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Taxes and Financial Frictions: Implications for Corporate Capital Structure

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Abstract: According to data from Compustat, we observe three general trends between 1980 and 2012. First, firms have been reducing their reliance on debt, as leverage ratios have fallen and an increasing fraction of firms are now actually net lenders. Second, the frequency at which firms neither issue external equity nor distribute dividends to shareholders has fallen. Third, marginal corporate income tax rates have fallen significantly as well. Using Compustat balance sheet data, we structurally estimate a model in which heterogeneous firms finance investment with equity and debt. Our model incorporates costly external finance as well as a detailed tax structure, including personal, dividend and corporate income taxes. We conclude that there has been a significant reduction in the cost of external equity, while overall leverage ratios have fallen mainly because of a lower tax advantage of debt.

Keywords: financial frictions, capital structure, firm dynamics, corporate saving, debt, equity

JEL Classification Numbers: G32, L11, E21

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1 Introduction

Debt and equity are important sources of finance for firms in the United States. Firms frequently borrow, but since 1980, leverage ratios have declined so much that an increasing fraction of firms are now actually net lenders. Meanwhile, equity issuance is commonplace, and the frequency at which firms neither issue equity nor distribute dividends has fallen (i.e., zero net equity issuance). However, existing explanations for the shift in borrowing behavior imply that the rate of zero net equity issuance should increase (not decrease). In this paper, we structurally estimate a model in which firms finance investment with equity and debt. The objective is to understand both the shift of firms toward net lending and the decline in the rate of zero net equity issuance since 1980. We find that leverage ratios have fallen and more firms are net lenders mainly because of a lower tax advantage of debt. At the same time, our estimated external financing frictions have declined significantly, helping to explain the declining frequency of zero net equity issuance.

Using a framework that is closely related to [Hennessy and Whited \(2007\)](#) and [Katagiri \(2014\)](#), we build a dynamic model in which heterogeneous firms finance investment with either equity or debt. Firms can borrow or lend, they can raise funds directly from shareholders (i.e., external equity), they can distribute funds to shareholders as dividends and they can accumulate internal equity. The firm’s financing decision is distorted by two factors. First, since it will be costly for firms to raise external equity and to distribute funds to shareholders, there will be an incentive for firms to do neither. The main financial friction is the cost firms must pay to obtain external equity financing. Second, we incorporate a detailed tax structure, whereby the firm’s debt choice is distorted by personal, dividend and corporate income taxes.

We assume that equity issuance incurs a cost, which can include *direct* costs such as underwriting fees or *indirect* costs that might arise out of an asymmetric information problem. There is some empirical evidence, however, that equity issuance costs have been falling. [Kim, Palia, and Saunders \(2008\)](#) document that average underwriting fees for both initial public offerings (IPOs) and seasoned equity offerings (SEOs) fell between 1975 and 2004. Nevertheless, underwriting fees do not fully account for all the direct costs that may be incurred by a firm since stock issuance is not the only way firms can raise external equity. For example, firms can also raise equity through mergers, private placements, or employee stock options (e.g., see [Fama and French, 2005](#)) and these other methods may have different costs. Furthermore, it is inherently difficult to measure *indirect* equity issuance costs. For example, because managers may have more information about the firm than investors, they may be reluctant to issue external equity for fear of the negative signal it may send about

the firm’s prospects.

Therefore, we structurally estimate our model using Simulated Method of Moments (SMM). We obtain information on firm-level balance sheet data from Compustat between 1980 and 2012. To identify how external financing frictions have changed over time, we split our sample and separately estimate our model using data from the early 1980s and data from the late 2000s. For our estimation, we pick moments which are a priori informative for the parameters we seek to estimate. First, we measure net equity issuance at the firm level.¹ In contrast to the existing literature, we match the frequency at which net equity issuance is zero (i.e., when firms neither issue external equity nor distribute dividends). In our data, the frequency of zero net equity issuance has declined from 13.1% in 1980 to 2.0% in 2012. As external financing costs induce firms to follow (S, s) decision rules with respect to net equity issuance, we view this particular moment as being directly informative about the cost of obtaining external equity. Second, we match the empirical observation that firms have been reducing their reliance on debt. In our Compustat data, the fraction of firms with non-positive net debt has increased from 11.9% to 41.4%. Third, since marginal tax rates are crucial for the tax advantage of debt, we discipline the model to firm-level marginal corporate income tax rates which have been falling over time.² In order to do this, we allow for a more detailed tax structure than is usually modeled in the literature.

Using this exercise, we estimate the external financing cost has fallen from 23.5% to 6.4% between 1980 and 2012.³ To put these numbers in context, note that [Kim, Palia, and Saunders \(2008\)](#) report that the average underwriting fee for SEOs has fallen from 5.41% between 1975 and 1989, to 4.60% between 1999 and 2004. [Altinkilic and Hansen \(2000\)](#) also report that the average underwriting fee, between 1990 and 1997 was 5.38%. Using a structural estimation approach on a sample that covers 1988 to 2001, [Hennessy and Whited \(2007\)](#) estimate that the marginal equity issuance cost is 9.1%. Our estimates are still within the range of values commonly used in the literature. Overall, this suggests that indirect equity issuance costs were relatively more important in the early 1980s. Costs have declined so much that the total equity issuance cost, in recent times, is quite similar to measures of the direct costs reported in the literature.

We then use our model to determine which features explain the increasing frequency of

¹To measure net equity issuance, we follow the primary approach of [Covas and Den Haan \(2011\)](#). See [Covas and Den Haan \(2011\)](#) or [Karabarbounis, Macnamara, and McCord \(2014\)](#) for a discussion of the measurement issues.

²We obtain marginal tax rates from the Marginal Tax Rate database, where marginal tax rates are estimated using a non-parametric procedure detailed in [Blouin, Core, and Guay \(2010\)](#)

³In our benchmark specification, the equity issuance cost is directly proportional to the amount of funds raised. However, in an alternative fixed-cost specification, average external financing costs fall from 11.4% to 4.0%.

net lending and the decreasing frequency of zero net equity issuance. According to our model, the best explanation for the shift in net borrowing is the decline in the tax advantage of debt. If only taxes changed between 1980 and 2012, our model indicates that the frequency of net lending would have increased from 12.2% to 50.2% (versus 11.9% to 41.4% in the data). The decline in marginal corporate income tax rates is the main explanation for why debt has become less tax advantaged. Since firms can use debt to reduce its overall corporate income tax bill, lower marginal tax rates have reduced the incentives of firms to borrow. Firms then choose to lend (rather than distributing more funds to shareholders) as a precaution, given the possibility of future financial constraints. While an increase in idiosyncratic uncertainty has also generated a precautionary incentive to reduce debt issuance, the quantitative effect of this on the net borrowing position is smaller than the shift in taxes.

