,000,000, and have a market value of publicly traded shares of \$8,000,000 to qualify for trading.

¹⁵This is a simplification, since some private firms do have access to private capital or venture capital funds, but captures the difficulty private firms have finding outside investors for their projects, due to monitoring difficulties of private firms. Very few firms use external equity financing for financing operations, and those that do, mostly raise equity from the owners (see Appendix C.1.1). When a firm raises money from its owner, we can think of the firm as an entrepreneur operating a technology and deciding to invest in his company: as long as he is constrained, changes in the external cost of equity will not have a large impact in the investment of the firm. I discuss the evolution of venture capital backed firms, and their behaviour around the IPO, in Section C.1.3

¹⁶Note that we are assuming that private firms are risk neutral. However, there is evidence pointing at the poor diversification of private firms (Moskowitz and Vissing-Jorgensen (2002)), so it is likely that private firms, when owned by an undiversified owner, exhibit risk aversion. This would give the IPO an extra value, since private firms are getting rid of the inherent risk of the firm. I include this in a reduced form in this paper, by assuming that private firms need to distribute as dividends at least a fraction ϵ of after tax profits. Modelling explicitly this feature would require a more complex model. In order to focus on the financial friction mechanism and to keep the model simple, it abstracts from risk aversion, but all the insights would still hold if private firms were risk-averse.

begins. After exogenous exit (private and publicly traded firms) or endogenous exit (publicly traded firms), new firms will replace the exiting ones starting as privately held.

Technology

Both privately held and publicly traded firms have access to same production function

$$y = \exp(z + \theta) (k^\alpha n^{1-\alpha})^\varrho, \quad (1)$$

where k is the amount of capital, and n the labor used in production. The parameter $\varrho < 1$ controls the degree of returns to scale.

Financing

Firms can finance themselves via three different ways: retained earnings, borrowing funds, or equity issuance. The firm can save (b can be negative) or borrow, but there is a borrowing constraint such that $b \leq \gamma k$, with $0 \leq \gamma \leq 1$ ¹⁷.

The budget constraint of privately held firms and publicly traded are (2) and (3) respectively, where d and e have non-negativity constraints, and $\xi(e)$ is the equity issuance cost.

$$d + k' - b' = (1 - \tau_c)(y - wn) + (1 - (1 - \tau_c)\delta)k - (1 + (1 - \tau_c)r)b \quad (2)$$

$$d - e + \xi(e) + k' - b' + (1 - \tau_c)\kappa = (1 - \tau_c)(y - wn) + (1 - (1 - \tau_c)\delta)k - (1 + (1 - \tau_c)r)b \quad (3)$$

The budget constraints are identical but for two ingredients: public firms can issue equity, subject to equity issuance costs, and they have to pay an operation cost κ . Substituting for the optimal n given k , and rearranging, we obtain in the right-hand side the following term, and call it cash on hand $m(x)$:

$$m(x) = (1 - \tau_c)\pi(x) + k - b \quad (4)$$

where profits $\pi(x)$ are as follows:

$$\pi(x) = \Phi(w)k^{\frac{\alpha}{1-(1-\alpha)\varrho}} \exp(z + \theta)^{\frac{1}{1-(1-\alpha)\varrho}} - \delta k - rb \quad (5)$$

and $\Phi(w)$ ¹⁸ is a function of the wage and parameters. I introduce a slight different timing assumption to simplify the state space¹⁹. Let's introduce a new variable, called net worth a , i.e. $a = k - b$ ²⁰. The timing assumption is that the firm chooses a' inter-period, and then intra-period the firm decides how to allocate the net worth available a between capital k and debt (or savings) b , taking into account the borrowing constraint. This timing convention allows to simplify the idiosyncratic state space of the firms, which now is $x \equiv \{\theta, z, a\}$. Introducing this, and substituting $b = k - a$, we obtain that firms maximize profits intra-period:

$$\pi(x) = \max_k \Phi(w)k^{\frac{\alpha}{1-(1-\alpha)\varrho}} \exp(z + \theta)^{\frac{1}{1-(1-\alpha)\varrho}} - \delta k - r(k - a) \quad (6)$$

$$\text{s.t. } k \leq \phi a \quad (7)$$

¹⁷For the sake of simplicity, I assume the parameter governing the borrowing constraint is the same for private and public firms.

¹⁸ $\Phi(w) = \frac{w}{(1-\alpha)\varrho} \frac{1}{(1-\alpha)\varrho-1} \left(\frac{w}{(1-\alpha)\varrho} (1-\alpha)\varrho - w \right)$

¹⁹This timing is made on the spirit of Buera and Moll (2015)

²⁰Note the difference of net worth with total assets of the firm as they appear in the balance sheet of firms, which in the model would be given by $at = max(a, k)$.

with $\phi = \frac{1}{1-\gamma} \geq 1$. The solution of this problem²¹ is:

$$k^*(x) = \begin{cases} k^{unc}(\theta, z) & \text{if } k^{unc}(\theta, z) \leq \phi a \\ \phi a & \text{if } k^{unc}(\theta, z) > \phi a \end{cases} \quad (8)$$

There are two reasons why the borrowing constraint might not be binding in equilibrium: getting a negative productivity shock, and the ‘precautionary savings motive’. Note that, in a world with no uncertainty, the optimal choice of net worth a' for next period would be such that the firm is constrained, i.e. $a' = k^{unc}(\theta, z)/\phi$, since there is a tax advantage to debt and there exists an uninsured exogenous exit risk. However, when introducing uncertainty, there will be a precautionary savings motive for hoarding assets if the firm expects its productivity to grow in the future, since internal financing is cheaper than external financing, therefore the borrowing constraint might be optimally not binding.

3.1 Private Firms

Private firms maximize the stream of dividends received by the private capital fund, subject to their borrowing constraint. They cannot issue equity, $e = 0$. The problem they solve is the following:

$$W(\theta, z, a) = \max_{\{d, a'\}} (1 - \tau_d)d + \beta(1 - \varsigma)E [\max\{W(\theta, z', a'), W^{IPO}(\theta, z', a')\}]$$

$$\text{s.t. } d + a' = (1 - \tau_c)\pi(\theta, z, a) + a \quad (9)$$

$$d \geq \varepsilon(1 - \tau_c)\pi(\theta, z, a) \quad (10)$$

They choose d and investment to maximize the future stream of dividends. Then, the death shock ς and the productivity shock z' realize. After that, the firm can choose whether to do an IPO and start the following period as public, or whether to remain privately held. To formalize other frictions that affect privately held firms, I assume they need to distribute at least a fraction ε of their after-tax profits. The purpose of this is twofold. Firstly, it is a simple way of modelling in a reduced-form the low diversification of privately held firms (Moskowitz and Vissing-Jorgensen (2002)), and hence the need to smooth dividends²². Secondly, this parameter is key in matching the speed at which firms can undo financing frictions, and therefore the speed at which they can grow before they do an IPO²³.

IPO

An IPO is when a private firm raises capital by offering its stock to the public for the first time. Going public has different costs: direct, such as underwriting fees, legal fees, etc.; and indirect, such as underpricing, principal-agent problems, disclosure of public information, etc. I model an IPO in a reduced form way as a fixed cost that needs to be paid upfront, i.e. before the IPO takes place. Paying it upfront prevents firms with very low assets to do an IPO, even if their productivity is very high and they are very constrained. This is in line with the listing requirements imposed by many listing exchanges, which do not allow firms not meeting certain thresholds to list. The value of doing an IPO is therefore the value of the firm being publicly traded, after the IPO cost is paid:

$$W^{IPO}(\theta, z, a) = V(\theta, z, a - \xi_0) \quad (11)$$

²¹ $k^{unc}(\theta, z) = \left(\frac{r+\delta}{\varrho\alpha\exp(z+\theta)}\right)^{\frac{\varrho(1-\alpha)-1}{1-\varrho}} \left(\frac{w}{\varrho(1-\alpha)\exp(z+\theta)}\right)^{-\frac{\varrho(1-\alpha)}{1-\varrho}}$

²²Just think of a regular model with entrepreneurs owning the private firm with concave utility function (i.e. featuring risk aversion). The need for consumption smoothing will force the firm to distribute dividends every period.

²³In unreported results, I do a sensitivity analysis setting $\varepsilon = 0$ and all results remain qualitatively unchanged.

In order to keep tractability, I assume that the private capital fund transfers the whole ownership of the firm to the mutual fund. Note that this assumption is without loss of generality given the previous assumptions made in the model: since the final owner of the private capital fund and the mutual fund is the household, the pricing and the discount factor will be the same, and hence the objective function of the firm does not change with the share of equity the private fund keeps.

Once the firm is public, it can decide how much equity to issue. The cost of doing an IPO is therefore the fixed cost of the IPO, plus the equity issuance costs of the equity issued during the first period as public, so that the overall cost of the IPO expressed as a spread of the equity issued is:

$$\text{Cost IPO} = \frac{\xi_0 + \xi(e(\theta, z, a))}{e(\theta, z, a)} \quad (12)$$

3.2 Public Firms

Public firms maximize profits, subject to their borrowing constraint. They can issue equity e , but subject to equity issuance costs $\xi(e)$. They have to pay a fixed cost every period, $\kappa > 0$. This fixed cost represents the higher costs of operating as a public firm, such as auditing costs, reporting costs, etc. Note that because of this fixed cost of operation, it might be the case that firms want to exit the economy if they receive a bad productivity shock and the value of continuing operations falls below zero. Firms can only distribute positive profits, i.e. $d \geq 0$, and cannot do share repurchases, i.e. $e \geq 0$.²⁴ Note publicly traded firms cannot return to being public. This assumption is made for simplicity²⁵, and we could think of it as having a cost of reverting back to privately held that is so high that no firm does so in equilibrium.

$$V(\theta, z, a) = \max_{\{d, e, a'\}} (1 - \tau_d)d - e + \beta(1 - \varsigma)E[\max\{V(\theta, z', a'), 0\}]$$

$$\text{s.t. } d - e + \xi(e) + a' = (1 - \tau_c)(\pi(\theta, z, a) - \kappa) + a \quad (13)$$

$$d \geq 0; e \geq 0 \quad (14)$$

3.3 Entry and Exit

Entry in the model is exogenous, since the mass of firms that enters is exactly that of those exiting. Firms start as private. When they are born, they draw a fixed component of productivity θ and a transitory component z , which will evolve over time. This implies ex-ante heterogeneity, i.e. permanent productivity θ and draw of z ; and ex-post heterogeneity, i.e. posterior realizations of z after entry²⁶. Private capital fund, who provides financing only at the early stage of their life, knows the distribution of entrants, but they do not know the type θ or productivity z before making the initial investment. They have access to a technology that transforms $\vartheta a_{\text{init}}^2$ units of final good into a_{init} initial financing. The quadratic cost of financing the firm aims to capture in a very reduced form way the informational frictions of start-ups. The amount of financing provided to each firm is then given by:

$$a_{\text{init}} = \text{argmax}\{E[W^{PR}(\theta, z, a_{\text{init}})] - \vartheta a_{\text{init}}^2\} \quad (15)$$

²⁴Some authors allow for share repurchases (see for instance, Gourio and Miao (2011)). Share repurchases are taxed at capital gains tax, but dividends are taxed at income tax. If $\tau_g < \tau_d$, firms would only make distributions via share repurchases. To avoid this, these models impose an exogenous lower bound. In this case firms will always start making distributions via share repurchases, until they reach the limit, and from that point they make the rest of the distributions as dividends. Comparing it to the framework presented here, firms would start making distributions earlier (via share repurchases), while not distributing dividends. However, for firms distributing dividends, the overall distribution is the same, and the only thing that changes is its 'label'. This is true even in the presence of capital gains taxes, as long as $\tau_d > \tau_g$. When estimating the distribution tax, I take into account the amount of share repurchases and its different taxation, computing therefore an estimate of the overall tax on distributions, i.e. dividends and share repurchases. See Appendix B.1.

²⁵Less than 2% of firms in the data actually decide to delist and go back to private (see Appendix A.2.).

²⁶This is in line with findings of Pugsley et al. (2018). Using micro data for the US, they provide evidence that ex-ante differences in the growth potential of firms accounts for most of the size heterogeneity across firms of a given age.

There is exogenous exit in the model, given by ς . There exists the possibility of endogenous exit of publicly traded firms, since they have to pay a fixed cost of operation that might make the expected continuation value negative.

3.4 Timing

The timing of the problem is as depicted in Figure 2. At the very beginning of the period, and before operation takes place, private firms decide whether to do an IPO or remain private, and publicly traded firms decide whether to exit or not. Privately held or publicly traded firms that received the exogenous exit shock at the end of last period also exit the economy. At the same moment, firms replacing those exiting (exogenously or endogenously) enter the economy. Next, all firms operate, and make the payout and investment decisions. After all these decisions are made, firms receive the shock to productivity, and the exogenous exit shock.

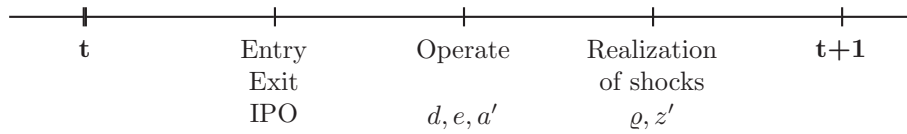


Figure 2: Timing of the Problem

3.5 Government

Government transfers to the household in a lump-sum way the receipts of taxes,

$$T_t = \int (\tau_d d_t^{PU}(x_t) + \tau_c \pi_t(x_t)) d\mu_t^{PU} + \int (\tau_d d_t^{PR}(x_t) + \tau_c \pi_t(x_t)) d\mu_t^{PR}. \quad (16)$$

3.6 Household

There is a continuum of homogeneous workers, characterized by a representative household. Every period, they supply their work \bar{L} inelastically. They decide how much to consume, C , and how much to save in the risk-free asset, A_{t+1} , the shares φ_{t+1} they own of the mutual fund composed by all public firms, and the shares of the private capital fund they own ψ_{t+1} .

$$\max_{\{C, \varphi_{t+1}, \psi_{t+1}, A_{t+1}^{HH}\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t U(C)$$

$$C_t + \varphi_{t+1} \Omega_t^{PU} + \psi_{t+1} \Omega_t^{PR} + A_{t+1} = \quad (17)$$

$$\varphi_t (D_t^{PU} + \Omega_t^{PU} - P_t^{IPO}) + \psi_t (D_t^{PR} + \Omega_t^{PR} + P_t^{IPO} - E_t) + (r_t A_t^{HH} + w_t \bar{L}) + A_t^{HH} + T_t, \quad (18)$$

where the net dividends received from the public firms conforming the mutual fund and from private firms in the private capital fund, respectively, are defined as

$$D^{PU}_t = \int ((1 - \tau_d) d_t^{PU}(x_t) - e_t(x_t)) d\mu_t^{PU} \quad (19)$$

$$D^{PR}_t = \int ((1 - \tau_d) d_t^{PR}(x_t)) d\mu_t^{PR}. \quad (20)$$

The ex-dividend price of the mutual fund and the private capital fund valued at time t , with pricing kernel m_t , is

$$\Omega_t^{PU} = m_t(1 - \varsigma) \int E[V_{t+1}(x_{t+1})]d\mu_t^{PU} \quad (21)$$

$$\Omega_t^{PR} = m_t(1 - \varsigma) \int E[W_{t+1}(x_{t+1})]d\mu_t^{PR}. \quad (22)$$

The cost of acquiring new firms for the mutual fund at the IPO (P^{IPO}) is received by the private capital fund²⁷. E_t is the cost of financing new entrants, i.e.

$$E_t = M_{et} \int_{\theta} \int_z \vartheta a_{\text{init}}(\theta, z)^2 dF_z dF_{\theta} \quad (23)$$

$$P_t^{IPO} = \int I_{IPO}(x_t) V_t(\theta, z, a - \xi_0) d\tilde{\mu}_t^{PR}, \quad (24)$$

$$(25)$$

where M_{et} is the (exogenous) mass of entrants, that replace firms exiting the economy; $\tilde{\mu}_t^{PR}$ is the distribution of firms at the beginning of the period, i.e. before entry or IPO decisions take place.

There is no aggregate uncertainty, and since there is a continuum of private and publicly traded firms, the problem of the household is deterministic. I focus in steady state, where all allocations are constant, so I can drop the time subscripts. In equilibrium, households own all the shares of the private capital and the mutual fund, and the pricing kernel is $m = \frac{1}{1+r}$. Hence, in steady state, consumption of the representative household is given by her budget constraint,

$$C = D^{PR} + D^{PU} + rA^{HH} + w\bar{L} + T - E. \quad (26)$$

3.7 Equilibrium

Given taxes τ_d, τ_c , entry costs ϑ , and equity issuance costs $\xi(e)$; a stationary recursive competitive equilibrium consists on aggregate prices $\Theta = \{w, r\}$, policies for privately held firms ($d^{pr}, a^{pr'}, l, k, I_{IPO}$), policies for publicly traded firms ($d^{pu}, e^{pu}, a^{pu'}, l, k, I_s$), aggregate level of consumption for the household C , and distributions over idiosyncratic states (μ^{PR}, μ^{PU}) such that:

1. **Privately held firms.** Given prices, taxes, and equity issuance costs, $\{d^{pr}, a^{pr'}, l, k, I_{IPO}\}$ solve the private firm's problem (9).
2. **Publicly traded firms.** Given prices, taxes, and equity issuance costs, $\{d^{pu}, e^{pu}, a^{pu'}, l, k, I_s\}$ solve the publicly traded firm problem (13).
3. **Household** consumption is given by (26).
4. **Government's** budget constraint (16) is satisfied (all tax revenue is rebated back to consumers as a lump sum transfer).
5. Given prices, taxes, equity issuance costs, and optimal policies, the distribution of private firms μ^{PR} and of publicly traded firms μ^{PU} is stationary.
6. Labor and assets market clears.

²⁷Remember the fixed cost is paid by the firm right before doing the IPO, and this is included in the price of the firm at the IPO.

$$\text{Labor : } \sum_{j \in \{PR, PU\}} \int l(\theta, z, a) d\mu^j = \bar{L} \quad (27)$$

$$\text{Capital : } \sum_{j \in \{PR, PU\}} \int a(\theta, z, a) d\mu^j + A^{HH} = \sum_{j \in \{PR, PU\}} \int k(\theta, z, a) d\mu^j \quad (28)$$

3.8 Discussion

IPO decision

The IPO choice depends on the permanent level of productivity θ , the level of transitory productivity z and its stochastic process, and the amount of net worth a the firm has, given the frictions of the model. This implies the IPO choice does not follow a productivity or size cut-off rule. The advantage of going public is having access to (costly) equity issuance, and therefore reducing the financing constraints, and avoiding to have to pay a fraction of the profits as distribution every period. The disadvantages are having to pay a one-off cost ξ_0 , and a going-on cost κ ever after. Hence, firms trade-off the cost-benefit of the IPO, and the decision depends on how much constrained the firm is, and how much constrained it expects to be in the future.

Only firms with high permanent type θ will ever go public. They are more constrained, benefit more from equity issuance, and they can afford the ongoing fixed cost of operation²⁸. Firms with very low net worth cannot go public, no matter what their productivity is, since they must be able to pay the fixed cost of IPO ξ_0 up-front, and pay the ongoing costs of operation κ . This generates a *lower threshold* for the amount of net worth at IPO. Firms with very high level of net worth never go public, no matter what their transitory productivity is. They are very large and unconstrained, and paying the fixed and on-going costs of being public is not worth it.

Firms deciding to go public are those that have relatively low net worth compared to their productivity: they are very constrained, so they benefit a lot from the extra finance if they go public. They expect to maintain the positive shock for a long period if the process of the shock is persistent, so it is worth for them to go through the IPO process. Expectations about future productivity, i.e. persistence and volatility of the shock, matter when the firm decides to do an IPO. The firm will weigh in how constrained it is now, and the possibility of being constrained in the future, which is governed by the productivity process, giving rise to rich dynamics for the IPO decision. It is possible that firms do an IPO but raise no extra equity: they want to avoid the restrictions of privately held firms (in the model, in the form of a fixed proportions of dividends that need to be distributed), and hence do an IPO with no further equity issuance. However, as in the data, this is much less frequent: in the calibrated exercise of next section, only 7% of the firms that do an IPO do not raise any equity.

The IPO choice is history-dependent. To see this, think of a firm starting with a low transitory shock and low net worth. If the subsequent shocks it receives are positive shocks, the firm will begin growing and accumulating net worth, eventually being able to pay the fixed cost in order to do an IPO and become publicly traded. If the firm receives initially a bad stream of shocks (below the long run mean value), it continues reinvesting its profits in the firm and doing ‘precautionary savings’, since the firm expects its productivity to grow in the long run. If the firm was able to accumulate enough net worth before they finally receive a high productivity shock, the costs of doing an IPO at that moment might outweigh its benefits, so it remains private. Hence, the model allows the existence of large privately held firms, such as Cargill or Koch Industries in the US²⁹. In sum, as happens in the US, not all large firms are publicly traded.

²⁸Those with low θ will never do an IPO, even if it were free ($\xi_0 = 0$), because the on-going costs are too high for them.

²⁹Cargill is the largest privately held company in the US, with 160,000 employees and revenues of nearly \$115 billions.

The Asymmetric Effect of Taxes on Optimal Decisions

It is key to understand the effect of taxes on policies and the value of firms to understand the mechanism through which taxes impact the IPO decision. In this section, I explain the intuition on how taxes affect firms' choices, which is formally derived in Appendix C.2. Think of two identical firms, with the sole difference that one is public and the other one is private. Corporate taxes distort both privately and publicly traded firms. Since investment is not tax deductible, corporate taxes distort investment. *Ceteris paribus*, lower corporate income tax has two effects. First, it increases optimal size at maturity. Second, it allows constrained firms to grow faster, since they have more after-tax profits to reinvest in the firm. Hence, this tax distorts more *constrained* firms than unconstrained ones, no matter whether they are private or public.

However, distribution taxes affect differently private and public firms. Private firms are under the 'new view': they always finance at the margin with internal resources, so distribution taxation does not affect their investment decision. Publicly traded firms can be under the 'new view' or the 'traditional view' depending on their stage at the life cycle. If they are constrained and are therefore issuing equity, they fall under the 'traditional view', and the distribution tax distorts their investment decisions by increasing the cost of external funds. If the firm is financing investment internally with retained funds, or it is already mature and it is distributing dividends, then they fall under the 'new view', and the distribution tax does not distort their decisions. Market value of privately held and publicly traded firms do depend on distribution taxation, since it is simply the discounted stream of future dividends, so it also impacts the proceeds at IPO. In sum, this tax distorts more *public firms* accessing the equity markets, and the IPO value of the firm.

This differential effect of the same taxes on firms is the key mechanism explaining the changes in selection and behaviour of publicly traded firms after a change in corporate and dividend taxes, which in turn brings a redistribution of resources.

4 Estimation

I estimate the baseline model to match key moments of the US economy during 1970-80. First, I assume some functional forms for the transitory productivity process and the equity issuance costs. Then, I describe the data used, and partition the parameters of the model in three groups: directly assigned, externally estimated, and estimated within the model. Finally, I show the model fit and perform some validation exercises.

Transitory productivity process. The component of productivity follows an AR(1) with 0 mean.

$$z_{t+1} = \rho_z z_t + \epsilon_t; \text{ where } \epsilon_t \sim N(0, \sigma_z) \quad (29)$$

I discretize this process with a twenty five point discrete Markov chain using the method developed by Tauchen (1986).

Distributions. Upon entry, firms draw the transitory productivity component z from the stationary distribution of the previously described AR(1) process. The fixed productivity component θ is drawn from a Pareto distribution:³⁰

$$F_\theta(\exp(\theta)) = \begin{cases} 1 - \left(\frac{\theta_{min}}{\exp(\theta)}\right)^\eta & \text{if } \exp(\theta) > \theta_{min} \\ 0 & \text{otherwise.} \end{cases} \quad (30)$$

³⁰The fixed component of productivity θ is discretized into ten grid points.

The tail of the Pareto distribution, η , is key for matching the skewness of the size distribution of firms.

Equity Issuance Costs. I parametrize the cost of issuing equity to be linear-quadratic in equity issued:

$$\xi(e) = \xi_1 e + \xi_2 e^2$$

The rationale for this functional form is to prevent constrained firms from issuing unrealistically large amounts of equity.³¹

Data Sources. Several data sources are used for estimating the model³². The main data source is Compustat North America, a panel of publicly traded firms with balance sheet and cash flow data. This dataset is matched with CRSP to obtain the IPO date, whenever possible. Thomson Reuter’s Securities Data Company (SDC) Platinum provides information about the issuance of securities and the costs associated with these. The Business Dynamics Statistics, a publicly available dataset with annual aggregate statistics describing firm’s employment, provides information about the employment distribution. The data on age at IPO is obtained from Jay Ritter’s website³³. Finally, I complement these with data from Davis et al. (2006), which provides data comparing publicly traded and privately held firms from LBD from the 1970s to the 1990s. Tax rates are computed with data from NIPA and TAXSIM, adjusted with other datasets, as explained in Appendix B.1.

Assigned Parameters. The model period is set to a year. I set the discount rate to match the equilibrium interest rate of $r = 0.04$. Following Gilchrist et al. (2014), I set the share of capital $\alpha = 0.3$. Capital depreciation is set to 6%. Exogenous exit is set to $\zeta = 0.04$ ³⁴, which implies an average life of a firm of 20 years. The minimum theta, θ_{min} , is set to 0.3, so that the productivity shocks are relevant for all permanent types, given that the mean value of z is 0³⁵.

Table 2: Assigned Parameters

Parameter	Value	Def./Source
<i>Assigned parameters</i>		
Share of capital	α 0.3	
Capital depreciation	δ 0.06	FRED
Discount factor	β 0.9615	Risk-free interest rate of 0.04
Exogenous exit rate	ζ 0.04	Exp. life of firms 20 years
Minimum θ	θ_{min} 0.3	See text

Parameters assigned in the baseline calibration and their targets.

Parameters estimated without solving the model. To estimate these parameters, I use the structure of the model and the data available without the need of solving the model. Corporate taxes are fixed at 35.4%, and distribution taxes at 34.9%, their levels in the 1970s (see Appendix B.1).

To estimate the degree of returns to scale, and the process of the transitory productivity shock, I use data from Compustat following the estimation procedure described in Appendix B.³⁶ I estimate a

³¹Absent other real frictions, if this cost was just linear, i.e. $\xi(e) = \xi_1 e$, the firm would be able to raise as much funds as needed as long as the marginal benefit of funds was larger than $\frac{1}{1-\xi_1}$.

³²See Appendix A.1 for a more detailed description of the data used.

³³<https://site.warrington.ufl.edu/ritter/ipo-data/>

³⁴This is approximately the exit rate for medium-sized firms (firms with 10-19 workers). Exit rates are higher for smaller firms and lower for larger firms: it is around 14% for firms with 1-4 workers, while it is less than 1% for firms with more than 250 employees

³⁵If the values for the permanent type θ are too high with respect to the transitory shocks z , there is no action coming from idiosyncratic uncertainty. If the values for the permanent type θ are too small, then this fixed heterogeneity doesn’t play any role, and the IPO choice is given only by the transitory component. θ_{min} is chosen in a range such that both play a role in the IPO choice.

³⁶The identification assumption here is that privately held and publicly traded firms follow the same process for idiosyncratic shocks, an assumption also made in the model.

decreasing returns to scale parameter very close to 0.85, so I set $\varrho = 0.85$. This value is in between the values estimated by Burnside et al. (1995), who find estimates between 0.8 and 0.9, and has been used extensively in this literature (Midrigan and Xu (2014), Jermann and Quadrini (2007)). I estimate the shock process with data from 1970-80, and find the persistence of the shock to be $\rho_z = 0.82$ and the standard deviation of the shock $\sigma_z = 0.22$. The estimates are in line with those found in the literature (see for instance Gourio and Miao (2010), Gilchrist et al. (2014)).³⁷

Parameters estimated by solving the model. The remaining eight parameters are calibrated jointly in equilibrium to match the moments depicted in Table 4. Although all the moments are jointly determined in general equilibrium and are thus affected by changes in all the parameters, some parameters are specially relevant for matching certain moments. In order to match the first three moments of Table 4, the skewness of the firm distribution is key. The tail of the distribution of permanent productivity η , which is estimated to be 5.7, together with the cost of operation κ and the fixed cost of doing an IPO ξ_0 , match the employment share of public firms (29%), the share of publicly traded firms (0.12%), and the 43% employment share of firms with more than 1000 employees.³⁸ The

Table 3: Parameters estimated without solving the model.

Parameter		Value	Source
<i>Frictions</i>			
Corporate Income tax	τ_c	35.4	NIPA
Distribution Tax	τ_d	34.9	TAXSIM
<i>Technology and shock process</i>			
Decreasing returns	ϱ	0.85	Compustat
Persistence of prod. Shock z	ρ_z	0.82	" "
Std. Deviation z	σ_z	0.22	" "

Parameters estimated without solving the model, as explained in Appendix B.1 (taxes), Appendix B.2 (equity issuance costs) and Appendix B.3 (decreasing returns and shock process).

fixed cost of operation κ is estimated to be 0.016, which implies a 0.7% of the average output of public firms in the baseline economy. The fixed cost of going public, ξ_0 , is 0.071 in the baseline economy.³⁹ The parameters governing equity issuance costs are the linear term ξ_1 and the quadratic term ξ_2 , which are 0.09 and 1.56 respectively. The quadratic term is especially important in matching the average equity to sales at IPO, whereas the linear component of equity issuance costs helps matching average equity to sales. The parameter determining the tightness of the borrowing constraint ϕ is set to 1.56, which implies an average debt to assets ratio of public firms of 0.34. The parameter governing the cost of entry ϑ , is set to 6.5. This parameter is closely related to the average incumbent firms' employment growth: size at entry determines firm growth over the life cycle. The dividend smoothing parameter, ε , which is 0.26 in the calibration, determines the speed at which constrained firms can accumulate

³⁷In unreported results, I carry out sensitivity analysis with respect to these parameters. Although quantitatively the results differ, qualitatively they go in the same direction. One exception is the case with low persistence, which predicts larger firms doing IPOs after a decrease in taxes.

³⁸Note that the distribution of firms in the economy is the result of the interaction of the pareto shape of the fixed component of productivity, the transitory shocks and the financial frictions of the model. Even though the tail of the pareto of the fixed component of the distribution may seem large, the equilibrium interaction of all these ingredients results in a firm size distribution that follows Zipf's law for firms with at least one worker, with a shape parameter of 1.1, close to that found in the data by Axtell (2001).

³⁹To put the importance of this fixed cost of doing an IPO into perspective, this cost implies on average around 19% of the sales of firms doing IPOs in the model.

resources. Because of this, these two parameters are key in order to match the life-cycle features of the model, like the median age at IPO of 9 and the aggregate employment growth of incumbents of 1.9%.

Table 4: Targeted moments

	Data	Baseline	Par.	Descr.	Value
Employment share public firms	29%	29%	κ	Fixed cost public	0.016
Share of public firms	0.12%	0.12%	ξ_0	Fixed cost IPO	0.071
Emp. Share >1000	43%	43%	η	Tail of Pareto dist.	5.7
Firm emp. Growth	1.9 %	1.9%	ϑ	Cost of initial fin.	6.5
Average equity to sales at IPO	0.4	0.4	ξ_2	Equity issuance costs	1.13
Average equity to sales	0.01	0.02	ξ_1	Equity issuance costs	0.09
Av. Debt to Capital public firms	0.34	0.34	ϕ	Borrowing constraint	1.565
Median age at IPO	9	9	ε	Dividend smoothing	0.26

First two moments are from Davis et al. (2006) for the year 1980. Next two moments come from BDS. Since only data from 1977 is available at BDS, these targets are computed as averages from 1977 to 1982. Next moments computed from Compustat are averages over 1970-1980, as explained in Appendix A. Last moment from Ritter database for the year 1980.

4.1 Performance of the Baseline Model

To explore further implications of the baseline model, I conduct some further exercises to test the performance of the model by testing the model along some non-targeted dimensions.

Untargeted moments. Table 5 shows further statistics with their data counterpart. The model matches reasonably well the average size of privately held and publicly traded firms, which is another check confirming the good match of the distribution of firms of the model, particularly the relationship between publicly traded and privately held firms. Although not targeted directly in the calibration, since the intended match was the amount of equity issued, the model is in line with the average spreads observed in the data (14% vs a 12% in the data)⁴⁰. Average employment at IPO to average employment of publicly traded firms is 0.2 in the data and 0.8 in the model, implying that firms doing IPO in the model are larger than in the data. Note that dispersion of employment at IPO, measured as the ratio of the 75th percentile to the 25th percentile, is larger in the model (11.5) than in the data (7.9), so firms going public are more dispersed in the model. Stock market capitalization to GDP is 0.4 both in the model and the data.