We next consider the effect of the fall in external equity costs. Intuitively, lower external equity costs have helped cause a decline in the frequency of zero net equity issuance. However, easier access to external finance has actually led to an increase in debt issuance. On the one hand, the lower cost of obtaining external equity can cause firms to substitute from debt to equity. On the other hand, a lower cost of external equity can cause firms to issue more debt today, as they are less concerned about needing to raise external equity in the future. This is the traditional precautionary motive, whereby firms have an incentive to save, accumulate internal equity, reduce distributions to shareholders in order to avoid the financial constraint in the future. In our analysis, the precautionary motive dominates and the lower external equity costs have actually encouraged firms to use more debt.

The theoretical literature, recognizing the significance of external financing, often assumes that firms can raise funds directly from shareholders. To break the irrelevance result of [Modigliani and Miller \(1958\)](#), many papers assume that firms must pay a cost when issuing equity.⁴ In these papers, there is a wide range of parameter values commonly used for equity issuance costs, ranging from 2.8% in [Gomes \(2001\)](#) to 30% [Cooley and Quadrini \(2001\)](#). Some authors have disciplined the equity issuance cost using actual flotation costs (e.g., [Gomes, 2001](#) and [Covas and Den Haan, 2012](#)). Others have taken a structural estimation approach in order to overcome the inherent measurement issues ([Hennessy and Whited, 2007](#); [DeAngelo, DeAngelo, and Whited, 2011](#); [Nikolov and Whited, 2014](#); [Eisfeldt and Muir, 2016](#); [Nikolov, Schmid, and Steri, 2018](#)). The contribution of this paper is twofold. First, we identify how

⁴A list of papers that assumes costly equity issuance includes (but is not limited to) [Gomes \(2001\)](#), [Cooley and Quadrini \(2001\)](#), [Hennessy and Whited \(2005\)](#), [Hennessy and Whited \(2007\)](#), [Covas and Den Haan \(2012\)](#), [DeAngelo, DeAngelo, and Whited \(2011\)](#), [Gomes and Schmid \(2010\)](#), [Katagiri \(2014\)](#), [Karabarbounis, Macnamara, and McCord \(2014\)](#), [Nikolov, Schmid, and Steri \(2018\)](#) and [Begenau and Salomao \(2018\)](#). Other papers implicitly assume that the cost of external equity is infinitely large, by assuming that firms can only distribute funds to shareholders – e.g., [Arellano, Bai, and Zhang \(2012\)](#), [Khan and Thomas \(2013\)](#), [Khan, Senga, and Thomas \(2016\)](#), [Jo and Senga \(2018\)](#), [Arellano, Bai, and Kehoe \(2018\)](#).

this cost has changed over time. Second, we emphasize the empirical moments we use to estimate the cost of external financing. In contrast to the literature, we utilize the frequency of zero net equity issuance and marginal corporate income tax rates in our estimation. We argue that both of these moments are directly informative for the two key trends we seek to explain.

Moreover, since we seek to match the empirical trends in firm financing, this paper is related to literature seeking to understanding why firms are increasing their holdings of cash, a fact which has been highlighted by [Bates, Kahle, and Stulz \(2009\)](#), [Opler, Pinkowitz, Stulz, and Williamson \(1999\)](#) and [Sánchez and Yurdagul \(2013\)](#). While our model does not distinguish between cash and debt, the increase in cash holdings is obviously related to the downward shift in the net debt position (debt minus cash) of firms since the 1980s. Theoretical explanations for why firms hold cash include the traditional precautionary motive, in which firms hold cash as a buffer to protect themselves from financial frictions. Papers making this argument include [Han and Qiu \(2007\)](#), [Palazzo \(2012\)](#), [Almeida, Campello, and Weisbach \(2004\)](#), [Gamba and Triantis \(2008\)](#), [Riddick and Whited \(2009\)](#), [Bolton, Chen, and Wang \(2011\)](#), and [Morellec, Nikolov, and Zucchi \(2013\)](#). Some papers further link cash holdings to research and development, such as [Lyandres and Palazzo \(2016\)](#) and [Ma, Mello, and Wu \(2018\)](#).

In the literature, a frequent explanation for the rise in cash holdings is that there has been an increase in cash flow risk. This is an argument made by [Bates, Kahle, and Stulz \(2009\)](#), [Boileau and Moyen \(2016\)](#), [Armenter and Hnatkovska \(2017\)](#), and [Zhao \(2017\)](#). [Armenter and Hnatkovska \(2017\)](#) also argue that equity has become cheaper relative to debt. However, as we show, both of these explanations imply that the rate of zero net equity issuance should have increased. In this paper, we are able reconcile these two conflicting trends through a structural estimation approach. [Falato, Kadyrzhanova, Sim, and Steri \(2018\)](#) attributes the rise in cash to a rise in intangible capital, while [Curtis, Garín, and Mehkari \(2017\)](#) focuses on the role of inflation. [Nikolov and Whited \(2014\)](#) argues that the growth of cash holdings arises out of an agency conflict between shareholders and managers. [Foley, Hartzell, Titman, and Twite \(2007\)](#) argue that it is, at least partially, a consequence of tax costs associated with repatriating foreign income. [Chen, Karabarbounis, and Neiman \(2017\)](#) attribute changes in the flow of corporate savings to sectoral changes in the cost of capital.

This paper is organized as follows. Section 2 presents the motivating empirical evidence. Section 3 formulates a model to rationalize the key empirical observations and Section 4 characterizes the optimal financing policy. In Section 5, we describe our structural estimation strategy and the main results are examined in Section 6. And finally, Section 7 concludes.

Figure 1: Use of Debt in Compustat Over Time

Note: The left panel plots the fraction of firms in our sample with (1) no debt at all and (2) no net debt (debt minus cash ≤ 0). The right panel plots the 10th, 25th, 50th, 75th and 90th percentiles of leverage in our sample, where leverage is defined as net debt (debt minus cash) divided by total assets.