Table 5: Non-Targeted moments

	Data 70s	Model	Source
<i>Composition & Selection</i>			
Ratio av. size public to av. size private	323	337	Davis et al. (2006)
Av. spread equity issuance costs	12%	14%	SDC
Relative emp. at IPO to public	0.2	0.8	Compustat
p75 to p25 emp. at IPO	7.9	11.5	Compustat
Stock market cap. to GDP	0.4	0.4	Compustat
<i>Behaviour</i>			
Fraction firms dist > 0	0.8	0.8	Compustat
Distribution to sales	0.02	0.2	Compustat
Investment to sales	0.06	1.3	Compustat
Financial Assets to Assets	0.3	0.2	Compustat
Emp. Growth public	2.2%	3.7%	Compustat

All moments are averages in the period 1970-1980. Unless otherwise noted, moments refer to publicly traded firms. Moments computed from Compustat are averages over 1970-1980 from the sample including domestic firms with variables winsorized at 1%, and constructed as explained in Appendix A.

⁴⁰This statistic is computed as total costs of issuing equity divided by total equity issued, both in the model and the data. It includes both IPOs and SEOs.

The share of firms making distributions is 0.8 in the data and the model. The model overpredicts dividend and investment to sales. This is to be expected, since the model features no adjustments costs in real variables for the sake of simplicity. Hence, investment to sales is not smoothed in the model, and small constrained firms are investing very intensively, being the reason for such a large average investment rate. Dividends here are obtained as a ‘residual’⁴¹, i.e. the remaining funds after all the profitable investments are exhausted, so the model cannot match the smoothing of dividends present in the data, making distributions to sales larger in the model than in the data. Financial assets (FA) to total assets, a measure of the stock of savings of the firm, is 0.2, compared to the 0.3 in the data⁴². Aggregate employment growth of publicly traded firms is somewhat larger in the model (3.7%) than the data (2.2%).

Firm size distribution. Table 6 depicts a more detailed size distribution for all the firms in the economy. The baseline model is calibrated to match the share of employment of firms with more than 1000 employees (see bottom row, fourth and fifth column of Table 6). The model does a remarkably good job matching the share distribution of firms, despite being an untargeted measure. The model matches well the higher end of the employment distribution, but underpredicts slightly the employment of small firms and overpredicts that of medium-sized firms.

Table 6: Size distribution

<i>Size bins</i>	Share Firms		Empl. share	
	Data	Model	Data	Model
1 to 9	0.79	0.78	0.14	0.09
10 to 19	0.11	0.11	0.08	0.05
20 to 49	0.06	0.05	0.10	0.07
50 to 99	0.02	0.02	0.07	0.07
100 to 499	0.01	0.03	0.127	0.22
500 to 999	0.001	0.002	0.05	0.06
> 1000	0.002	0.002	0.43	0.43

Data from BDS from the year 1977.

Dynamics around IPO. It is particularly important that the model is able to replicate the characteristics of firms going public, and their dynamics around this IPO date. Chemmanur et al. (2009) use the Longitudinal Research Database (LRD) to understand the behaviour of firms around the IPO date. They find that: 1) firms larger in size and with higher sales growth are more likely to go public; 2) TFP exhibits an inverted U-shape around IPO; 3) sales and employment increase both prior and after IPO. To understand whether the model is in line with these findings, I run some tests on a simulation of 100,000 firms in the baseline economy.

First, I run a simple probit regression of the indicator of a firm doing an IPO on size (sales) and employment growth. I find that coefficients on size and employment growth are both positive⁴³ and statistically significant at 1%. Hence, in the model firms larger in size and with higher growth rates are more likely to go public, qualitatively in line with the findings in the data.

Secondly, I want to test the dynamics of TFP around the IPO. Chemmanur et al. (2009) compute TFP for firms going public, in each of the five years prior to becoming public, and each of the five years after doing an IPO. In the left panels of Figure 3, the findings of their paper are depicted. In the right panel of the same figure, I show the same picture obtained with the simulated firms of the model,

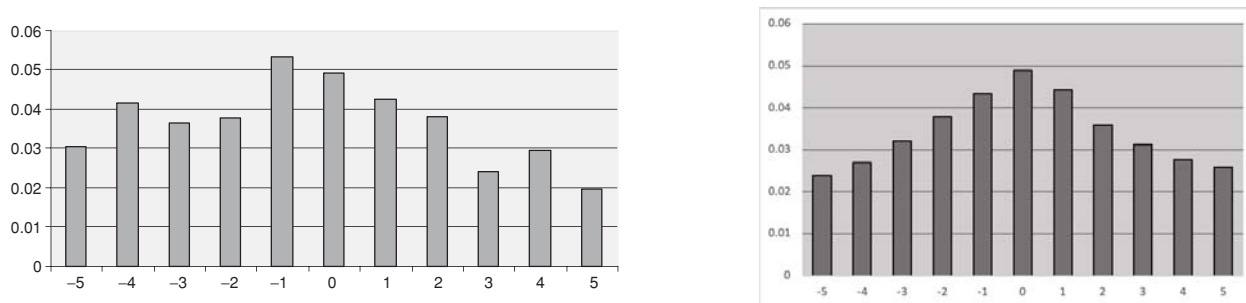
⁴¹Some papers in the literature fix this by imposing a dividend smoothing function for the firm, but it is not used here for the sake of simplicity.

⁴²Net financial assets, on the other hand, are larger in the model than in the data. This is because firms in the data are holding at the same time large amounts of financial assets and financial liabilities, something the model cannot capture.

⁴³0.019 and 0.9 respectively

where I normalize the values at IPO to be the same as those in the data for the sake of comparison. The inverse U-shape relationship of TFP around the IPO date is replicated by the model. The reason for this inverse U-shape is the decreasing returns to scale technology of firms, together with the mean reversion of the productivity process. After a of good productivity shock, the firm is very constrained, so TFP increases. After a series of good productivity shocks, the firm is so much in need for funds that decides to do an IPO. Once they are already public, and with the chance of using equity financing, they increase their operations. With the shock process slowly tending towards its long run average, TFP starts decreasing after IPO.⁴⁴

Figure 3: Dynamics around IPO



Average TFP five years before and after IPO. Left: Findings from Chemmanur et al. (2009). Right: Findings from a simulation of 10,000 firms in the baseline model. Value at IPO ($t=0$) normalized to that of the data.

Finally, due the same mechanism just explained, firms are growing in size before the IPO following the increases in productivity. After the IPO, firms are less constrained and can slowly reach their optimal size. Hence, the model also replicates qualitatively that sales and employment are growing both before and after the IPO.

5 Counterfactual Analysis

5.1 Changes in Taxes and the Stock Market Boom in the 1990s

In this section, I show the impact of changing only taxes in general equilibrium.⁴⁵ I show that only the changes in taxes observed in the US from the 1970s to the 1990s (see Table 7) can explain one third of the increase in stock market capitalization to GDP of the period, predicting an increase in IPOs and changes in payout and investment policies that are consistent with the data.

Table 7: Exogenous Changes

	70s	→	90s	Source
τ_c	35.4		28.9	See Appendix B.1
τ_d	34.9		20	See Appendix B.1

Exogenous changes fed to the model.

⁴⁴The same phenomenon occurs in Clementi (2002), who uses an entrepreneurial firm model with a decreasing return to scale technology to rationalize the inverted U-shape of ROA around the IPO date.

⁴⁵Note that this exercise is not revenue neutral: the change in tax policy reduces tax revenues, which are still rebated back lump-sum to the household. This is because this paper wants to focus on the direct impact of these changes in taxes on firms' policies, regardless on how this policy was financed.

Changes in selection (IPO) and behaviour of publicly traded firms. The decrease in corporate taxes makes firms less distorted, and hence they can accumulate resources faster and grow more. The decrease in distribution taxes makes the market value of the firm increase notably, so the proceeds at IPO increase. Furthermore, this value increases even more for constrained firms, since now they can access cheaper external funds if they are public. This results in smaller (firms with low net worth and low z) and larger firms (large net worth and high z) doing IPOs. These two sets of firms are constrained, but before the cost of external funds was too high, so they did not find profitable to do an IPO. When the external cost of funds decrease due to the decrease in distribution taxes, the benefits outweigh the costs, they decide to do an IPO and expand their operations by using external financing. Table 8 presents the results in the baseline after the exogenous change in taxes in the economy regarding changes in IPO choice, composition of public firms, and their behaviour (payout, investment and savings policy). Since distribution and corporate taxes decrease, now it is more appealing to go public, so the share of publicly traded firms increases. Smaller and larger firms are willing to go public, but how this change reflects in the median and dispersion of employment at IPO depends on the underlying distribution of private firms, and how it changes. In equilibrium, the median size at IPO decreases 5.4%. Dispersion at IPO, measured as the ratio of the 75th percentile of employment to the 25th, increases 0.4%. There have been more changes relatively at the top of the distribution, since 90th to the 50th percentile of employment at IPO increases 11%. These changes are lower than that observed in the data, partly because of the dynamics of private firms that allow them to accumulate resources faster, decreasing the incentives of the IPO even if it is more appealing than before, and partly because the general equilibrium forces (increase in wages) offset partially the benefit of being public. Changes in taxes can explain more than one third of the increase in stock market capitalization to GDP observed in the data (47.4% vs 138.4%), since now there are more publicly traded firms and their market valuation is higher.

There are two opposing forces affecting average size of public firms. *Ceteris paribus*, changes in taxes make incumbent publicly traded firms larger on average, since they are less distorted and they can accumulate resources faster. On the other hand, the selection effect, i.e. smaller firms entering into public and the increase in wages in general equilibrium make average size of publicly traded firms decrease. In equilibrium, the latter effect dominates, so the average size of public firms decreases 6.3%, whereas it decreased 23% in the data.

Most of the change in composition is driven by changes in distribution taxes. Appendix D.1 decomposes the effect of each component by changing only one of the taxes at a time. The changes of only distribution taxes would get an increase in the share of publicly traded firms that is more than 70% of that of the full model, and accounts for most of the increase in stock market capitalization to GDP. This is because this tax affects asymmetrically privately held and publicly traded firms, benefiting mostly the latter. However, changes in corporate taxes account for most of the aggregate changes, and this is because this tax affects directly private *and* public firms in the economy.

After the changes in taxes, the share of firms issuing equity increases 42%, and equity to sales increases 46%. Since firms are less distorted and have more after-tax internal funds to use, they make 18% more distributions to sales. Constrained firms are less financially constrained and invest more, increasing investment to sales 6%. Note that in this model debt has a tax advantage, since firms can deduct interest rate payments from the corporate tax. The only reason for the constraint not to be binding is the '*precautionary savings motive*': since external financing is more expensive than internal financing, those firms that expect to grow decide to save in order to finance future investment. When corporate taxes decrease, the tax-advantage of debt is lower, so firms increase their precautionary savings, making financial assets to assets of public firms increase 12%. This is in line with the findings of Sánchez et al.

Table 8: From 70s to 90s: Changes in Taxes**Panel A** - Changes in taxes

	Data 70-90	Model
<i>Selection & Composition</i>		
Share public firms	26.0%	16.7%
Avg size public	-23%	-6.3%
Median size at IPO	-58.9%	-5.4%
p75 to p25 emp at IPO	53.6%	0.2%
Stock market cap to GDP	138.6%	46.7%
<i>Behaviour public</i>		
Fraction eq>0	146.1%	41.6%
Equity to sales	253.9%	45.9%
Distributions to sales	68.3%	17.8%
Investment to sales	43.71%	13.2%
Financial Assets to assets	22.6%	13.2%

Panel B - Changes in Taxes: Entrants vs Incumbents

	Data		Model	
	Entrants	Incumbents	Entrants	Incumbents
Equity to sales	421.17%	89.37%	42.40%	143.89%
Dist. to sales	85.76%	71.76%	28.17%	11.74%
Investment to sales	99.9%	69.2%	27.06%	11.54%
FA to assets	31.0%	15.7%	20.93%	12.24%

Percentage changes from baseline. Data of public firms from Compustat: changes from 1970-80 to 1990-00. Model: changes from initial steady state to the new steady state introducing exogenous changes from Table 7.

(2013) or Armenter and Hnatkowska (2017), who find that savings and net financial assets increase during this period, and the latter already points at the importance of taxes for this result.⁴⁶

Panel B of Table 8 separates entrants (firms who did IPO in the previous 5 years) and incumbents (those who did IPO more than five years ago), both in the data and the model⁴⁷. The model is successful in replicating that both entrants and incumbents increase distributions, investment and FA, but the increase is higher for entrants. This is because entrants are constrained when they do their IPO. Once they are public, they can benefit from the ‘cheaper’ access to equity, hence increasing their equity issuance and investment. They become unconstrained faster, and hence start making distributions earlier and hoarding assets to avoid costly external financing. The model also replicates the increase in equity issuance by both entrants and incumbents, although in the model the latter increase is larger than the former, whereas in the data the opposite happens.

⁴⁶Having a larger buffer of savings and access to cheaper equity, they respond more to shocks to productivity, increasing the volatility of employment growth 3.1%. This mechanism, i.e. changes in taxes as a source of the increase in employment growth volatility, is a new channel contributing to the increased volatility observed during this period in publicly traded firms. Other sources found in the literature are increased competition, R&D, changes in corporate governance or financial development. See Comin and Philippon (2005), Comin and Mulani (2009).

⁴⁷The model results come from a simulation of 100,000 firms born from the stationary distribution of z and a truncated pareto distribution to the types that eventually go public.

Aggregate Effects. The effects of these changes in behaviour in aggregate variables are depicted in the first column of Table 9. Financial frictions decrease because external equity issuance is cheaper and because firms have more after-tax profits to reinvest, hence they are less distorted. This makes output increase 2%. Aggregate capital, K , increases 5.9%, though less than the increase in net worth held by firms, A^f , which rises 7.4%. This is a consequence of the increase in savings for ‘precautionary reasons’: the stock of net financial assets, i.e. A^f-K , increases. Lower misallocation makes TFP increase 0.7%. Consumption increases 1.1%, thanks to the rise in profits the household receives from firms and the increase in wages.⁴⁸

Table 9: From 70s to 90s - Aggregates

Employment share		
	Data	Model
Size > 500	3.5%	3.3%
Aggregates		
		Model
Y		2.5%
K		6.5%
A^f		8.2%
TFP		0.7%
Consumption		1.5%
Emp. Share top 1%		1.9%

Percentage changes from baseline. Size is measured as number of employees. Net worth of firms are $A^f = \sum_{j \in \{PR, PU\}} \int a(\theta, z, a) d\mu^j$.

Implications for the rise in concentration. In the model, the employment share of firms with more than 500 employees increases 3.3%, nearly explaining the increase observed in the data of 3.5%. Furthermore, the employment share of the largest 1% firms increases 2.9%. Autor et al. (2017), among other authors, find there is a widespread increase in concentration from the 1980s until nowadays. The channels I present here, i.e. decrease in corporate and distribution taxes, are channels contributing to the rise in concentration. The mechanism for this increase in concentration relies heavily on the general equilibrium forces inducing a reallocation towards more productive firms. Modelling private and public firms is important for this increase in concentration. If all firms were publicly traded⁴⁹, the employment share of the largest 1% increases only by 0.14%, while in the main exercise with private and publicly traded firms increases 2.2%. Hence, it is key the way taxes impact asymmetrically private and publicly traded firms to generate the concentration patterns at the evry top. The increase in stock market valuation would be only 33%, explaining less than full model, which predicts an increase of 47%, since we are missing the selection channel (*IPO channel*). Hence, introducing the modelling of the IPO choice is important to understand both the changes in the selection into public *and* the changes in stock market capitalization to GDP.

Are direct Equity Issuance Costs important for Changes in Selection?. Up to now, only changes in taxes have been considered. However, average underwriting spreads, which are the direct costs of issuing equity, decreased nearly 2pp in the 1990s, and 5pp points in the 2000s (see Appendix

⁴⁸This increase is in spite of the 23% decrease of aggregate tax receipts, and hence the amount rebated lump-sum to the household.

⁴⁹To compute the all publicly traded firms economy, I set $\xi_0 = \kappa = 0$, so that all firms are publicly traded, and from that baseline I change the taxes in general equilibrium. The full set of results is available upon request.

B.2). Hence, this might be one of the main drivers behind the changes in selection observed in the period. To understand whether this is the case, in Appendix D.2 I only change equity issuance costs in the baseline economy, by decreasing ξ_1 and ξ_2 proportionally, so that the equilibrium equity spread decreases as in the data⁵⁰. Changes in equity issuance costs observed in the 1990s would increase the share of publicly traded firms in the economy by 2%, but it predicts a substantially lower increase in stock market to GDP (1.2%, versus the 47% of the main exercise). Its macroeconomic impact is small, given that it only impacts the pool of publicly traded firms: output increases 0.1% and TFP 0.03%. Hence, even though this channel might contribute to the increase in IPOs, changes in taxes are needed to rationalize both the changes in selection *and* behaviour of publicly traded firms, and they are crucial for the macroeconomic results.