2 Empirical Motivation

Our analysis is based on Standard and Poor’s Compustat industrial files, which includes detailed income statement, balance-sheet and cash flow data for public companies. We use annual fundamental data from 1980 to 2012. Marginal corporate tax rates are taken from the Marginal Tax Rate database, where marginal tax rates are estimated using a non-parametric procedure detailed in [Blouin, Core, and Guay \(2010\)](#). We impose the following restrictions. We exclude financial firms (SIC 6000-6999), utilities (SIC 4900-4999) and public administration (SIC 9000-9999). We drop any firm-year observations without any information on assets, liabilities, debt, capital, cash holdings, or marginal corporate tax rates. We drop any firm-year observations with non-positive assets or capital. And finally, we drop observations that violate the accounting identity of assets equal to equity plus debt by more than 10%. This leaves us with 14,752 firms and 131,688 firm-year observations. For more details on the data, see Appendix A.

We start our analysis by analyzing how the use of debt has changed between 1980 and 2012. First, consider the left panel of Figure 1, which shows that the fraction of firms not borrowing has grown dramatically between 1980 and 2012. Between 1980 and 2012, the number of firms with no debt at all on their balance sheets grew from 5.7% to 18.9%,

Figure 2: Net Equity Issuance and Marginal Tax Rates

Note: The left panel plots the fraction of firms in our sample with zero net equity issuance, negative net equity issuance and positive net equity issuance. Following [Covas and Den Haan \(2011\)](#), net equity issuance is calculated as the annual change in the book value of equity net of retained earnings minus cash dividends. The right panel plots the 10th, 25th, 50th, 75th and 90th percentiles of marginal corporate income tax rates in our sample.

peaking at 20.1% in 2011. However, many firms also simultaneously hold cash balances while also borrowing. Between 1980 and 2012, the number of firms with at least as much cash as debt increased from 11.9% to 41.4%, peaking at 45.8% in 2010. The firms with no *net debt* (debt minus cash) account for a significant fraction of total employment. In 1980, 5.6% of all employment in the sample was located within firms with no net debt, and by 2012 this had risen to 22.4%.

Similar patterns can be observed in the overall distribution of leverage across firms. A firm's leverage ratio is defined as net debt (debt minus cash) divided by total assets. The right panel of Figure 1 plots the 10th, 25th, 50th, 75th and 90th percentiles of leverage ratios of individual firms. Between 1980 and 2012, the median leverage ratio fell from 23.6% to 7.6%. However, as can be seen in Figure 1, the 90th percentile of leverage has not fallen as much as the 10th percentile. The 90th percentile fell from 53.1% to 50.6%, while the 10th percentile fell from -0.7% to -29.2%. Therefore, there has been an increase in the dispersion of leverage across firms, and this higher dispersion has been driven mostly by an increase in net lending behavior.

We next focus on the frequency at which firms adjust their equity holdings. To measure

net equity issuance, we follow the primary approach of [Covas and Den Haan \(2011\)](#).⁵ For each firm, we compute net equity issuance as the annual change in the book value of equity net of retained earnings minus cash dividends distributed to shareholders. If net equity issuance is positive, the firm is raising external equity, while the firm is distributing funds to shareholders if net equity issuance is negative. If net equity issuance is zero, the firm is doing neither. It should be noted that even if net equity issuance is zero, the firm's total equity can still increase or decrease through changes in the level of retained earnings.

The left panel of Figure 2 plots the frequency at which firms have chosen positive, negative or zero net equity issuance. There has been an increase in the frequency of positive net equity issuance and a reduction in the frequency of negative net dividend issuance. Moreover, there has been a noticeable decrease in the fraction of firms with zero net equity issues, falling from 13.1% in 1980 to 2.1% in 2012. In our model, costly external finance will create an incentive for firms to follow (S, s) decision rules with regards to net equity issuance. As a result, we interpret the decline in zero net equity issuance as evidence that the cost of obtaining external equity has fallen over time.

The right panel of Figure 2 plots marginal corporate income tax rates (after interest deductions) over time for the 10th, 25th, 50th, 75th and 90th percentiles. These marginal tax rates are obtained from the Marginal Tax Rates Database, which are estimated using a non-parametric procedure detailed in [Blouin, Core, and Guay \(2010\)](#). As is evident from Figure 2, there has been a clear fall in marginal tax rates over this period. While the median marginal corporate income tax rate was 44.0% in 1980, it had fallen to 30.3% in 2012. In our model, falling marginal tax rates (relative to personal income tax rates) will decrease the incentive for firms to issue debt and increase the incentives for firms to accumulate internal equity.

3 Model

Using a framework that is closely related to [Hennessy and Whited \(2007\)](#) and [Katagiri \(2014\)](#), we build a firm financing model in which heterogeneous firms finance investment with either equity or debt. Firms can borrow or lend, they can raise funds directly from shareholders (i.e., external equity), they can distribute funds to shareholders as dividends, and they can accumulate internal equity. Two key frictions distort the incentives of firms to accumulate debt. First, since it will be costly for firms to raise external equity and to distribute funds to shareholders, there will be an incentive for firms to do neither. Second, we incorporate a detailed tax structure, whereby the firm's debt choice is distorted by personal,

⁵See [Karabarbounis, Macnamara, and McCord \(2014\)](#) for a discussion of the measurement issues.

dividend and corporate income taxes.

3.1 Firms

Firms are perfectly competitive and produce a single homogeneous good. Both capital and labor are inputs in the firm's production function, $f(s, k, n) = s[k^\alpha n^{1-\alpha}]^\gamma$, where s is an idiosyncratic productivity shock, k is the stock of capital and n is the amount of labor. It is assumed that $\gamma \in (0, 1)$, implying that there are decreasing returns to scale at the firm level. Building on the "span of control" models of [Lucas \(1978\)](#) and [Rosen \(1982\)](#), diminishing returns to scale can be interpreted as a consequence of the decreasing ability of an entrepreneur to manage larger operations. With perfect competition, firm-level diminishing returns make it possible for heterogeneity to exist in equilibrium, preventing the most productive firms from taking over the market completely. Assuming a competitive labor market, the firm's profits can be denoted by $\pi(s, k; w) = \max_n \{f(s, k, n) - wn\}$, where w is the wage. Since the wage will be constant over time in a stationary equilibrium, the wage w will often be omitted and profits will be written as $\pi(s, k)$.

Idiosyncratic productivity follows an AR(1) process:

$$\ln s' = \rho_s \ln s + \sigma_{\varepsilon_s} \varepsilon_s \quad (1)$$

Next period's productivity is s' and ε_s is an i.i.d. innovation drawn from $N(0, 1)$. In what follows, we denote by $H(s'|s)$ and $h(s'|s)$ the conditional cumulative distribution and probability density functions for s' , respectively.

3.2 Financing Sources

Each period, the firm chooses the level of dividends d . Compared to our empirical analysis in Section 2, "net equity issuance" is $(-d)$. If d is positive, the firm is distributing funds to shareholders and net equity issuance is negative. If d is negative, the firm is raising external equity and net equity issuance is positive. If $d = 0$, the firm is doing neither and net equity issuance is zero.

The firm borrows using a defaultable one-period non-contingent bond. It promises to pay b' tomorrow and in return the firm receives $q(s, k', b')b'$ today, where q is the price of the bond. If b' is negative, the firm is lending. The bond price $q(s, k', b')$ depends on the firm's current productivity s , its choice for capital k' and the amount of bonds b' . Section 3.6 discusses how the bond price is determined.

Every period, the firm starts with a current level of productivity s , an initial level of

capital k and a required debt payment b . If the firm does not default on its debt payment, it chooses dividends d , next period's capital k' and bonds b' . The choices for (d, k', b') must satisfy the following budget constraint:

$$d + k' = e(s, k, b) - c_f + q(s, k', b')b' \quad (2)$$

where

$$e(s, k, b) = \pi(s, k) - T_c(\pi(s, k) - \delta k - cb) + (1 - \delta)k - b \quad (3)$$

is defined to be the firm's internal equity and c_f is a fixed operating cost. Notice that the firm can accumulate more internal equity with a larger capital stock k or through lending (i.e., negative b). Because of the fixed operating cost, $c_f > 0$, firms will endogenously choose to exit. However, as discussed in Section 3.5, there will also be exogenous exit. $T_c(\pi(s, k) - \delta k - cb)$ denotes the total corporate income tax bill, which will be discussed in more detail in Section 3.4. To summarize, when choosing next period's capital stock k' , the firm has access to three sources of funding: (1) debt qb' , (2) internal equity e , and (3) external equity (through $d < 0$).

3.3 Dividend and Equity Costs

The firm's budget constraint defined in Equation (2) only reflects the costs paid directly by the firm. Shareholders also pay a cost (explained below) which depends on the level of dividends d chosen by the firm. When $d < 0$, this cost represents the cost of issuing external equity. When $d > 0$, this cost represents the dividend tax paid when the firm issues dividends to shareholders.

The equity issuance cost is assumed to be a fraction λ of the amount of equity raised. This cost is interpreted to include direct costs (such as underwriting fees) associated with the issuance of equity. It also captures indirect costs that might arise out of asymmetric information problems. For example, because managers may have more information about the firm than investors, they may be reluctant to issue external equity for fear of the negative signal it may send about the firm's future prospects. While we do not explicitly model asymmetric information, this specification is intended to capture both direct and indirect costs of equity issuance in a reduced-form fashion.

Following [Hennessy and Whited \(2007\)](#), the dividend tax, $T_d(d)$, is assumed to be

$$T_d(d) = \int_0^d \tau_d(x) dx,$$

where $\tau_d(d) = \bar{\tau}_d [1 - \exp(-\phi_d d)]$ is the marginal dividend tax rate. The marginal tax rate is zero for $d = 0$ and is increasing with d (since $\phi_d > 0$). The progressivity parameter, ϕ_d , will influence the overall level of debt of firms, as firms at the margin will trade off distributing more funds (and increasing debt issuance) or distributing less funds (and reducing debt issuance).

In actuality, a firm can distribute funds to shareholders using dividends or by buying back its own shares from shareholders. While d is referred to as “dividends” and $T_d(d)$ is referred to as a “dividend tax” in this paper, the model does not distinguish between dividends or share repurchases. However, there are tax advantages to distributing funds to shareholders via share repurchases rather than dividends (e.g., see [Green and Hollifield, 2003](#)). Following the logic of [Hennessy and Whited \(2007\)](#), the dividend tax in this paper is assumed to be progressive in order capture the incentives jointly created by dividend and capital gains taxation. Intuitively, for small distributions, the firm will use mostly share repurchases. In this case, the marginal tax rate will be low because the firm can purchase stock from the investors who will pay a lower capital gains tax. For larger distributions, the marginal investor will be subject to a higher capital gains tax rate, and firms may switch towards dividend issuance because of regulatory concerns.

The overall dividend/equity cost is summarized by the following function:

$$\Lambda(d) = \begin{cases} -\lambda d & \text{if } d < 0 \\ T_d(d) & \text{if } d \geq 0 \end{cases}$$

As it is costly both to issue equity (i.e., $d < 0$) and issue dividends (i.e., $d > 0$), this function will create an incentive for firms to choose $d = 0$. The parameters λ and ϕ_d will be useful for controlling the frequency at which firms choose $d = 0$.

In Section 6.3, we will consider an alternative specification in which firms pay a fixed cost to issue equity, which does not depend on the amount issued. Combined with the dividend tax, our benchmark variable-cost specification and the fixed-cost specification will both create an incentive for firms to choose $d = 0$. However, the fixed cost will also create an incentive for firms to issue large amounts of equity, relatively infrequently. According to our measures of equity issuance in Section 2, equity issuance is actually relatively frequent in the data. We will discuss this further in Section 6.3.

3.4 Corporate Income Taxes

Firms must pay a tax on their corporate income. The firm’s taxable income is assumed to be profits minus economic depreciation and interest expense, $\pi(s, k) - \delta k - cb$. The

depreciation rate of capital is δ and c is a parameter which captures the interest expense deduction. The corporate income tax is assumed to be progressive. Given a taxable income of x , the marginal corporate income tax, $\tau_c(x)$, is given by

$$\tau_c(x) = \frac{\bar{\tau}_c}{1 + \exp(-\phi_c(x - \bar{x}_c))} \quad (4)$$

where $\bar{\tau}_c$ is the maximum marginal corporate tax rate. The parameter ϕ_c controls the progressivity of the corporate income tax, and $\bar{x}_c$ is a shift parameter. Given a taxable income of x , the total corporate income tax is then defined to be:

$$T_c(x) \equiv \int_0^x \tau_c(y) dy.$$

This specification contrasts with the usual approach of modeling only two marginal tax rates depending on whether taxable income is positive (e.g., [Hennessy and Whited, 2007](#)). Our model will generate more dispersion in marginal tax rates. We will discipline $(\bar{x}_c, \phi_c)$ using observed marginal corporate income tax rates. As discussed in Section 4, the marginal corporate tax rate will be crucial for determining whether debt is tax advantaged. When marginal corporate income tax rates are high, firms will have an incentive to borrow more in order to reduce their taxable corporate income.