5.2 What happened after 2000? Exploring other Channels

During the 2000s, distribution and corporate taxes kept on decreasing, although less than in the previous period. However, as shown in Section 2, there was a change in the selection patterns of firms becoming publicly traded, which cannot be explained by taxes alone. In this section I explore other changes in the economic environment that might affect the selection patterns and that can be studied within this framework, namely changes in cost of being public, access to borrowing and changes in the idiosyncratic shock process. I assess a) if they can explain the ‘reversal’ in selection, b) their implication for public firms’ behaviour, and c) their macroeconomic implications. Although each of these ingredients might contribute to part of the observed changes, I find there is no channel that can simultaneously explain all the patterns observed in the data. Other possible causes for this trend are the increase in M&As⁵¹ and the increase in private capital financing. However, a more complex model is needed for assessing these channels, and hence this is left for future work.

Changes in taxes. Panel A of Table 10 shows the changes in taxes from the 1970s to the 2000s, and the Column (1) of Panel B of the same table shows the percent changes from the baseline after changing *only* taxes. Changes in taxes help explain the trends in behaviour of firms. The fraction of firms doing equity issuance increases 53% from the 1970s. Equity to sales also increases from the 1970s baseline, but less than in the 1990s experiment, again in line with the data. Average investment of public firms increases 21.9%, less than the increase in their data counterpart. Firms keep a larger stock of savings in the firm, since corporate taxes are lower and hence the tax advantage of debt decreases. Output increases 4.4%, and TFP 1.3%, since firms are less distorted and the lowering of financial frictions lowers misallocation. Note the employment share of the largest 1% firm increases 2.3%, therefore increasing further concentration. However, changes in regulations alone cannot explain changes in selection after 2000. Although they predict a lower increase in the share of publicly traded firms than in the 1990s counterfactual exercise (Table 8), the change from the 1970s is not negative, as is the case in the data.⁵² Market capitalization to GDP increases even further than in the previous exercise, even though the share of publicly traded firms is smaller, mainly due to the larger valuation of firms thanks to lower taxes.

⁵⁰This is attained by decreasing ξ_1 and ξ_2 by 15%, so that the average spread on equity issuance decreases 13% in the new equilibrium, as was observed in the data.

⁵¹Gao et al. (2013) acknowledges the decrease in the number of IPOs since the 2000s, and points at a change in the incentives of small firms to grow by getting acquired by a larger firm (as opposed to operate individually) as a cause of the decrease of IPOs.

⁵²Davis et al. (2006) do not have information on the share of publicly traded firms in the 2000s. Hence, I compute the statistic for the 2000-2010 period as the average of the number of publicly traded firms in Compustat divided by the overall number of firms from BDS. The share of publicly traded firms computed in this way is very similar to that of Davis et al. (2006) in the 1990s (0.14% vs 0.15%). BDS does not have data for the decade of the 1970s, but in the 1980s the average share of publicly traded firms is 0.11%, so again it is very close to that reported by the aforementioned paper.

Changes in the cost of being public. During this period there was also an increase in the costs of being publicly traded. The passing of the Sarbanes-Oxley Act of 2002 (SOX), especially Section 404, which imposed additional compliance costs on publicly traded firms has been argued to be one of the causes for the decrease in IPOs. Indeed, Iliev (2010) exploits a natural quasi-experiment to isolate the effects only due to the Sarbanes-Oxley Act (SOX), and finds that this rule imposed higher real costs to public firms, which were especially high for small firms⁵³. Through the lens of my model, this would be translated into a higher ongoing cost of operation κ . Due to the impossibility of accurately measuring the increase in the cost of being public brought by the passing of this law, here I perform a slightly different exercise. Given that taxes changed, I ask 1) by how much should the fixed cost of being public κ increase, such that the model predicts the same change in the share of public firms as the one we observe in the data?; and 2) is this change consistent with other changes in behaviour and selection of publicly traded firms observed in the period?. Table 10, column (2) depicts the results of changing the taxes to those of the 2000s and increasing the fixed cost of being public. In order to obtain the same change in the share of publicly traded firms since the 1970s (-10%), the fixed cost of being public κ needs to increase 60%. This implies that the average size of publicly traded firms increase, which is consistent with the data. Furthermore, compared to column (1), the median size at IPO and the dispersion at IPO increases, which is in line with the data change from the 1990s. The increase in the cost of being public decreases market capitalization to GDP substantially, therefore being at odds with the data. It also decreases the fraction of firms using equity financing, again contrary to what we observe in the economy. The increase in the cost of being public imposes a higher cost on publicly traded firms, which makes the employment concentration decrease. At the aggregate, these higher costs decrease output, TFP and consumption if compared to column (1), since they have no productive use in the model.

Changes in financial development. In the period studied, there was a process of deregularization in the banking sector in the US, improving access to credit for corporate firms⁵⁴. This view is supported by empirical evidence (Demanyk et al. (2007), Jayaratne and Strahan (1996)). Changes in access to credit could potentially affect the IPO choice, since bank debt is a substitute of equity financing. Indeed, during this period debt holdings to capital stock increased 28% for publicly traded firms. To capture this, I increase the borrowing constraint parameter ϕ such that, in the new equilibrium, debt to capital of public firms increase to match that of the data, 0.44.⁵⁵ If small private firms benefited more from these changes in regulations, the experiment conducted here could be thought of as a *lower bound* of the effect of financial development. Column (3) of Table 10 shows the effect of the changes in taxes and the change in the access to debt. An increased access to borrowing has two opposing effects on private firms. It allows them to grow faster, and hence they can do an IPO at a younger age. However, they have more access to financing while being private, so the option of becoming public is less appealing. Comparing column (1) to column (3), less firms are doing IPOs and their median size is larger, suggesting the latter force wins. However, the dispersion of employment at IPO decreases, which suggests a larger concentration of employment of firms doing IPOs. Not only public firms benefit from more debt financing, but also private firms. This makes labor demand increase significantly, which makes wages go up. Average financial assets to assets increase slightly from column (1). However, if we measured this statistic as a weighted average, it would change from 43.4% in column (1) to 30.5% in column (3). Small firms can accumulate resources much faster, and hence they can increase their stock

⁵³Sarbanes-Oxley Act purpose was to improve the quality of financial reporting in order to increase investor confidence, after a series of corporate governance scandals in the US. However, Iliev (2010) finds suggestive evidence that the costs of Section 404 compliance outweigh the benefits.

⁵⁴See Kroszner and Strahan (2014) for a detailed review of the regulation and deregulation of the US banking industry.

⁵⁵This is obtained increasing ϕ 24%. This assumes implicitly that the constraint of privately held firms was relaxed equally to that of publicly traded firms.

Table 10: From the 70s to the 00s**Panel A:** Exogenous changes in taxes fed to the model.

	70-80 →	00-10
τ_c	35.4	23.6
τ_d	34.9	19.9

Panel B: From the 70s to the 00s: changes in selection, behaviour of public firms and aggregates

	Data 70-00	(1) Only Taxes	(2) Taxes & Fixed Cost	(3) Taxes & Access to debt	(4) Taxes & Increase ρ_z decrease σ_z
<i>Selection & Composition</i>					
Share public firms	-9.8%	19.1%	-8.6%	17.2%	10.9%
Avg size public	8.0%	-8.0%	7.2%	-5.4%	-3.8%
Median size at IPO	-42.5%	-9.7%	-7.1%	-5.9%	-37.4%
p75 to p25 emp at IPO	423.8%	4.4%	28.7%	14.5%	35.4%
Market cap to GDP	188.4%	56.9%	37.7%	49.9%	52.9%
<i>Behaviour public</i>					
Frac eq>0	143.6%	53.1%	50.1%	46.4%	66.8%
Equity to sales	154.6%	39.0%	33.5%	32.4%	47.2%
Dist to sales	131.2%	28.7%	26.0%	22.4%	22.1%
Investment to sales	85.3%	21.9%	22.1%	37.8%	-43.8%
Financial Assets to assets	27.8%	20.8%	20.2%	24.7%	-18.3%
<i>Share of employment</i>					
Size > 500	5.7%	3.5%	2.9%	6.3%	1.4%
<i>Aggregates</i>					
Y		4.4%	4.0%	8.3%	-2.2%
K		12.0%	11.4%	23.5%	10.2%
A_f		16.7%	16.2%	13.1%	3.6%
TFP		1.3%	1.2%	2.6%	-4.6%
Consumption		2.4%	2.1%	5.6%	-3.7%
Emp share largest 1%		2.3%	1.8%	5.0%	0.5%

Panel A: exogenous changes fed to the model, computed as in Appendix B.1. **Panel B:** Data from BDS and public firms from Compustat: changes from 1970-80 to 1990-00. Model, Column (1): changes from initial steady state to the new steady state introducing exogenous changes in taxes of Panel A. Column (2): changes in column (1), and changes in borrowing capacity such that b/k in the new equilibrium is 28% larger, which is given by an increase in ϕ of 24%, i.e. $\phi = 1.94$. Column (3): changes of column (1), increasing κ such that the observed increase in the share of publicly traded firms is the same as in the data, i.e. an increase of κ of 50%. Column (4): changes of column (1), and change in shock process ($\rho_z = 0.85$, $\sigma_z = 0.18$). Net worth of firms is $A_f = \sum_{j \in \{PR, PU\}} \int a(\theta, z, a) d\mu^j$.

of savings substantially, dragging simple averages up. The borrowing constraint being more relaxed, large firms do not need to save as much since they can use debt, hence financial assets to total assets decrease for these firms, which is what makes the weighted measure decrease. Because of this, note that in the aggregates net worth of firms (A_f) increase much less than the aggregate capital stock, so net aggregate savings stock decreases as compared to column (1). Stock market capitalization to GDP decreases since output increases more than proportionally than the value of public firms. Public

firms make slightly less distributions as compared to (1), since wages increased significantly, and they use less equity financing since they have more access to debt. While constrained and small firms can invest more because they can borrow more, large firms invest less, since the increase in wages of the general equilibrium forces makes them optimally smaller. Investment to sales of publicly traded firms increases 37.8%, closer but still far from the increase of 85% of its data counterpart. At the aggregate, an increase in access to borrowing further boosts output and aggregate capital, that increase 8.3% and 23.5% respectively. Having less financial frictions, TFP and consumption increase 2.6% and 5.6% respectively.

Changes in the process of idiosyncratic volatility. During this period, there have been important changes in the process of idiosyncratic shocks faced by firms. Davis et al. (2006), using LBD data (which comprises the universe of firms in the US), show that firm volatility decreased in this period, and this view is supported by Bloom et al. (2017)⁵⁶. In this section I carry out a qualitative experiment to understand what would be the impact of either of changes in the firm productivity process on firms' selection, behaviour and macroeconomic aggregates. To this purpose, I assume persistence of the shock increased in the same manner for publicly traded and privately held firms (using Compustat data, I find it increases from $\rho_z = 0.82$ to $\rho_z = 0.85$)⁵⁷, and I decrease the volatility of the shock 20% (from $\sigma_z = 0.22$ to $\rho_z = 0.18$), which is within the decrease of employment growth dispersion estimated by Bloom et al. (2017). Results are shown in Column (4) of Table 10. The share of publicly traded firms decreases as compared to (1), though still less than in the data. Dispersion at IPO and market capitalization decreases slightly from column (1), at odds with the data. The fraction of firms issuing equity and the amount of equity issued increases, while investment and financial assets decrease, at odds with the data. At the aggregate, output and TFP decrease. Interestingly, aggregate capital and aggregate net worth held by firms increase since the 1970s baseline despite the lower volatility of the shock, since being the persistence of the shock higher, firms are able to undo their financial constraints faster⁵⁸.

Although all these changes can explain part of the patterns observed in the data, none is able to simultaneously explain all of them. Arguably, it is a combination of these forces, together with some changes that are not being accounted for here (increase in M&As or increase in private capital financing) the ones responsible for these changes.

6 Conclusion

This paper highlights how changes in the economic environment impact differently privately held and publicly traded firms, and their decision to list in a stock exchange (do an IPO), an issue that has been overlooked by the literature. I use a very parsimonious model of firm dynamics featuring a life cycle. Firms are born privately held and small due to financial frictions, and they can finance investment with retained earnings and debt. Public firms can also issue costly equity, though they need to pay an on-going fixed cost of operation. Private firms can do an IPO and become public by paying a

⁵⁶While overall firm-level volatility decreased, that of publicly traded firms increased. Using Compustat, Comin and Philippon (2005) show there was an increase in firm level volatility, and Macnamara (2019) structurally estimates a firm dynamics model and finds that the implied volatility of the productivity shocks increased from the 1980s to the 2000s. In Appendix B.3 I show there is an increase in the volatility of the idiosyncratic shock in my sample of publicly traded firms from Compustat too. However, Davis et al. (2006) reconcile the overall decrease in firm volatility and the increase in the volatility of publicly traded firms by showing this is due mainly to cohort effects of firms doing IPOs, rather than changes in size or age, although they are agnostic what is driving these changes in cohorts. This model is not equipped with heterogeneity in the idiosyncratic shock process followed by firms of different cohorts, and hence cannot reconcile these diverging trends in volatility of public and privately held firms, an issue that is outside the scope of this paper.

⁵⁷See Appendix B.3 for details.

⁵⁸As in Moll (2014)

fixed cost. Despite the intended simplicity of the framework, the calibrated model is successful in matching key moments of the size distribution, and the distributional characteristics of private and publicly traded firms. The dynamics of firms around the IPO date are consistent with those found in empirical evidence by Chemmanur et al. (2009). I use this model in several counterfactual exercises to understand the impact of some important changes in the economic environment in the US since the 1970s on: 1) the selection of firms into publicly traded, 2) the behaviour of publicly traded firms, and 3) the distributional and aggregate implications. The large decrease in corporate and dividend taxes from the 1970s to the 1990s benefits more publicly traded firms comparatively, which incentivizes IPOs and creates a stock market boom. The patterns of the changes in IPO choice, payout, investment and savings choices are in line with the data. Due to the asymmetric impact of the decrease in taxes on constrained and publicly traded firms, concentration of employment increases, explaining nearly all of the increase in concentration found in the data. Since misallocation is lower, output, TFP and aggregate capital increase. I perform some counterfactual exercises to understand what could be the reasons for the decrease in publicly traded firms in the 2000s, since changes in taxes cannot account for it. I find that an increased cost of being public, increased access to debt, or changes in the idiosyncratic shock process can partially rationalize the decrease in the share of publicly traded firms, although it is not in line with the data along all dimensions.

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Appendix A. Data

Appendix A.1. Data Sources

COMPUSTAT North America

I use data from COMPUSTAT North America obtained via WRDS. I match this database with CRSP data for obtaining the IPO date, whenever available. I use an unbalanced panel of firms from 1970-2010, and I use different subsets of this data in the different exercises, as noted in the main text. I drop ETFs, ADRs, by dropping observations with NAICS 525. I also exclude firms whose industry classification is in utilities (SIC codes between 4900 and 4949), the financial sector (SIC code between 6000 and 6999) and public administration (SIC code between 9000 and 9999), following the literature⁵⁹. I also exclude observations reporting a value of acquisitions to assets larger than 10%, since these firms might behave differently. I finally exclude firms reporting negative employment, sales, wages or investment. I keep only firms that are publicly traded⁶⁰, i.e. year-observations of firms after the year of IPO, as defined in the next lines. All dollar values are in million dollars (1999 real terms, deflated using the GDP deflator from the U.S. Bureau of Economic Analysis⁶¹), and all firm-level measures are winsorized at the 2nd and 98th percentile. The final sample consists of 238,414 firm-year observations. The raw variables I use are the following:

- **Dividends.** Total amount of dividends, other than stock dividends, declared on all equity capital of the company, based on the current year's net income (DVT item). We restrict the analysis to those reporting DVT greater or equal to 0.
- **Distributions.** Total amount of distributions, defined as the sum of dividends (DVT) and share repurchases (PRSTK item).
- **Equity Issuance.** Funds received from issuance of common and preferred stock (SSTK item). I restrict the analysis to those reporting SSTK greater or equal to 0.
- **Assets.** Total value of assets reported on the Balance Sheet (AT item). Realize that in the model, what I call assets is really the net worth of the firm with an abuse of notation. The model counterpart of total assets, as appear in the balance sheet, is $at = \max(a, k)$, and it is the statistic used for all the reported tables.
- **Sales.** Gross sales (SALE item).
- **Employees.** Number of company workers as reported to shareholders. This is reported by some firms as an average number of employees and by some as the number of employees at year-end (EMP item).
- **Earnings.** Measured as Operating Income Before Depreciation (OIBDP item).
- **Investment.** Capital expenditures (CAPX item). The model counterpart is $\max\{k'(x') - (1 - \delta)k(x), 0\}$. However, since in the model capital invested tomorrow depends on the realized shock, I obtain this statistics by simulating the path of 10,000 firms and computing the realized investment in capital.
- **Debt.** The item represents the sum long term debt (DLTT item) and debt in current liabilities (DLC item).
- **Cash stock to assets.** The ratio of cash holdings (CHE item) to assets (AT item).