3.5 Default and Exit

Given the choices for capital k' and debt b' , the realization of the firm's internal equity next period, e' , will depend on the realization of productivity tomorrow in accordance with Equation (3). Then, given tomorrow's productivity s' and tomorrow's internal equity e' , the firm will have three options: (1) continue and not default, (2) exit and not default, and (3) default. We now explain in detail the payoffs the firm receives from each of these options.

If the firm chooses to continue and not default, it receives the value $V_c(s', e')$, which is defined below in Equation (5). After the firm chooses to continue, it is hit with an exogenous exit shock with probability η . We introduce exogenous exit to prevent firms from accumulating so much internal equity so that they will never need to issue external equity. If the firm is forced to exit (exogenously), it receives the exit value, $V_x(e')$, which is defined below in Equation (6). If the firm does not exit, it receives $V(s', e')$, the value of an incumbent firm that is able to operate (see Section 3.8 for the definition of $V(s', e')$). Therefore, the value of continuing is given by

$$V_c(s', e') = (1 - \eta)V(s', e') + \eta V_x(e') \quad (5)$$

If the firm chooses to exit and not default, it receives

$$V_x(e') = e' - \Lambda(e') \quad (6)$$

In this scenario, the firm repays its debt in full. If $e' \geq 0$, the firm distributes a final dividend to shareholders, and pays the dividend tax (i.e., through $\Lambda(e')$). Notice that $V_x(e') \geq 0$ in this case. If $e' < 0$, the firm must raise external equity from shareholders in order to repay its debt. This will also incur the external equity cost (through $\Lambda(e')$). In this case, $V_x(e') < 0$ and thus firms will prefer to default (this is discussed next).

If the firm chooses to default, it receives the value of zero. As discussed below, default may or may not lead to the exit of the firm. If $b' \leq 0$, choosing the default option would imply that the firm would give up its savings. However, since tomorrow's internal equity $e' \geq 0$ when $b' \leq 0$, this will imply that the value of exit is non-negative (i.e., $V_x(e') \geq 0$). Therefore, the firm will never choose the default option if $b' \leq 0$.

Given these assumptions, the continuation value of a firm is given by

$$CV(s, k', b') = E \left[\max \left(\underbrace{V_c(s', e(s', k', b'))}_{\text{continue}}, \underbrace{V_x(e(s', k', b'))}_{\text{exit}}, \underbrace{0}_{\text{default}} \right) \middle| s \right] \quad (7)$$

The firm chooses whether or not to continue, exit or default before it learns whether it will be forced to exit exogenously next period. Therefore, exit in this model can happen in one of three ways. First, the firm chooses to continue operating, but it is nevertheless hit with an exogenous exit shock. Second, the firm may endogenously choose to exit today (notice it avoids paying the fixed operating cost by doing so). Third, the firm may default. However, default may or may not lead to exit. As will be seen in Section 3.6, after default, the lender will choose between re-negotiating the debt or liquidating the firm.

There will then be a default threshold, $s'_d(k', b')$, such that the firm will default iff $s' < s'_d(k', b')$. Since the firm will not default if it chooses to continue or exit, this default threshold is defined to be the value of productivity, s'_d , such that

$$\max(V_c(s'_d, e(s'_d, k', b')), V_x(e(s'_d, k', b'))) = 0 \quad (8)$$

where next period's internal equity $e(s', k', b')$ is defined in Equation (3). Notice that the value of not defaulting (i.e., $\max(V_c, V_x)$) may be strictly positive for any value of s' . This is the case when $b' \leq 0$. In such a case, the default threshold is $s'_d = 0$.

3.6 Bond Price

In the case of default, the lender pays a deadweight bankruptcy cost equal to $\xi(1 - \delta)k'$. This bankruptcy cost is motivated by various costs of bankruptcy, such as legal costs or costs related to the liquidation of the firm's assets. This is along the same lines as the "costly state verification" problem in [Townsend \(1979\)](#). However, the idiosyncratic productivity shock is persistent and observable by the lender.

After the firm has chosen to default, the lender chooses between two potential courses of action: liquidation or re-negotiation. If the lender liquidates the firm, it will recover

$$R_L(s', k') = \pi(s', k') - T_c [\pi(s', k') - \delta k'] + (1 - \xi)(1 - \delta)k' \quad (9)$$

Alternatively, the debt is re-negotiated to the point where the borrower is just indifferent between repaying and defaulting.⁶ Specifically, the debt payment re-negotiated to the point where internal equity is $e'_r(s')$, where e'_r is implicitly defined by

$$V_c(s', e'_r) = 0$$

If the debt is re-negotiated, the lender will then recover

$$R_R(s', k') = \pi(s', k') - T_c [\pi(s', k') - \delta k'] + (1 - \xi)(1 - \delta)k' - e'_r(s') \quad (10)$$

In both of these cases, it is assumed that the interest deduction is disallowed in default and that the firm's taxable income is $\pi(s', k') - \delta k'$. Comparing Equations (9) and (10), this implies that the lender will liquidate the firm when $e'_r(s') > 0$. Taking into account the optimal liquidation strategy, the lender then will recover $R(s', k')$ when the firm defaults:

$$R(s', k') = \pi(s', k') - T_c [\pi(s', k') - \delta k'] + (1 - \xi)(1 - \delta)k' - \min(e'_r(s'), 0) \quad (11)$$

After default, the firm will also exit if $e'_r(s') > 0$.

The firm's bond is purchased by risk-neutral lenders who must pay a constant tax rate, τ_i , on interest income. This is a tax rate at the individual level. Since there is no aggregate uncertainty, lenders can diversify away all idiosyncratic risk. Therefore, the bond price, $q(s, k', b')$, is set to guarantee the lender an expected pre-tax return equal to the risk-free rate, r . After taxes, the lender's return will be $r(1 - \tau_i)$. This implies that the bond price is

⁶Notice that the debt is re-negotiated to the point where $V_c(s', e'_r) = 0$, not $\max(V_c(s', e'_r), V_x(e'_r)) = 0$. This assumption is innocuous. As we will see, the lender will re-negotiate the debt when $e'_r(s') < 0$. In this case, $V_x(e'_r)$ would be negative anyway.

given by

$$q(s, k', b') = \frac{1}{1+r} \left[1 - H(s'_d(k', b')|s) + \frac{1}{b'} \int_0^{s'_d(k', b')} R(s', k') h(s'|s) ds' \right] \quad (12)$$

where $s'_d(k', b')$ is the default threshold, $H(s'_d(k', b')|s)$ is the default probability and $R(s', k')$ is the amount the lender recovers in default (which is defined in Equation (11)). Note that although the lender pays a tax on interest income, this tax does not show up in the bond pricing equation. Since the lender expects to receive a return equal to r (before taxes), but the after-tax risk-free rate is $r(1 - \tau_i)$, the interest income tax makes debt more expensive to the firm relative to the after-tax risk-free rate.