⁵⁹These companies are usually excluded since they face additional regulations and hence might have different payout behavior, and their dividend patterns are quite different from other companies.

⁶⁰Compustat also keeps track of some firms before their IPO, and even some firms that never become publicly traded, as long as they need to file documents to the SEC. Since I want to focus on publicly traded firms, and unfortunately these are not representative of the full set of privately held firms, I exclude these observations.

⁶¹Accessed at <https://www.bea.gov/iTable/iTable.cfm?ReqID=9&step=1&reqid=9&step=1&isuri=1>

- **Financial Assets.** This item is defined as the sum of cash and short-term investments (CHE item), other current assets (ACO item), and account receivables (RECT item). The model counterpart is $\max(a - k, 0)$.
- **Financial Liabilities** This item is defined as the sum of long-term debt (DLTT item), current debt (DLC item), other current liabilities (LCO item) and accounts payable (AP item). The model counterpart is $\max(k - a, 0)$.
- **Net financial assets to total assets.** Computed as (Financial Assets-Financial Liabilities)/Assets. The model counterpart is $(a-k)/at$ ⁶².
- **Market capitalization to GDP.** I compute this statistic as follows. First, I compute market value of a firm by multiplying the net number of all common shares outstanding at the end of the year (CSHO item), times the closing price at the end of the year (PRCC). Then, I compute the market capitalization by summing the market value of all firms operating. Then, I compute the market value to GDP by dividing this last item by nominal GDP obtained from FRED. The market capitalization to GDP computed in this way is very close to that obtained by the Worldbank.
- **IPO.** I match firms in the Compustat North America and CRSP databases by using the company identifier PERMCO from the CRSP/Compustat Merged available at WRDS. Whenever a firm in Compustat is matched to CRSP and the IPO date from CRSP is available, I use this date as IPO date. If this date is missing, I use the IPO date available in Compustat (IPODATE item). In case both items are missing, I compute the IPO date as the year of the first positive observation of closing price (PRCC_F item). In the final sample, the IPO date variable comes from the first definition for 72% of the firms used in the sample, 6% come from the second definition, and the remaining 22% come from the third definition. Results in the paper are robust to restricting the definition to either of the definitions. This is also the definition of '*Year of entry to public*'.

In the model, firms are either making distributions, or issuing equity, and optimally never choose to do both at the same time. However, in the data you can find firms making distributions and issuing equity at the same time. Therefore, I need to take a stand when defining the share of firms making distributions, and the share of firms issuing equity. I define it therefore as:

- **Fraction of firms doing equity issuance.** Ratio of the count of firms issuing equity ($equity_issuance_{it} > 0$) and not making distributions ($distributions_{it} \leq 0$), to the total number of firms operating, per year.
- **Fraction of firms making distributions (dividends).** Ratio of the count of firms making distributions (or dividends, i.e. $d_{it} > 0$) and not issuing equity ($equity_issuance_{it} \leq 0$), to the total number of firms operating, per year.

In the tables in the main text, unless otherwise noted, all changes are those of simple averages, but those of equity and distributions, which are employment weighted. This is because payout policies feature large outliers that drive sometime the averages (in the data and the model), even after winsorizing. For instance, while employment weighted average increased 860% from the 70s to the 90s, weighted averages increased 253%. Unless otherwise noted, the rest of the statistics are simple averages.

⁶²Note that, in the data, most firms hold financial assets *and* financial liabilities. However, in the model firms hold financial assets *or* financial liabilities.

Appendix A.2. Additional Empirical Facts about Public Firms

Table 11: More statistics.

	1970-1980			1990-2000			2000-2008		
	Mean	Median	sd	Mean	Median	sd	Mean	Median	sd
Employees	7.00	1.54	15.21	5.39	0.50	14.56	7.56	0.70	17.84
Employment at IPO	1.58	0.54	5.33	2.36	0.22	9.15	3.62	0.31	11.62
Fraction firms eq>0	0.12	0.11	0.03	0.30	0.30	0.04	0.30	0.30	0.03
Equity Issuance to Sales	0.05	0.00	0.46	0.41	0.00	1.47	0.40	0.00	1.48
Fraction dividends>0	0.67	0.66	0.03	0.38	0.37	0.03	0.35	0.36	0.02
Dividends to sales	0.01	0.01	0.02	0.01	0.00	0.03	0.01	0.00	0.04
Fraction distributions>0	0.77	0.76	0.08	0.56	0.55	0.04	0.58	0.58	0.02
Distributions to sales	0.02	0.01	0.03	0.02	0.00	0.06	0.03	0.00	0.07
Investment to Sales	0.06	0.02	0.14	0.11	0.04	0.24	0.11	0.03	0.25
Employment growth	0.03	0.02	0.20	0.03	0.02	0.26	0.00	0.00	0.24
Volatility emp. growth	0.14	0.12	0.10	0.20	0.16	0.16	0.18	0.14	0.14
Debt to capital	0.34	0.29	0.27	0.40	0.28	0.45	0.44	0.26	0.57
Financial Assets to Assets	0.32	0.30	0.15	0.39	0.35	0.23	0.41	0.37	0.25
Net Fin. Assets to Assets	-0.12	-0.13	0.26	-0.04	-0.08	0.39	-0.01	-0.04	0.39

Source: Compustat. Differences in simple means are statistically significant for all, but volatility of employment growth of entrants between 1990-00 and 2000-10, and overall equity to sales between 1990-00 and 2000-10. Averages over a ten year window. Variables are winsorized at 2%. For more information about data construction, see Appendix A.1. Volatility of employment growth computed as in Comin and Philippon (2005).

Table 12: Publicly traded firms: entrants vs incumbents.

	1970-1980		1990-2000		2000-2010	
	Ent.	Inc.	Ent.	Inc.	Ent.	Inc.
Equity to sales	0.09	0.01	0.75	0.16	0.71	0.27
Investment to sales	0.08	0.05	0.15	0.08	0.17	0.09
Distribution to sales	0.01	0.02	0.02	0.03	0.03	0.03
Volatility of employment growth	0.16	0.14	0.25	0.20	0.24	0.18

Source: Compustat. Differences in simple means are statistically significant for all, but volatility of employment growth of entrants between 1990-00 and 2000-08, and overall equity to sales between 1990-00 and 2000-10. Averages over a ten year window. Variables are winsorized at 1%. For more information about data construction, see Appendix A.1. Ent. stands for entrants, defined as firms that did their IPO in the previous five years. Inc. stands for incumbents, defined as firms that did their IPO more than five years before. Volatility of employment growth computed as in Comin and Philippon (2005)

Table 13: Employment Weighted Statistics

	1970-1980	1990-2000	2000-2008
Equity Issuance to Sales	0.01	0.02	0.02
Distributions to sales	0.02	0.03	0.04
Investment to Sales	0.05	0.07	0.07
Financial Assets to assets	0.28	0.28	0.29
Net Financial Assets to Assets	-0.16	-0.21	-0.18

Source: Compustat. Employment weighted means by year then averaged in a 10 year window. Variables are winsorized at 2%. For more information about data construction, see Appendix A.1.

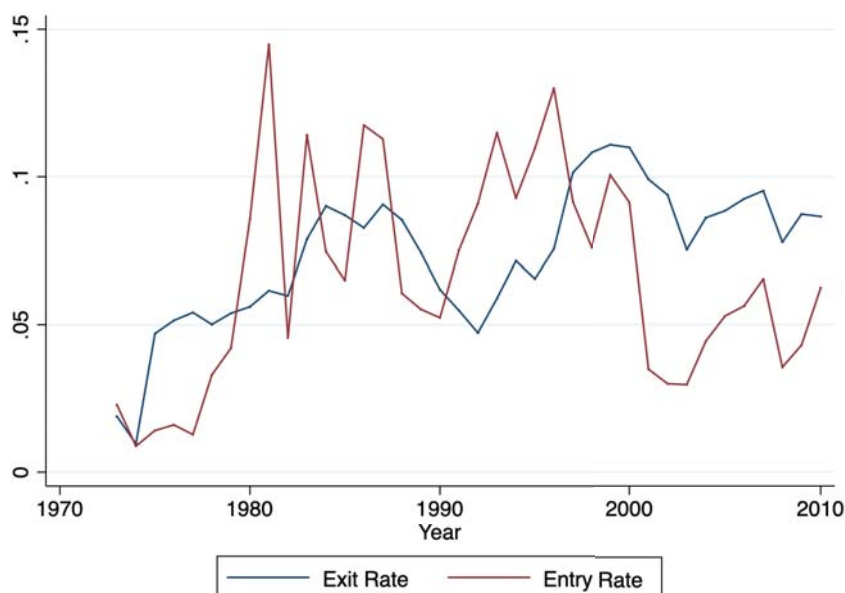
Table 14: Increase in Averages by Industry.

	1970s to 1990s				1970s to 2000s			
	Fract. Eq>0	Eq/y	Dist/y	Inv./y	Fract. Eq>0	Eq/y	Dist/y	Inv./y
Agriculture, Forestry, Fishing	1.37	0.99	0.68	1.26	1.32	-0.04	0.07	0.76
Mining	1.33	0.46	0.46	0.25	1.31	1.05	0.36	0.56
Construction	1.42	6.07	0.08	0.39	1.38	3.50	0.02	-0.08
Manufacturing	1.50	14.17	0.56	1.21	1.47	16.86	1.08	1.39
Transportation, Communications, Electric, Gas, And Sanitary Services	1.42	6.46	0.61	0.61	1.40	3.22	1.23	0.43
Wholesale Trade	1.44	6.70	0.73	0.25	1.42	5.19	1.11	-0.06
Retail Trade	1.48	9.99	0.59	1.08	1.45	3.07	1.77	0.56
Services	1.44	7.54	0.60	0.35	1.43	3.81	1.34	-0.09

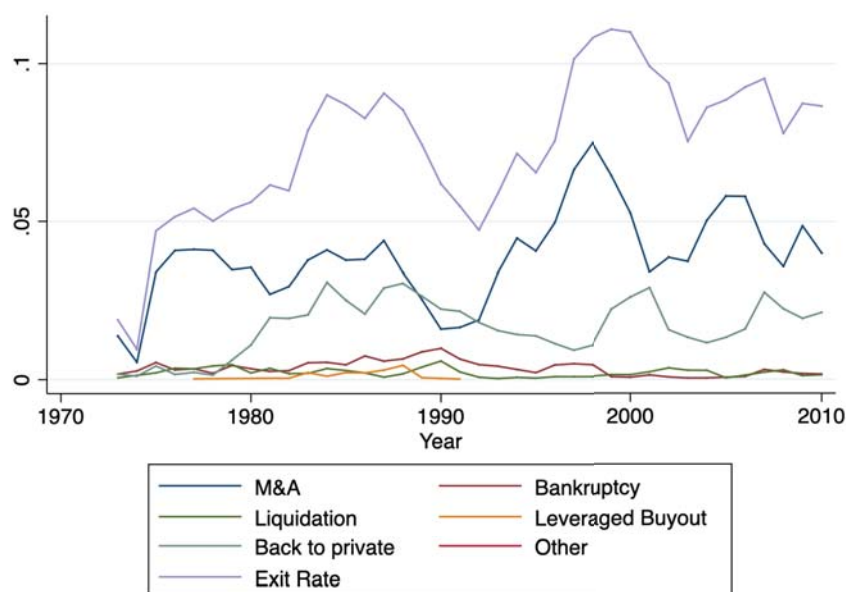
Source: Compustat. Increase in simple means by industry ($mean_x/mean_{70} - 1$). Averages over a ten year window. Variables are winsorized at 1%. For more information about data construction, see Appendix A.1. Eq> 0 refers to the fraction of firms doing equity issuance. Volatility of employment growth computed as in Comin and Philippon (2005).

Figure 4: Exit and Entry Rates into Publicly Traded

A: Overall Exit and entry Rates



B: Exit Rates by Reason of Exit



Source: Compustat. Reason of exit as recorded by item DLRSN in the last entry of the firm.

Appendix B. Changes in Economic Environment.

Appendix B.1. Taxes

The most important regulations affecting taxes were the Economic Recovery Tax Act (ERTA) of 1981, and the Tax Reform Act (TRA) of 1986. The former reduced the highest rate to 50%; the latter reduced the marginal tax rate on the highest incomes to 28%. These rate reductions implied a drop in marginal rates paid on dividends, since dividends are taxed as ordinary income. Regarding corporate taxes, increases in depreciation and lower rates adopted in 1981 made the tax rates decrease. The TRA decreased corporate tax rates in 1986, but more restrictive depreciation offset partially this decrease initially, but led finally to lower tax rates in the 1980s and 1990s. In 2003, the US congress enacted the Jobs and Growth Tax Relief Reconciliation Act (JGTRRA), which decreased dividend and capital gains taxation, though this decrease was often seen as a temporary cut.

Table 15: Estimated Tax Rates

	Corporate tax	Distribution tax
1970-1980	35.4	34.9
1990-2000	28.9	20.0
2000-2010	23.6	19.9

Distribution Taxes

On top of the aforementioned changes in regulations, there were other changes affecting distribution taxes. First, after the enactment of the Employment Retirement Income Security Act (ERISA), there was a substantial increase in the percentage of corporate stock held by non-taxed entities. The share of corporate equities held in tax-exempt entities went from 10% in 1970 to 30% in 2000. Second, there was an increase in share repurchases during this period: using Compustat data, the share of distributions made as share repurchases increased from 13% in 1971 to 53% in 2000. In this section, I try to account for all these changes and estimate a unique tax on distributions, in the spirit of McGrattan and Prescott (2005).

The base data I use is from TAXSIM tables, adjusted with data from the Financial Accounts of the Federal Reserve Board⁶³, the Investment Company Institute, and Compustat.

I start using dollar-weighted average marginal dividend income tax rates for US. These rates are computed by the National Bureau of Economic Research (NBER) using micro data from the Individual Income Tax Models available from the Statistics of Income Division of the Internal Revenue Service, with the TAXSIM model. The TAXSIM model calculates the rates by first calculating the tax liability of each individual income tax return in the sample, then increasing dividend income by 1%. Then, it recalculates the tax liability assuming that other incomes and expenses remain constant. The difference in aggregate tax divided by the difference in aggregate income is the marginal tax rate on the average dollar of dividend income. These rates that include federal plus state taxes. Before 1979 and after 2008, only data for federal taxes is available. To adjust for this, I compute the rates increasing the federal tax by the average ratio of federal plus state to federal tax rates in the years available. This rate is depicted in Figure 5 as ADJ 1.

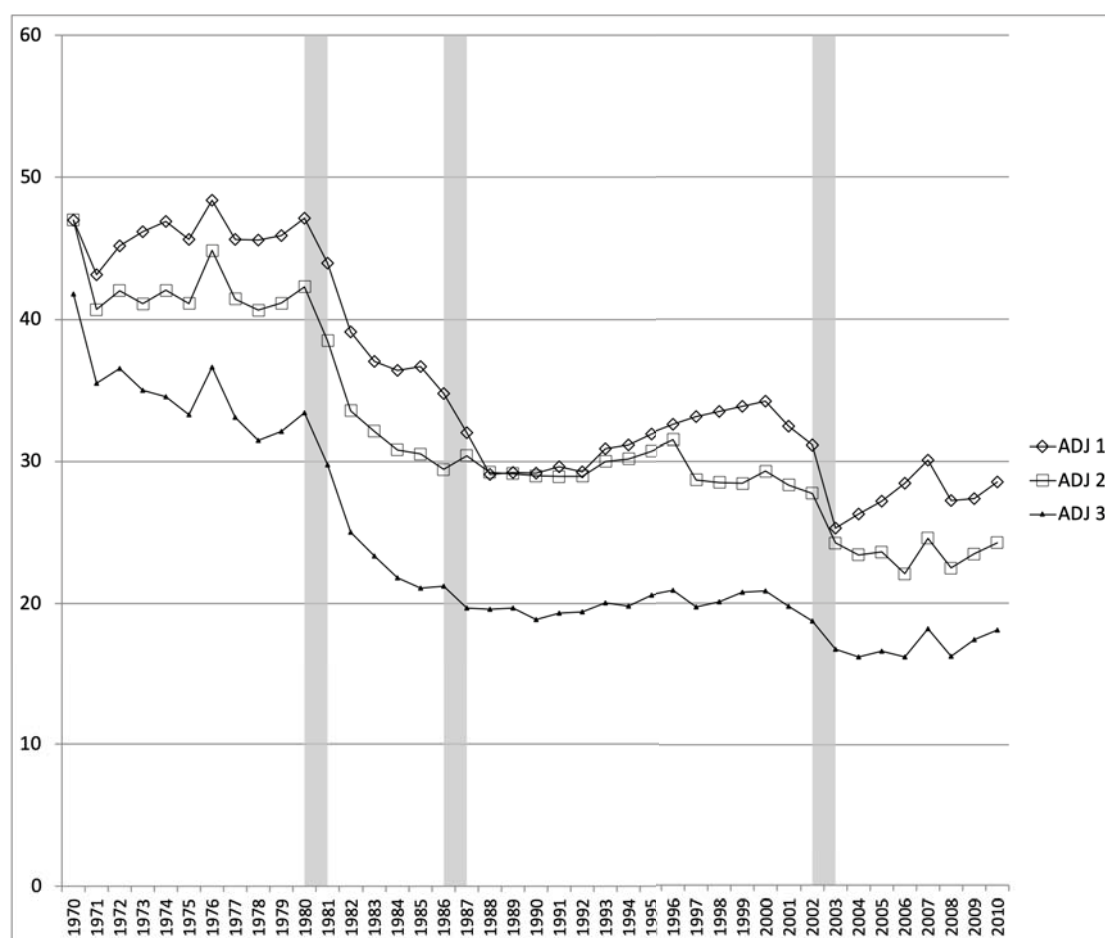


Figure 5: Distribution taxes 1970-2008.

Next, I adjust the tax rate for share repurchases. Share repurchases is a way of distribution to shareholders, by which the firm repurchases its own shares from the market. This is taxed at capital gains rate, rather than personal income tax. The fraction of share repurchases to overall distributions (dividends plus shares repurchases) increased from 13% in 1971 to 53% in 2000⁶⁴. Since my model does

⁶³ Accessed at <https://www.federalreserve.gov/datadownload/Choose.aspx?rel=Z1>

⁶⁴ This is obtained from Compustat, hence assumes the behaviour regarding share repurchases evolved in the same way for privately and publicly traded firms, which is not necessarily true, since share buybacks in privately held firms is rare. However, the decrease in distribution taxes is robust to accounting for share repurchases or not (see Appendix B.1). The main reason is that, during the 70-80, the amount of share repurchases was not very high. From the late 1980, although the share of repurchases as a ratio to overall distributions increased substantially to almost 50%, the distribution tax rates and capital gains tax rates were very similar.

not allow for share repurchases, I adjust the distribution tax to account for this computing the yearly average of dividend tax and capital gains tax weighted by each share of the overall distributions. This rate is depicted in Figure 5 as ADJ 2.

Finally, I adjust for the share of corporate shares held in non-taxed entities. To do so, I multiply the marginal rates by the fraction of equity held outside of nontaxed accounts. Non-taxed accounts include pension funds, individual retirement accounts (IRAs), and nonprofit organizations. I obtain the fraction of equity held in pension funds from Table L.223 of the Financial Accounts. I also include the corporate equity in pension funds held in the form of mutual funds, with data from Table L.122 and L.117. The fraction of corporate equity in NGOs is obtained from Table L.101a. Finally, I estimate the fraction of equity held in individual retirement accounts (IRA) with data from the Retirement Market of the Investment Company Institute. I use data from IRA Holdings of Mutual Funds by Type of Fund (Domestic equity). The distribution rates after all adjustments are depicted in Figure 5 as ADJ 3. The averages for the periods considered are in Table 15.

Corporate tax

I estimate corporate taxes by computing aggregate corporate tax rate. To do so, I use aggregate data from NIPA tables from 1970 to 2008. Concretely, I compute it as the NIPA profit tax liability (NIPA table 1.16, line 19) less Federal Reserve Bank profits (NIPA Table 6.16 B, C, D; line 11) to the NIPA corporate before-tax profits (NIPA 1.16, line 18) less Federal Reserve Bank profits. This is depicted by NIPA effective tax rate in Figure 6. This is the rate used in the main text. Although a good measure of the effective tax rate, this decrease could be driven by the increase of S-corps experienced during these decades (which yields a decrease in the numerator, since these firms don't pay corporate tax), rather than a decrease of the effective tax. To make sure this is not the case, I use different tax estimation techniques and depict them too in Figure 6 as a robustness.

I compute the GAAP effective tax rate, which is the tax rate estimated from financial data, using Compustat. I compute it as the ratio of total taxes paid (TXT item) to pre-tax income (PI item) taxes. There are some downsides of measuring taxes this way. Firstly, we would be focusing only on publicly traded firms, so it can paint a misleading picture for the average C-corp in the US. Secondly, it includes items such as deferred taxes, foreign taxes, etc. Thirdly, differences in financial accounting and tax reporting, such as different depreciations methods or certain deductions, that can make GAAP effective tax rates different from the actual effective tax rate that would be computed with tax accounting. Nonetheless, it is a good approximation of how much publicly traded firms effectively pay in the concept of corporate taxes on average. The rates computed by these method are higher than those computed from NIPA, but the trend and the percentage change is very similar, which leads us to think that the decrease in corporate taxes did decrease effective tax rates paid by firms.

Finally, and for the sake of comparison, I also depict the top marginal federal statutory corporate tax rate. Effective tax rates and marginal tax rates convey different - but complimentary- information. Marginal tax rates give the tax rate faced by the last dollar of income earned, while effective tax rates are the average taxation rate for the income earned. Because effective tax rates take into account deferrals, deductions, etc., effective tax rates tend to be lower than marginal tax rates. We observe that top marginal tax rate decreased from nearly 50% in 1970 to 35% in 2000 and 2010.

Taxation of Firms by Organization Type

This paper is focusing on corporate taxations, and hence on C-corporations, since virtually all publicly traded firms are C-corporations, and need to be a C-Corporation when they do an IPO. However, for the aggregates, there exists other organizational forms (S-corporations, partnerships, etc...) which, although they face different tax treatment, they have in common that they face personal income taxes on their profits, instead of double taxation at the firm level (corporate tax) and personal level (dividend tax). Table 16 shows the share of firms by organization type, and their employment. C-corporations are larger on average, mostly driven by very large firms.

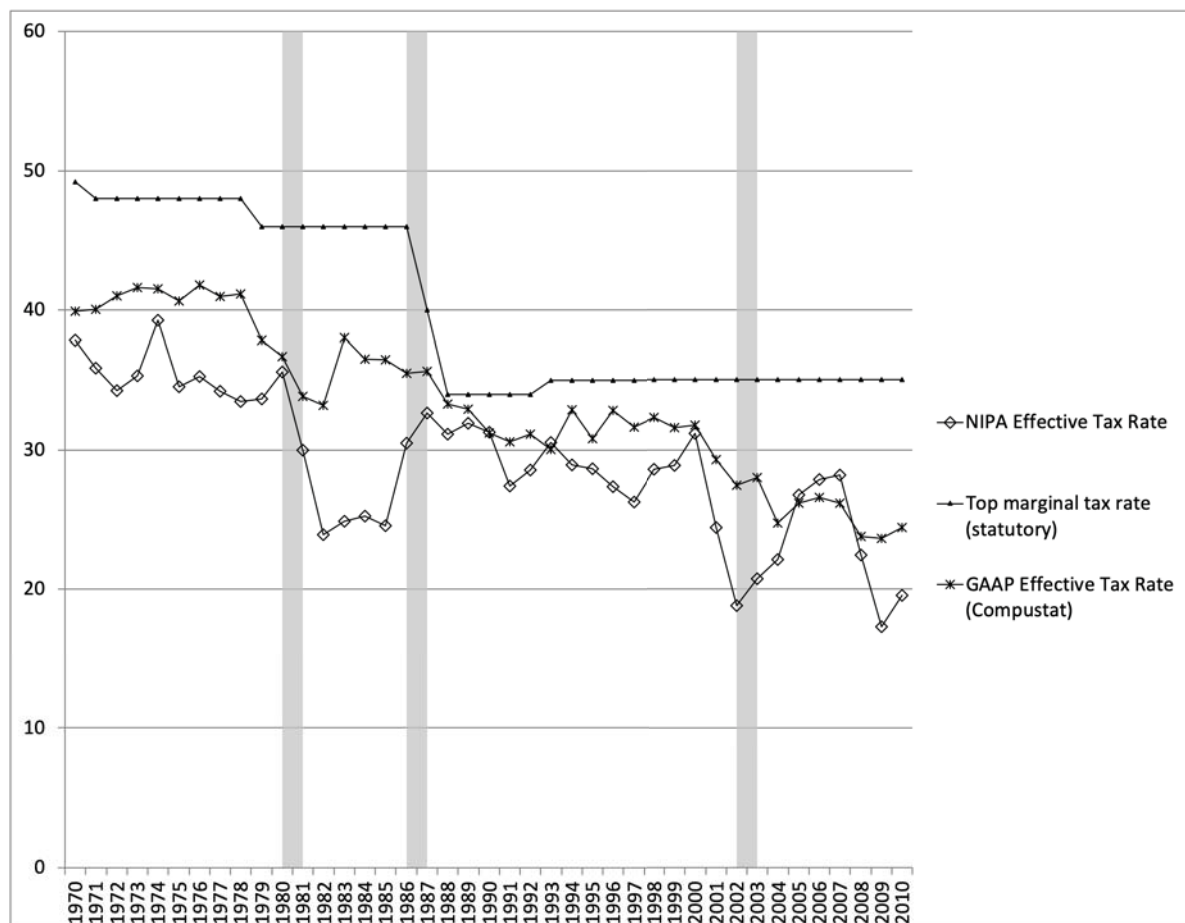


Figure 6: Corporate taxes 1970-2010.

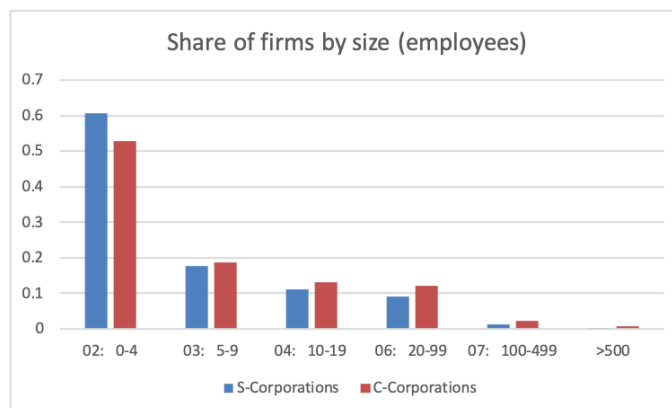
Hence, if taxes faced by these pass-through entities have suffered different changes in the period studied, aggregate consequences showed in the main section of the paper might not hold. Here I argue that including these firms, i.e. including a fraction of firms that only pay personal taxes on the profits, would not change much qualitatively the results. First, note that the tax on profits of pass-through corporations is like the corporate tax of C-corporations, since it is paid on profits, no matter whether

Table 16: Firms by organization type.

Type	Share of firms	Share of employment
Corporation	0.22	0.47
S-Corporation	0.43	0.25
Partnership	0.10	0.10
Other	0.25	0.18

Source: SUSB, year 2007. Other include sole proprietorship, non-taxed entities, etc.

Figure 7: Size distribution by organization type.



Source: SUSB, year 2007. Corporations by size: S-corps vs C-corps.

these are kept in the firm or distributed. Hence, think of a firm in the model of medium or low fixed component of productivity, θ . These firms are not productive enough to do an IPO, and hence remain always privately held. Since they do not have the capacity to issue equity, their optimal decisions are not directly distorted by changes in dividend tax (see Appendix C.2). In other words, the changes in their optimal policies are only affected directly by corporate taxes. Hence, as long as we observe decreases in corporate taxes and personal income taxes, the channels impacting aggregates after the changes in taxes would be the same to those of the main text.⁶⁵ According to Gravelle (2004), the marginal tax rate on non-corporate firms (partnerships and other non-corporate firms) decreased from an average of 0.25 in the 1970s to an average of 0.22 in the 1980s. Furthermore, the top marginal tax rate of personal income has decreased significantly, from being 0.7 in the 1970s to nearly a half, 0.37 in the 2000s. Although non of these estimates tell us the actual change in taxes faced by all non C-corporation firms, these can be understood as a lower bound and an upper bound for the decrease in taxes.

Appendix B.2 Equity issuance costs.

There are two types of costs associated with financing via equity: informational costs and transaction costs. Transaction costs are associated with the compensation to underwriters plus all the legal, accounting, and other fees. Informational costs are related to the extra premium that is associated with the bad signal that a firm may transmit to the market when trying to raise funds as well as the deterioration in balance sheet. The latter are very hard to quantify and the number of empirical studies that address the issue is very limited, so the focus here is on the former.

There are several reasons why the costs of issuing equity may have decreased in the period. The main change in the piece of regulation affecting equity issuance costs in the period is the Glass-Steagal Act of 1933, which was aimed at the separation of commercial and investment banking, and with this purpose it prohibited commercial banks from underwriting issues. During the 1980s and 1990, this piece of legislation was gradually eroded, until it was completely repealed in 1999. Kim et al. (2008) examine the effect of commercial bank entry on underwriting spreads, and find a decrease in underwriting costs due to the pro-competitive effects of this entry.

I use the Thompson's Securities Data Corporation (SDC) Global New Issues database from 1970-2010 to compute direct costs of issuing equity. I keep only those observations trading in main stocks markets: NYSE, Amex and NASDAQ (EXCHC codes NYSE Alter, NYSE Amex, NYSE Arca, NYSE MKT,

⁶⁵This would be the case assuming organizational choice is fixed and exogenous. Changes in the endogenous choice of organizational forms and the composition of firms is a very interesting research question, but it is out of the scope of this paper. For papers exploring these avenues, see Chen et al. (2017) or Dyrda et al. (2018)

Nasdaq). I restrict the analysis to primary offerings (as indicated by variable SHTYPC), since these are the ones linked to inflows of capital to the firm⁶⁶.

Following Lee et al. (1996), I compute the total transaction costs of an issue as a percentage of the proceeds as follows:

$$\text{total cost} = GPCTP + EXPTH * 10 / PROCDS \quad (31)$$

where the first item ($GPCTP$) is gross spreads (management fees, underwriting fees, and selling concession); and the second item ($(EXPTH/1000)/PROCDS * 100$) are other direct expenses (registration fee, printing, legal and auditing costs) as percentage of the proceeds.

Table 17 shows mean total costs measured as spreads. These decreased from 12.26% at the beginning of the sample, to be 10.71% in the 1990s, and decrease to 7.86% in the 2010s.

Table 17: Summary table

	(1) 1970-1980*		(2) 1990-2000		(3) 2000-2010	
	Mean	SD	Mean	SD	Mean	SD
Gross Spreads	7.16	2.22	6.72	1.47	5.67	1.40
Other Costs	4.50	3.80	3.83	3.66	2.24	3.01
Total Spread	12.26	5.39	10.71	4.63	7.86	3.78
Observations	311		4601		2242	

Source: SDC Platinum. * Before 1980 there are only 3 observations in this dataset, so I take observations until 1985 to take the averages of the first period.

Appendix B.3. Productivity shock process and production function curvature.

To estimate the shock process, I use a reduced form estimation approach.⁶⁷ I use the Compustat sample from 1970-2010 described in Appendix 6 to estimate the curvature of the production function and the parameters governing the stochastic volatility process of the idiosyncratic technology shock. Assuming a Cobb-Douglas⁶⁸, sales and gross profits⁶⁹ differ up to a constant. The approach used here is similar to that of Gilchrist et al. (2014) and Gourio and Miao (2010). The identifying assumption is that the production function and the productivity shock process for privately held and publicly traded firms is the same.

From equation (5), solving for l we have that

$$l = \frac{w}{\exp(z + \theta) k^{\alpha \varrho}} \frac{1}{(1-\alpha)\varrho} \quad (32)$$

Plugging this back, we obtain:

$$f(\theta, z, k) = \exp(z + \theta) \frac{1}{1-(1-\alpha)\varrho} k^{\frac{\alpha\varrho}{1-(1-\alpha)\varrho}} \left[\left(\frac{w}{(1-\alpha)\varrho} \right)^{\frac{(1-\alpha)\varrho}{1-(1-\alpha)\varrho}} \right] \quad (33)$$

⁶⁶Secondary offerings are offerings of shareholders selling their existing shares, and therefore lead to no inflow of funds to the company.

⁶⁷Although this estimation may suffer more from endogeneity issues and does not account for exit, it is widely used in the macro literature. For the sake of comparison, I compute TFP using these alternative methodologies, namely that of Olley-Pakes (Olley and Pakes (1996)), Levinsohn-Petrin (Levinsohn and Petrin (2003)) and Wooldridge (Wooldridge (2009)). Although they imply different levels (the process is more persistent and more volatile), the trends in time are very similar: all of them predict an increase in the volatility of the shock, and a slight increase in persistence.