Furthermore, note that it is allowed for b' to be negative (i.e., the firm is a net lender). In this case, the default threshold is $s'_d = 0$ and the firm will never default. The bond price is equal to $1/(1+r)$ and the firm earns the pre-tax return of r . Instead of paying a tax on interest income, however, the firm's interest earnings will be included in the firm's taxable corporate income, and the corporate income tax will be paid.

3.7 Entry

Potential entrants pay a fixed cost, c_e , to enter. Following [Hopenhayn \(1992\)](#), entrants learn their initial productivity after paying the fixed entry cost, c_e . Entrants start with no capital ($k = 0$), no debt ($b = 0$) and thus no internal equity ($e = 0$). Their initial productivity s is drawn from the cumulative distribution function $G(s)$. We assume that $G(s)$ corresponds to the invariant distribution of idiosyncratic productivity (i.e., a log-normal distribution with mean zero and standard deviation $\sigma_{\varepsilon s}/\sqrt{1 - \rho_s^2}$). The free entry condition is

$$\int \max(V_c(s, 0), 0) dG(s) \leq c_e$$

There will be a cutoff productivity for entrants, s_e , such that entrants will only operate iff $s \geq s_e$. This cutoff productivity is defined to be the value of idiosyncratic productivity, s_e , such that $V_c(s_e, 0) = 0$.

3.8 Firm's Problem

The firm's problem can now be formulated recursively. Define $V(s, e)$ as the value of operating for a firm with productivity s and internal equity e . This value function is defined

to be the solution to the following Bellman equation:

$$V(s, e) = \max_{k', b', d} \left\{ d - \Lambda(d) + \frac{E [\max (V_c(s', e(s', k', b')), V_x(e(s', k', b')), 0) | s]}{1 + r(1 - \tau_i)} \right\} \quad (13)$$

subject to

$$\begin{aligned} d + k' &= e - c_f + q(s, k', b')b' \\ e(s', k', b') &= \pi(s', k') - T_c [\pi(s', k') - \delta k' - cb'] + (1 - \delta)k' - b' \end{aligned}$$

where $V_c(s', e')$ is defined in Equation (5) and $V_x(e')$ is defined in Equation (6). A non-defaulting firm chooses tomorrow's capital stock k' , debt b' , and dividends d to maximize shareholder value. Today, shareholders receive dividends d , but also have to pay $\Lambda(d)$, which reflect costs associated with equity issuance or dividends. Future payoffs are discounted by the after-tax risk-free rate. Next period, the firm's internal equity will be $e(s', k', b')$, which depends on tomorrow's realization of productivity. Given this level of equity and the level of productivity tomorrow, the firm can decide whether to continue operating, to exit or to default.

4 Optimal Financing Policy

In this section, we analyze the firm's optimal financing policy. The first order condition for b' can be written as

$$\underbrace{(1 - \Lambda'(d)) \left[q + \frac{\partial q}{\partial b'} b' \right]}_{\text{MB}} = \underbrace{\frac{E [\mathbb{1}\{s' \geq s'_d\} (1 - \Lambda'(d')) (1 - c\tau'_c)]}{1 + r(1 - \tau_i)}}_{\text{MC}} \quad (14)$$

The left term of Equation (14) represents the marginal benefit of an additional unit of debt, while the right term represents the marginal cost. Naturally, at the optimal b' , the marginal benefit equals the marginal cost. If $\Lambda(d) = 0$, then Equation (14) reduces to the usual condition that firm will borrow up until the point where the marginal tax benefits of debt equal marginal bankruptcy costs.

The assumption of equity issuance costs and dividend costs introduces considerable dynamics into the firm's financing decision. At the margin, an increase in b' (holding k' fixed) allows the firm to increase dividends d by $q + (\partial q / \partial b') b'$. Through $1 - \Lambda'(d)$, the marginal benefit the shareholders receive depends on whether the firm is currently issuing equity (i.e., $d < 0$) or issuing dividends ($d > 0$). If the firm is currently issuing equity, $1 - \Lambda'(d) = 1 + \lambda$

and the marginal benefit of an additional unit of debt is higher because the additional borrowing allows the firm to reduce its equity issuance, which is costly. In contrast, if the firm is currently issuing dividends, $1 - \Lambda'(d) = 1 - \tau_d(d)$ and the marginal benefit of debt is lower. The additional debt issuance is used to issue more dividends to shareholders, but some of the extra dividends is lost to the dividend tax.

Meanwhile, the marginal cost of an additional unit of b' reflects the net cost of servicing the debt next period. Future debt service payments are discounted by the after-tax risk free rate, $1 + r(1 - \tau_i)$. Since the debt is fully repaid only in non-default states, a higher probability of default will decrease the marginal cost of debt issuance. Notice that a higher marginal corporate income tax rate, τ_c , reduces the marginal cost of debt. Higher debt issuance reduces the firm's taxable income, allowing the firm to reduce its corporate income tax bill. Furthermore, through $1 - \Lambda'(d')$, the marginal cost depends on whether the firm will be issuing equity or issuing dividends tomorrow. If the firm expects to be issuing external equity tomorrow, the marginal cost of more debt today is higher. Next period the firm would have to increase its equity issuance to repay the additional unit of debt. Similarly, if the firm expects to be issuing dividends tomorrow, the marginal cost of issuing more debt today is lower. Next period, it will be easier for the firm to repay the extra borrowing as it will only have to decrease dividends (rather than issuing more equity).

Now we consider how a change in equity issuance costs (i.e., λ) will influence the firm's optimal financing policy. A higher λ will directly affect firms currently issuing equity (i.e., $d < 0$). The marginal benefit of an additional unit of debt will be higher as additional debt will allow firms to substitute away from costly external finance. This will create an incentive for firms to issue more debt. Firms with low internal equity are more likely to be issuing external equity and more likely to be directly affected by higher equity issuance costs. Nevertheless, the marginal cost of debt finance will be higher if the firm expects to be issuing external equity next period. Indirectly, this will create a precautionary motive for firms to accumulate internal equity and that will tend to lower debt issuance. Which effect will dominate is not clear analytically. However, in our quantitative analysis in Section 6, the second effect dominates and an increase in λ will lead to lower debt issuance.