⁶⁸I will use a production function with parameter $\alpha = 0.3$

⁶⁹In the model, gross profits are $y - wl$. Its empirical counterpart is item OIBDP, operating income before depreciation

$$f(\theta, z, k) - wl(\theta, z, k) = \exp(z + \theta) \frac{1}{1-(1-\alpha)\varrho} k^{\frac{\alpha\varrho}{1-(1-\alpha)\varrho}} \left[\left(\frac{w}{(1-\alpha)\varrho} \right)^{\frac{(1-\alpha)\varrho}{1-(1-\alpha)\varrho}} - w \left(\frac{w}{(1-\alpha)\varrho} \right)^{\frac{1}{1-(1-\alpha)\varrho}} \right] \quad (34)$$

where the term between brackets is a constant in both equations. The empirical counterpart of this equation in logs is

$$\log y_{ist} = \beta_0 + \beta_s^k \log k_{ist} + u_{ist} \quad (35)$$

I use log real earnings and log real capital to estimate Equation (35)⁷⁰. I estimate this equation by fixed effects, including a full set of time dummies to capture aggregate trends, such as variations in aggregate productivity, and allowing the decreasing returns to scale parameter to vary by 2-digit SIC code. I obtain the estimated returns to scale from the estimated value of $\hat{\beta}_s^k$

$$\beta_s^k = \frac{\alpha\varrho_s}{1 - (1-\alpha)\varrho_s} \rightarrow \hat{\varrho}_s = \frac{\hat{\beta}_s^k}{\alpha - (1-\alpha)\hat{\beta}_s^k} \quad (36)$$

In Table 18, I show the average of the estimated the degree of decreasing returns from 36, $\varrho = 0.85$. This is in line with the DRS parameter used in the macro literature (Gilchrist et al. (2014), Midrigan and Xu (2014), Jermann and Quadrini (2007)).

I use the residuals from Equation (35) to estimate the process of productivity. First, I adjust the error term multiplying it by $e_{ist} = (1 - (1-\alpha)\varrho_s)u_{ist}$. Next, I subdivide the sample in three periods, 1970-80, 1990-00, and 2000-08. In each subperiod, I fit an AR(1) to the adjusted error term e_{ist} :

$$e_{ist} = \rho e_{ist-1} + \sigma_z \epsilon_{ist} \quad (37)$$

where ϵ_{ist} is iid, and they are drawn from a standard normal distribution. This implies assuming the decreasing returns to scale is constant throughout the period by SIC industries, while the shock process is allowed to change. The results of the estimation are presented in Table 18⁷¹.

Table 18: Estimation of the shock process

ϱ	1970-80		1990-2000		2000-08	
	ρ	σ	ρ	σ	ρ	σ
0.85	0.82	0.22	0.82	0.29	0.85	0.28

Appendix C. More on the model and its assumptions.

Appendix C.1. Privately Held versus Publicly Traded Firms

There are different advantages and disadvantages in the choice of becoming a publicly traded firm, that firms take into account when deciding whether or not to do an IPO. Becoming publicly traded is usually thought of as a 'one-way' process⁷², so firms carefully weigh in the pros and cons of doing an IPO. The main advantages are increased cash to finance investment and long term capital, liquidity for the shareholders, and an increased market valuation thanks to the public information available. The main disadvantages entail higher auditing and reporting costs, principal-agents problems, loss of

⁷⁰Using log real sales instead as dependent variable gives similar estimates, with slightly higher persistence and lower variance of the shock.

⁷¹The increase in the standard deviation of the shock observed is robust to using sales as dependent variable, using OLS instead of fixed effects, or instrumenting capital with its lagged value.

⁷²Although in practice there are firms that delist and go back to being private, usually through acquisition or leveraged buyout, it can be a difficult and costly process for most firms.

privacy and short-termism, among others. These different costs and advantages, have been studied extensively and with detail by a thriving branch of the corporate finance literature. In this paper I model them in a very stylized manner, focusing on the trade-off between access to new capital versus higher operating costs. Here, I present evidence supporting these two main features, i.e. that private firms finance mainly with retained earnings and debt; and the higher ongoing operating costs faced by publicly traded firms. I also comment on another implicit assumption made in the model, namely that private firms can only access to private financing at the start-up stage, and what their implications for the model are.

C.1.1 Private firms finance investments mainly with own resources

One of the main difficulties trying to understand the behaviour of privately held firms is finding data that are widely accessible. One of the most widely used datasets for non-publicly traded firms is the Survey of Small Business Finances (SSBF), sponsored by the Federal Reserve Board, that collects information on small businesses (fewer than 500 employees) in the United States. I use the full public dataset for the 2003 SSBF to analyze the sources of funding of investment for privately held firms.

The focus here is on establishing whether privately held firms use external equity issuance as a source of financing for operations. In the survey, only 6% of the firms claim they obtained *any* new equity investment to finance operations. Out of these firms, 88% were issuing equity from individual investors, who were the founding manager 71% of the times. This implies that it is mainly the owner/manager who mainly finances operations, so as long as she does not have deep pockets and she is constrained, changes in the external cost of equity will have very limited impact in the amount of equity raised⁷³⁷⁴.

Table 19: Use of external equity by organizational form.

	S-corps	C-corps	LLC filing as C-corps
<i>Using external equity</i>	5.4%	7.0%	7.0%
From individual investors	91.6%	81.9%	100.0%
From manager/owner	77.4%	59.4%	100.0%

Source: 2003 Survey of Small Business Finances. First row shows percentage of firms using external equity. Second row shows, out of these firms, how many are raising money from individual investors, and out of these, how many are raising the equity from manager/owner is shown in the third row. Responses to the last two questions have many less responses than the previous one.

The previous analysis takes into account all privately held firms, i.e. C-corporations paying corporate and distribution taxes; and S-corporations, LLCs and partnerships paying only income taxes on their profits. It is conventional wisdom that C-corporations can raise external equity more easily than pass-through entities. Indeed, there are less restrictions to be a shareholder in C-corporations, which might make it easier for them to raise equity. If we perform the same analysis separating by type of corporation⁷⁵, we observe that indeed C-corps obtain more external financing than S-corps. Nonetheless, this difference is minor if compared to publicly traded firms, since in the 2000s almost 26% were financing with equity.

⁷³Think of an entrepreneur who solely owns the firm, and can decide how much to invest in his firm k' , and how much to consume in the form of dividend from this firm. His budget constraint is $d + k' = \pi(k) + (1 - \delta)k$ and his utility is $U((1 - \tau_d)d)$. The euler equation is $(1 - \tau_d)U'(c_t) = \beta(1 - \tau_d)U'(c_{t+1})(\pi'(k_{t+1}) + (1 - \delta))$, so this firm will behave as in the new view, i.e. distribution taxes will not distort his investment decision. If the entrepreneur has access to more than one asset, then distribution taxation will distort her decisions. However, as long as this owner is an individual with no deep pockets and limited access to borrowing, changes in taxation will have little impact in the financing decision of the firm.

⁷⁴Other data also support this. For instance, The Kaufman Foundation surveyed the 5000 fastest growing private firms in US about their source of financing, and found that 67.2% use personal savings; and 51.8% bank loans; and only 6.5% have access to venture capital, and 7.7% to investment angels.

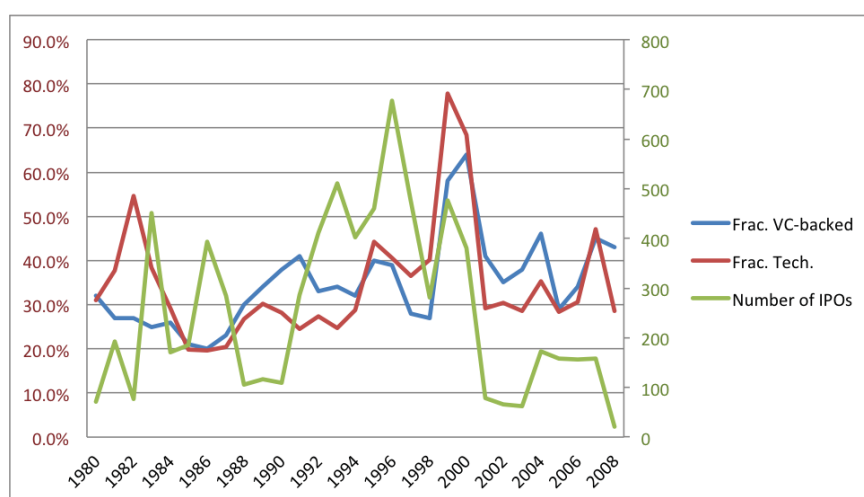
⁷⁵Other forms of corporations, i.e. partnerships, sole proprietorships, etc. had no answers in this question.

C.1.2 Venture capital, Technological Firms and IPOs

Even though most private firms are not receiving private capital financing, it is the case that firms that end up doing an IPO might receive disproportionately venture capital financing or other private capital funding. For tractability reasons, the model restricts this external financing to be only at the start-up stage. However, if firms receive financing by a venture capital, they might not be constrained at the stage of the IPO, and decide to go public only so that these investors can cash-out their investment. This would mean these firms are not constrained at the boundary of doing an IPO, and hence the model would be overstating the benefits of doing IPOs. If the ratio of venture capital backed firms increased in the period studied, this problem would be even more severe.

Figure 8 shows the number of IPOs (in green, on the right axis), the fraction of IPOs that received venture capital financing (blue, on the left axis), and the fraction of IPOs that were technological firms (red, on the left axis). Apart from a spike in 1999 and 2000, technological firms as a fraction of all IPOs was relatively constant slightly below 40%. This casts some doubts on some theories that hypothesize that it is the changes in composition of entrants, i.e. a shift towards more technological firms, that it is driving the changes in behaviour of publicly traded firms. The number of venture capital backed IPOs has increased steadily, from an average of 27% at the beginning of the 80s, to 39% in the 1990s. Hence, understanding the behaviour of venture capital backed firms at IPO is important to understand whether the mechanism at play here is still relevant.

Figure 8: Number of IPOs, Fraction of VC backed and Technological IPOs.



Source: Ritter's IPO dataset. Number of IPOs (in green, on the right axis), the fraction of IPOs that received venture capital financing (blue, on the left axis), and the fraction of IPOs that were technological firms (red, on the left axis).

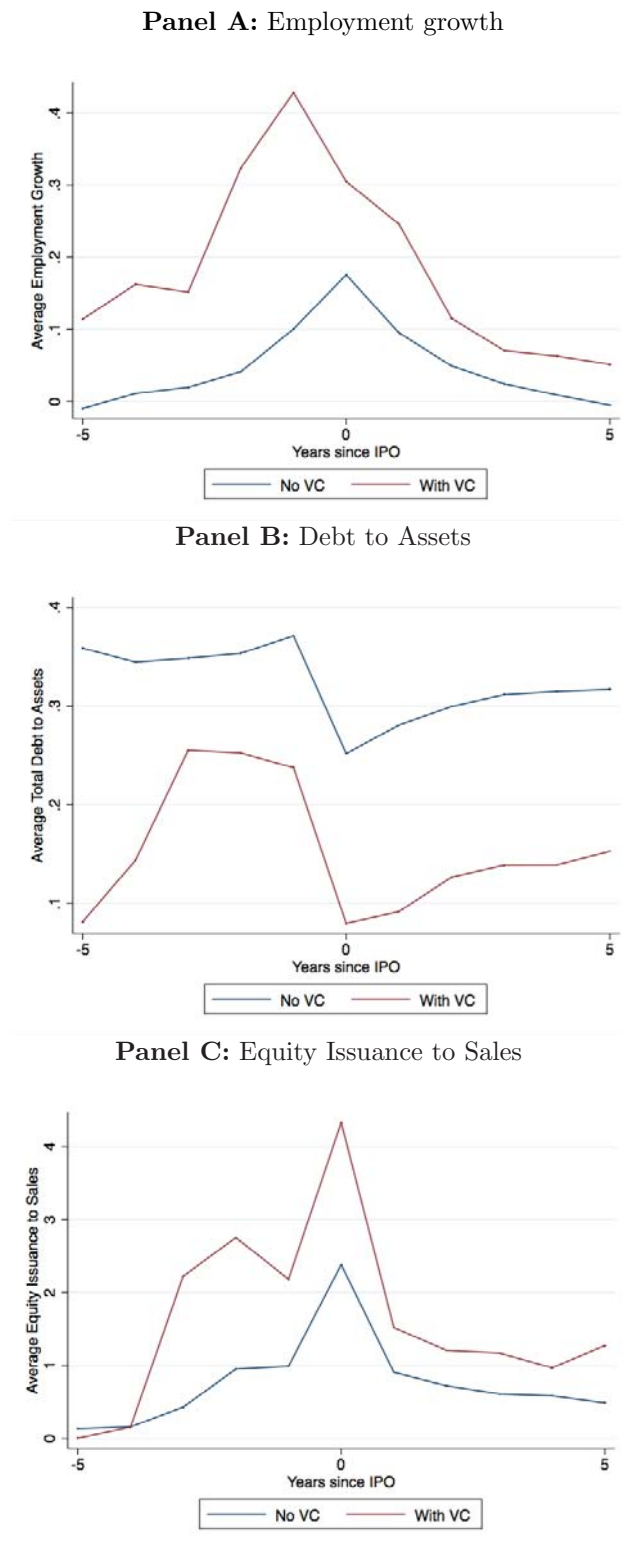
Using data from VentureXpert, I merge it with the panel data I have from Compustat North America, in order to understand whether the behaviour of venture backed firms is different from those that received no venture capital financing. Compustat sometimes retrieves data of firms before doing an IPO, if they have to file for any reason to the SEC, and in the recent years they have information of two years before the IPO⁷⁶. Although not completely representative, it allows us to get an idea of what the dynamics around the IPO date are.

Figure 9, Panel A, shows employment growth before and after IPO. As expected, this presents an inverted U shape around the IPO date (this follows directly from the TFP dynamics found in the

⁷⁶Companies that IPO on the NYSE, NYSE Alternext, or NASDAQ are required to file a Prospectus prior to the Initial Public Offering (IPO) date. Data is collected from the prospectus for up to two fiscal years on an annual basis and three years on a quarterly basis prior to the public offering if the data is available from the prospectus. It is possible for a company to have no data prior to the IPO date if the company did not exist prior to the IPO and presents no pro-forma data in the prospectus. Only one year of data was collected from the prospectus prior to 1997. Because of this, I use the whole period studied for the graphs in this section, i.e. from 1970 to 2008, to increase the number of observations prior the IPO.

literature). As it is known, venture capitalist backed firms outperform non venture capital backed firms⁷⁷. However, the dynamics around IPO are very similar, and still follow an inverted U shape. Venture backed firms rely less on debt, as shown in Panel B, and more on equity issuance, as shown by Panel C. Nonetheless, the dynamics of both types of firms are very similar. Firms issue a lot of equity at IPO, using this financing to grow, substituting (partly) debt with equity financing.

Figure 9: Dynamics around IPO of VC-backed and Non-VC-Backed



Source: Compustat and VentureXpert. Matched data by CUSIP. Year 0 is the year of IPO. Averages by years since/to IPO.

⁷⁷The reasons why this is the case are less clear. See Campbell and Frye (2006)

C.1.3 Ongoing costs of operating a publicly traded firm

Public companies are required by the SEC under the Securities 1934 Act to file certain periodic reports to keep the investing public informed⁷⁸. This includes an annual report to shareholders (Form 10-K) providing a comprehensive overview of the company's business and financial condition, including audited financial statements; quarterly reports required for each of the first three quarters of the fiscal year (Form 10-Q), and need to file a report for significant events (Form 8-K) such as an acquisition or disposal of assets, a change in control or bankruptcy, among other important events. Besides, all SEC registrants are required to provide their financial statements and schedules to the SEC and post them on their corporate websites in interactive data format. Furthermore, executive time is often incurred in the preparation of periodic reports filed with the SEC, and more personnel needs to be devoted for SEC reporting, financial planning, and taxation, among other activities. According to a survey performed by PWC (PWC, 2012), on average companies incur \$1.5 million of recurring costs as a result of being public; 84% of recently public firms hired between one and five new staff specifically to increase their SEC reporting capabilities, and nearly 60% hired new employees for financial planning and analysis. Because of all these, they find that 45% of firms indicated that the costs of being public exceeded their expectations.

C.1.4 The IPO decision

An IPO (Initial Public Offering) is the first time the stock of a C-corporation is traded on a public stock exchange. Although it is modelled in a very stylized manner in this paper, I want to review the main steps followed in the process, and how they relate to my paper.

The main reason for going public are two: raising new equity capital, and obtaining liquidity for the shares of the company. In the model, this is also going to be true: firms will go public to raise new equity, and to 'cash-out' the owner of the private firm⁷⁹. In an IPO, most of the shares offered are primary shares, i.e. new shares that bring new equity entering into the firm; as opposed to secondary shares, i.e. exchange of already existing shares. The latter will imply a capital gain or loss to the owner of the share (and therefore will be taxed at capital gains rate). The former will imply a dilution of the value of the shares in the company, which will change the value of existing shares, but this gain/loss is not taxed until it is realized, or until the shares are sold by the owners. Because of this, IPOs, unlike selling of a firm in an acquisition, are not directly taxed at capital gains rate.

An IPO starts with the interested firm looking for an investment bank to underwrite the equity issuance. This investment bank will be chosen depending on its reputation, its network, the industry expertise, etc. Since frictions in this market is not the focus of this paper⁸⁰, in my model there are no investment banks, and these are modelled as a mere costly technology' that allows privately held firms to become publicly traded. Once the investment bank is chosen, firms start the due diligence process and regulatory filings. The investment bank and the firm arrive to one of the underwriting arrangements: firm commitment, i.e. the investment bank purchases whole offer, and then resells it to the public; best efforts, i.e. the investment bank does not commit to sell a certain amount of shares, just acts as an intermediary between the company and the market; or a syndicate of underwriters, where the offering is made by several banks under the leading role of the main underwriting bank, diversifying some of the IPO risks.

After the IPO is approved by the SEC, the issuance date is decided. Before the effective date, the issuing company and the underwriter decide the offer price, and the exact numbers of shares to be sold. In most cases, IPOs are underpriced, i.e. the issuance price is lower than the true value of the

⁷⁸Most privately held firms are exempt of these filings, although there are some exemptions. Any company must file financial reports with the SEC when it exceeds \$10 million in total assets and a class of equity securities, like common stock, held by either 2000 or more people; or 500 or more people who are not accredited investors; or when it lists some of its securities on a U.S. exchange.

⁷⁹This would be especially important if private firms were risk averse and could not diversify the risk, which is not the case in this paper.

⁸⁰For papers using search models in this setting, see for instance Lagos and Rocheteau (2009) for an application in over-the-counter markets, or Chen et al. (2015) for a specific application to the IPO market.

share, usually making abnormal high returns on the first day of trading. This phenomenon is widely studied in the Corporate Finance literature, but in this paper it is captured in reduced form by the costs of doing an IPO.

Appendix C.2. The impact of taxes on optimal decisions

In order to easily see the impact of of taxes on firms' choices, let's first simplify the problem. This analysis builds on Erosa and González (2019). Assume there are only two periods, and privately held and publicly traded are in separate pools, so private firms cannot do IPO and publicly traded firms cannot exit, and that private firms do not smooth dividends, i.e. $\epsilon = 0$. Firms cannot borrow nor lend, so $a = k$, and there is only one type θ . There is no uncertainty, so productivity z is fixed. Firms are born at $t=1$, with given productivity and capital, operate and make investment decisions. In period $t=2$, firms operate, distribute as dividends everything left and liquidate:

$$W_2(z, k_2) = (1 - \tau_d)d_2 = (1 - \tau_d)((1 - \tau_c)\pi(z, k_2) + k_2)$$

$$V_2(z, k_2) = (1 - \tau_d)d_2 = (1 - \tau_d)((1 - \tau_c)\pi(z, k_2) + k_2) \quad (38)$$

At time $t=1$, the problem of the private firm looks as follows:

$$W_1(z, k_1) = (1 - \tau_d)d_1 + \beta [(1 - \tau_d)d_2] \quad (39)$$

$$d_1 = (1 - \tau_c)\pi(z, k_1) + k_1 - k_2 \quad (40)$$

$$d_1 \geq 0 \quad (41)$$

Their euler equation reads as follows:

$$\lambda_1 = \beta \lambda_2 \left((1 - \tau_c) \frac{\partial \pi(z, k_2)}{\partial k_2} + 1 \right) \quad (42)$$

where λ^d is the multiplier on the non-negativity constraint in dividends, and λ_t the multiplier on the budget constraint. Therefore, capital for next period k_2 is the one that solves:

$$d_2 > 0, \lambda^d = 0 \rightarrow \lambda_1 = (1 - \tau_d) ; \lambda_1 = (1 - \tau_d) \beta \left((1 - \tau_c) \frac{\partial \pi(z, k_2)}{\partial k_2} + 1 \right) \quad (43)$$

$$d_2 = 0, \lambda^d > 0 \rightarrow k_2 = (1 - \tau_c)\pi(z, k_1) + k_1 \quad (44)$$

From this problem, we obtain the following propositions:

Proposition 1 *The shadow value of funds of privately held firms is bounded below by $(1 - \tau_d)$, i.e. $\lambda \in [(1 - \tau_d), \infty)$*

Proof. Follows from Equation (43) and (44). ■

Proposition 2 *Distribution taxation τ_d affects the value of the privately held firm, $W_1(z, k_1)$, but does not affect their investment nor payout policies.*

Proof. Follows from Equation (43), since $(1 - \tau_d)$ appears in both sides of the equation, and from (44), since it is not affected by τ_d . ■

Realize this holds even if there is uncertainty, or if we plug back any of the ingredients we simplified. As can be seen from the euler equation, corporate taxation distorts the investment decision: higher τ_c will imply a lower k_2 . However, distribution taxation τ_d does not distort the optimal investment

decision. Hence, although it affects the value of the firm $W_1(z, k_1)$, it does not affect investment nor the payout policy.

The publicly traded firm problem at time $t=1$ looks:

$$V_1(z, k_1) = (1 - \tau_d)d_1 - e_1 + \beta [(1 - \tau_d)d_2] \quad (45)$$

$$d_1 - (1 - \xi)e_1 = (1 - \tau_c)\pi(z, k_1) + k_1 - k_2 \quad (46)$$

$$d_1 \geq 0 ; e_1 \geq 0 \quad (47)$$

The first order conditions read as follows, where λ_t^d and λ_t^e are the multipliers of the non-negativity constraints of d and e respectively, and λ_t is the multiplier of the budget constraint at time t :

$$d: (1 - \tau_d) - \lambda_1 + \lambda_1^d = 0 \quad (48)$$

$$e: -1 - (1 - \xi)\lambda_1 + \lambda_1^e = 0 \quad (49)$$

$$k_2: -\lambda_1 + \lambda_2 \left((1 - \tau_c) \frac{\partial \pi(z, k_2)}{\partial k_2} + 1 \right) = 0 \quad (50)$$

Realize that now, the shadow value of funds is bounded above and below:

Proposition 3 *The shadow value of funds of publicly traded firms is bounded below by $(1 - \tau_d)$ and above by $\frac{1}{1-\xi}$, i.e. $\lambda \in [(1 - \tau_d), \frac{1}{1-\xi}]$*

Proof. Follows from Equation (48) and (49). ■

This has further implications for the investment and payout policies, and yields to the next proposition:

Proposition 4 *Distribution taxation τ_d affects the value of all publicly traded firms, $V_1(z, k_1)$, but only affect investment and payout policy of those that are issuing equity, i.e. $\lambda_1 = \frac{1}{1-\xi}$*

Proof. Since in $t=2$, all firms issue dividends, $\lambda_2 = (1 - \tau_d)$. Hence, if the firm is issuing equity, i.e. $\lambda_1 = \frac{1}{1-\xi}$:

$$\lambda_1 = \frac{1}{1-\xi} = \beta(1 - \tau_d) \left((1 - \tau_c) \frac{\partial \pi(z, k_2)}{\partial k_2} + 1 \right) \quad (51)$$

Hence, τ_d distorts the optimal choice of capital k_2 . If the firm is distributing dividends, i.e. $\lambda_1 = (1 - \tau_d)$, distribution taxes cancel out since they are in both sides of the equality. If $\lambda_1 \in ((1 - \tau_d), \frac{1}{1-\xi})$, the firm is reinvesting all the profits, and the investment for next period is given by the budget constraint. Hence, these firms are not distorted by distribution taxes. ■

Realize that publicly traded firms are always distorted by corporate taxes, as privately held firms are.

Life cycle of firms

This two period example is simple, since we know for sure the last period the firm is distributing dividends. If there are more periods without uncertainty, the publicly traded firm will start issuing equity, $\lambda = \frac{1}{1-\xi}$. From that period on, firms will reinvest the profits, and start growing, while their shadow value of funds start decreasing, until they reach $\lambda = (1 - \tau_d)$, when they start distributing dividends, and distribute dividends ever after. For a more detailed explanation of the effect of dividend and corporate taxes on the life cycle of publicly traded firms, see Erosa and González (2019). Adding uncertainty makes this transition non-linear, i.e. a firm distributing dividends can be issuing equity the following if they receive a sufficiently high positive shock to productivity, and a constrained firm today can distribute dividend the following period if they receive a bad shock.

If firms are privately held, i.e. they start their life raising funds from the private capital fund. From that moment on, they decide whether to reinvest, or to distribute dividends, but cannot raise further

external funds via equity issuance. distribution taxation therefore allows privately held firms to raise more private capital funds at the initial stage, but does not affect any optimal policy from then on. Corporate taxes do distort optimal investment choices throughout the life cycle of the privately held firm.

Appendix D. Further Results.

Appendix D.1. Decomposition of Results

Which of the ingredients, i.e. distribution taxes or corporate taxes, are crucial for the results? To answer this question, Table 20 (Columns (2) and (3)) shows the results of computing the equilibrium changing only one of the ingredients at a time, maintaining the rest equal to their baseline value.

A decrease in corporate taxes makes all firms less distorted, increasing investment and aggregate capital. Decreasing only corporate taxes increases output 2.1%, which implies 84% of the increase from the

Table 20: Decomposition and Changes in Equity Issuance Costs

	Data 70-90	(1) Both taxes	(2) Only τ_c	(3) Only τ_d	(4) Change ξ_1, ξ_2
<i>Selection & Composition</i>					
Share public firms	26.0%	16.7%	8.4%	12.3%	2.0%
Avg size public	-23.0%	-6.3%	-2.8%	-5.9%	-1.0%
Median size at IPO	-58.9%	-5.4%	14.5%	-25.7%	-12.1%
p75 to p25 emp at IPO	53.6%	0.2%	11.5%	-10.4%	5.4%
Market cap to GDP	138.6%	46.7%	14.5%	30.5%	1.2%
<i>Behaviour public</i>					
Frac eq>0	146.1%	41.6%	-2.6%	36.8%	0.7%
Equity to sales	253.9%	45.9%	14.9%	33.3%	6.1%
Dist to sales	68.4%	17.8%	8.3%	9.0%	1.5%
Investment to sales	85.1%	13.2%	12.2%	1.6%	0.6%
Financial Assets to assets	22.6%	11.9%	11.9%	0.7%	0.0%
<i>Share of employment</i>					
Size > 500	3.5%	3.3%	2.7%	0.8%	-0.2%
<i>Aggregates</i>					
Y		2.5%	2.1%	0.5%	0.1%
K		6.5%	5.8%	0.9%	0.1%
A		8.2%	7.7%	0.7%	0.1%
TFP		0.7%	0.7%	0.1%	0.0%
Consumption		1.5%	1.2%	0.4%	0.0%
Emp share largest 1%		1.9%	1.4%	0.6%	0.1%

Percentage changes from baseline, making one of the exogenous changes at a time while keeping the rest constant to their baseline value. Data: changes from 1970s to averages in 1990-00. **Column 1** (Both taxes) corresponds to the results of the main text, where changes in τ_c and τ_d from Table 7 are introduced, i.e. $\tau_c = 28.9\%$; $\tau_d = 20\%$. **Column 2** shows the results in general equilibrium of changing only τ_c to the value of the 1990s, i.e. $\tau_c = 28.9\%$. **Column 3** shows the results in general equilibrium of changing only τ_d to the value of the 1990s, i.e. $\tau_d = 20\%$. **Column 4** shows the results in general equilibrium of decreasing only ξ_1 and ξ_2 15%, to obtain the equilibrium equity spread of the 1990s from Table 17, i.e. $\xi_1 = 10.7\%$.

baseline in the equilibrium with all the changes. It improves TFP by 0.7%, since the optimal allocation is less distorted, both for publicly traded and privately held. Not surprisingly, since this tax is the most distortive one, it is the one driving most of the results in the aggregates. Regarding selection of firms into public, this tax has relevant effects: the share of public firms increases 8.4%, while average size of public firms decrease 2.8%. Median size at IPO increases 14.5%. Firms have more after-tax profits, hence increasing distributions to sales by 8.3%. Also, when hit by a positive shock, they need more financing and issue more equity, increasing equity to sales by 14.9% , although the share of firms issuing equity decreases by 2.6%, since they have more after-tax to finance growth internally, they issue equity less often.

In the next column we find the results of decreasing only distribution taxes. Compared to the rest of the columns, clearly distribution taxes are the ones driving the changes in selection and behaviour of publicly traded firms. Remember, statically, a decrease in distribution taxes acts as a decrease in equity issuance cost if the firm is issuing equity (traditional view), distorting less investment of publicly traded firms growing, while it does not affect firms who are financing marginally with internal resources or are distributing dividends (new view), which were not distorted by this tax in the first place, i.e. privately held firms and mature publicly traded firms. Therefore, it is much more attractive to do an IPO for very constrained firms for two reasons: they can benefit from more equity issuance if they become public, and they obtain a higher market price for the firm due to lower distribution taxes. Because of this, the share of publicly traded firms increases 12.3%, the median size at IPO decreases 25.7%, and average equity to sales increases 33.3%. Note most of the effect on market capitalization to GDP come through this channel: the huge decrease in distribution taxes affects directly the value of the firm, increasing their market value, but does not change the optimal capital and asset holdings of firms that are not issuing equity. However, aggregate results of this change alone are milder, since they affect a smaller fraction of firms: constrained private firms that now become public, and publicly traded firms who want to issue equity. Therefore, output increases only 0.5% and capital stock increases 0.9%. TFP increases 0.1%, since lower distribution taxes help the most distorted firms, i.e. those with high productivity and low assets, to overcome their constraints.

Appendix D.2 Changes in Equity Issuance Costs

In this Appendix, I change only equity issuance costs from the baseline economy, in order to assess the importance of these on the decision to go public. Hence, I only change equity issuance costs in the baseline economy, by decreasing ξ_1 and ξ_2 proportionally, so that the equilibrium equity spread decreases as in the data. This is attained by decreasing ξ_1 and ξ_2 by 15%, so that the average spread on equity issuance is 10.7% in the new equilibrium. They alone imply an increase in the share of publicly traded firms lower than that caused by changes in taxes, even if these costs affect more directly public firms and the IPO choice. The decrease of equity issuance costs imply a decrease in the average size of public firms, and the median size at IPO. Note that qualitatively the impact on selection patterns is very similar to that of τ_d since this change works as a 'decrease' of costs of issuing equity, though the latter is larger, because of two reasons: 1)the decrease in dividend taxes is much larger; and 2)dividend taxes also affect directly the market value of firms, hence the proceeds of doing an IPO, and the size at the creation of the firm. At the aggregate, the impact of changes in equity issuance costs on output is small, increasing output around 0.1%.

Appendix E. Numerical Appendix

State Space

I discretize the net worth space into 300 grid points log-spaced. I follow the strategy of Buera and Shin (2011) to discretize the fixed component of productivity, $\bar{\theta} = \exp(\theta)$, which follows a Pareto distribution. Let $j \in [1, J]$ be the label of the discretized grids. Denoting the cdf of the original Pareto

distribution $F(\bar{\theta}_j) = 1 - \left(\frac{\theta_{min}}{\bar{\theta}_j}\right)^\eta$, I choose $\bar{\theta}_1, \bar{\theta}_{J-1}, \bar{\theta}_J$ such that $F(\bar{\theta}_1) = 0.4$, $F(\bar{\theta}_{J-1}) = 0.998$ and $F(\bar{\theta}_J) = 0.9991$. I then construct θ_j to be equidistant from $j = 1, \dots, J - 1$. I compute the discretized pdf such that it adds up to one, i.e. $\tilde{f}(\bar{\theta}_j) = (F(\bar{\theta}_{j+1}) - F(\bar{\theta}_j))/F(\bar{\theta}_J)$. I set $J=10$, and $\theta_{min} = 0.3$. Finally, z_t follows an AR(1) and it is discretized following Tauchen (1983) algorithm into 25 grid points, using $m=4$ as multiple for the discretization process.

Computation of Discrete Choices using Taste Shocks

In order to smooth out the discreteness of the IPO and the exit choice, a taste shock is added, following Iskhakov et al. (2017). The main idea is that every period firms receive a vector of additive-separable taste shocks ϵ to the value of being publicly traded or privately held. These shocks are i.i.d according to an Extreme Value type I distribution (Gumbel) with scale parameter σ_ϵ . The variance is set to $\sigma_\epsilon = 0.01$. By doing this, the choice that was previously discrete becomes a probability, so changes in the IPO choice become continuous. For more details about this methodology, I refer the interested reader to Iskhakov et al. (2017). All the results presented in the paper are not affected by the introduction of these shocks, and survive if the IPO choice is a discrete (0,1) choice.

The model is computed numerically, using the divide and conquer algorithm of Gordon and Qiu (2018).

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