Next, we consider the effect of dividend taxes. Dividend taxes will affect the tradeoff between distributing more funds to shareholders or decreasing debt issuance.⁷ Consider the effect of a higher ϕ_d , which will increase the marginal dividend tax rate. This will directly affect firms who are currently issuing dividends (i.e., $d > 0$). As a result, the marginal benefit of an additional unit of debt will be lower. Additional borrowing will be used to increase dividends which are taxed at a higher rate. Therefore, a higher ϕ_d will create an

⁷Notice that the firm could decrease debt so much that it becomes a net lender.

incentive to decrease debt issuance. Nevertheless, the marginal cost of debt finance will be lower if the firm expects to be issuing dividends next period. This will create a motive to increase debt issuance (lowering next period's internal equity). Which effect will dominate is not clear analytically. Nevertheless, in our quantitative analysis in Section 6, the first effect dominates as an increase in ϕ_d leads to an overall decrease in borrowing.

Finally, we consider how a change corporate and personal income taxes influences the firm's financing policy. Higher marginal corporate tax rates tend to reduce the marginal cost of debt issuance. Additional debt issuance can be used to reduce the firm's (higher) corporate income taxes at the margin. However, a higher personal income tax rate increases the marginal cost of debt issuance. Therefore, the crucial determining factor for the firm's debt policy is the marginal corporate income tax relative to personal income tax rates. If τ_c is high relative to τ_i , then debt will be tax advantaged. In contrast, if τ_c is low relative to τ_i , then equity will be tax advantaged.

5 Estimation Strategy

In this section, we describe our structural estimation technique and the associated parameter values. One set of parameters is set externally based on values commonly used in the literature. The remaining parameters are estimated using Simulated Method of Moments (SMM). With SMM, we solve for the unknown parameters by minimizing the weighted sum of squared errors between moments in the model and the data.⁸ In order to identify how the estimated parameters have changed over time, we divide our sample into two separate periods. First, we estimate these parameters using key moments from the early 1980s (i.e., 1980-1994). Second, we re-estimate these parameters using moments from the late 2000s (i.e., 1995-2012). As will be seen below, there are four sets of parameters that will change between the two parameterizations: (1) the tax parameters, (2) the equity issuance cost, (3) the productivity parameters, and (4) the fixed operating cost. The model can then shed light on which of these parameters will best explain the change in firm borrowing behavior between 1980 and 2012.

5.1 Calibrated Parameters

Table 1 lists the calibrated parameters. For the most part, these parameters are the same in both parameterizations. The model period is assumed to be a year. The wage is set to 1 and the annual risk-free interest rate is 4%. As this is a partial equilibrium analysis, the

⁸For an introduction to SMM, see [Strebulaev and Whited \(2012\)](#).

Table 1: Calibrated Parameters

Parameter	Notation	1980s	2000s	Target/Description
		Value	Value	
Wage	w	1	1	Normalization
Risk-free rate	r	0.04	0.04	Typical in literature
Interest deduction	c	0.0384	0.0384	Set to $r/(1+r)$
Depreciation rate	δ	0.10	0.10	Typical in literature
Capital share	α	0.35	0.35	Typical in literature
Returns to scale	γ	0.85	0.85	Burnside et al. (1995)
Bankruptcy cost	ξ	0.10	0.10	Hennessy and Whited (2007)
Exogenous exit rate	η	0.02	0.02	Katagiri (2014)
Max marginal div. tax	$\bar{\tau}_d$	0.12	0.12	Graham (2000)
Max corp. tax rate	$\bar{\tau}_c$	0.46	0.35	Top statutory tax rates
Personal income tax rate	τ_i	0.391	0.297	Tax Policy Center

Note: This table reports the set of calibrated parameters. The first parameter value corresponds to the first estimation, in which the non-calibrated parameters are estimated using data moments in the early 1980s. The second parameter value corresponds to the second estimation, in which the non-calibrated parameters are estimated using data moments in the late 2000s. The parameters which change between the two estimations are indicated in bold.

fixed entry cost c_e is set to normalize the wage to 1 in both calibrations. The depreciation rate of capital, δ , was set to 10%, a value consistent with values commonly assumed in the literature. The returns to scale parameter γ is set to 0.85, which is in the middle of the estimates of [Burnside, Eichenbaum, and Rebelo \(1995\)](#) and is the value chosen in [Katagiri \(2014\)](#). The capital share parameter was assumed to be $\alpha = 0.35$, which implies that the overall capital share is $\alpha\gamma = 0.2975$, a value which is consistent with the literature. The bankruptcy cost, ξ , was assumed to be 10%. This value is close to the values commonly used in the literature (e.g., 7% in [Katagiri, 2014](#) and 10.4% in [Hennessy and Whited, 2007](#)). As for the exogenous exit rate, we followed the strategy of [Katagiri \(2014\)](#), whereby the exogenous exit rate is assumed to be 2%.

The maximum corporate tax rate is set to 0.46 in the first estimation, and 0.35 in the second estimation. These tax rates correspond to the top statutory tax rates for the respective time periods. The maximum marginal dividend tax rate, $\bar{\tau}_d$, was set to 0.12, following [Graham \(2000\)](#). The personal income tax rate, τ_i , was chosen to be 0.3907 in the first estimation and 0.2971 in the second estimation. These numbers correspond to the marginal tax rates of a household with twice the median income during these time periods, according to the Tax Policy Center. The calibrated value of 0.297 is very close to the usual value of 0.29 used in the literature (e.g., [Hennessy and Whited, 2007](#)). It is also close to the average marginal tax rate of high-income households. For example, [Guner, Kaygusuz, and Ventura](#)

(2014) report that the average marginal statutory tax rate for the top 20% in the year 2000 was 27.9%.

5.2 Estimation Results and Model Fit

The remaining parameters are estimated via SMM to match moments computed from our Compustat data. We estimated seven parameters: the productivity parameters ($\rho_s, \sigma_{\varepsilon s}$), the parameters governing the corporate income tax schedule, $(\bar{x}_c, \phi_c)$, the dividend tax parameter, ϕ_d , the equity issuance cost λ and the fixed operating cost c_f . In total, we used seven moments to estimate seven parameters. The resulting parameters and moments are reported in Table 2. We chose moments that are a priori informative about the parameters we seek to estimate. Overall, the model is able to reproduce the targeted moments. In particular, the model matches the increasing frequency of net lending behavior as well as the decreasing frequency of zero net equity issuance.

We match the frequency of zero net equity issuance (i.e., the frequency of $d = 0$). We view this particular moment as being directly informative about the cost of obtaining external finance, λ , as a higher λ will create an incentive for firms to choose $d = 0$. In 1980, 13.1% of firms neither issued dividends nor issued equity, while this had fallen to 2.0% in 2012 (see Figure 2). According to our model, the cost of external finance is estimated to have fallen from 23.5% to 6.4%. To put these numbers in context, note that Kim, Palia, and Saunders (2008) report that the average underwriting fee for seasoned equity offerings (SEOs) fell from 5.41% between 1975 and 1989, to 4.60% between 1999 and 2004. Altinkilic and Hansen (2000) report that the average underwriting fee, between 1990 and 1997 was 5.38%. Hennessy and Whited (2007) estimate that the marginal equity issuance cost is 9.1%, using a structural estimation approach on a sample that covers 1988 to 2001.⁹ Our results here suggest that there has been a decline in equity issuance costs since 1980. In fact, the cost has declined so much that it is quite similar to measures of the direct costs reported in the literature.

To pin down the parameters of the productivity process ($\rho_s, \sigma_{\varepsilon s}$), we estimated a first-order autoregressive process of log sales, controlling for firm fixed effects. The moments we attempt to match from this regression are the persistence and the standard deviation of the residual. These two moments are directly informative for ρ_s and $\sigma_{\varepsilon s}$. Splitting our sample into two sets of observations before and after 1994, we find that the autocorrelation of log sales is roughly the same in the two time periods. However, the standard deviation of the

⁹Also following a structural estimation approach between 1980 and 2004, Eisfeldt and Muir (2016) estimate the average cost of external finance to be 2.3%. However, the specification of the external finance cost is quite different from this paper. They assume a fixed cost and a quadratic cost, but no linear cost. Meanwhile, this paper only models a linear cost.

Table 2: Estimated Parameters and Targeted Moments

		1980s		2000s	
Panel A: Parameters	Notation	Value	Std. Err.	Value	Std. Err.
Productivity persistence	ρ_s	0.626	(0.034)	0.629	(0.020)
Std. dev. of shock to productivity	$\sigma_{\varepsilon s}$	0.113	(0.005)	0.128	(0.005)
Corp. tax shift parameter	$\bar{x}_c$	0.057	(0.002)	0.162	(0.003)
Corp. tax progressivity parameter	ϕ_c	33.72	(1.15)	25.00	(0.89)
Div. tax progressivity parameter	ϕ_d	22.10	(9.29)	49.34	(38.39)
Equity issuance cost	λ	0.235	(0.067)	0.064	(0.037)
Fixed operating cost	c_f	0.067	(0.0009)	0.096	(0.0003)

		1980s		2000s	
Panel B: Moments		Model	Data	Model	Data
Autocorrelation of log sales		0.734	0.728	0.742	0.731
Std. dev. of innovation to log sales		0.363	0.365	0.408	0.412
Marginal corp. tax rate, 25th percentile		0.226	0.229	0.048	0.093
Marginal corp. tax rate, 75th percentile		0.448	0.448	0.318	0.331
Frequency of net lending		0.122	0.119	0.417	0.414
Frequency of zero net equity issuance		0.133	0.131	0.022	0.020
Exit rate		0.062	0.061	0.082	0.080

Note: Panel A reports the estimated parameters, while Panel B reports the moments in the model and the data. The model parameters are separately estimated via Simulated Method of Moments (SMM) using moments from the early 1980s and from the late 2000s.

residual increases from 0.365 to 0.412. As a result, while the estimated persistence stays roughly the same (i.e., ρ_s increases from 0.626 to 0.629), the estimated $\sigma_{\varepsilon s}$ increases from 0.113 to 0.128 between these two periods.

We also matched the 25th and 75th percentile of marginal corporate income tax rates. These moments will be directly informative for the parameters governing the marginal corporate income tax rate schedule, $(\bar{x}_c, \phi_c)$. As seen in Figure 2, marginal corporate tax rates fell between 1980 and 2012. As a result, the estimated values of $(\bar{x}_c, \phi_c)$ changed to reflect these trends. The effect of $(\bar{x}_c, \phi_c)$ on the corporate income tax rate schedule is illustrated in the left panel of Figure 3.

We also targeted the frequency of net lending (i.e., $b' \leq 0$). This moment increased from 11.9% in 1980 to 41.4% in 2012. This moment is informative for the marginal corporate income tax parameters $(\bar{x}_c, \phi_c)$ as marginal tax rates affect the incentives of firms to borrow. It is also informative for the dividend cost parameter, ϕ_d , as this affects the tradeoff between distributing profits to shareholders as dividends versus accumulating profits as savings (i.e., by lowering b'). The resulting marginal dividend tax rate, $\tau_d(d)$, is illustrated in the right

Figure 3: Marginal Corporate Income Tax and Dividend Tax

Note: The left panel plots the marginal corporate income tax rate schedule, $\tau_c(x)$. Analogously, the right panel plots the marginal dividend tax rate schedule, $\tau_d(d)$.

panel of Figure 3. The estimated values for ϕ_d indicates that there was an increase in marginal dividend tax rates.¹⁰

And finally, we matched the rate at which firms exited our sample, as in [Katagiri \(2014\)](#). We are taking a broad view of exit, because as noted by [Fama and French \(2004\)](#), many less-profitable firms exit through mergers. The exit rate increased from 6.1% in the first part of our sample to 8.0% in the second part of our sample. This moment is directly informative for the fixed operating cost c_f . Naturally, a higher fixed cost will induce firms to exit at a higher rate. As a result, the fixed operating cost is estimated to have increased from 0.067 to 0.096.

We now evaluate the model's fit with respect to untargeted moments. In Table 3, we report (1) the frequency of positive net equity issuance (i.e., $d < 0$), (2) the frequency of net lending (i.e., $b' \leq 0$), (3) the median leverage ratio, and (4) the standard deviation of the leverage ratio. We also separately report each statistic for small and large firms, where firms are classified as small/large if total assets are smaller/larger than the median level of assets.¹¹

In the data, the overall frequency of equity issuance has increased from 31.9% in 1980

¹⁰Recall that the “dividend tax” in the model captures the effects of dividend taxes and capital gains taxes. See Section 3.3 for a discussion.

¹¹While the overall frequency of net lending is a targeted moment, the corresponding frequencies for small and large firms are not.

Table 3: Untargeted Moments: Model vs Data

Moments	1980s		2000s	
	Model	Data	Model	Data
Frequency of positive net equity issuance				
Small firms	0.301	0.372	0.237	0.704
Large firms	0.084	0.265	0.114	0.430
All firms	0.190	0.319	0.175	0.569
Frequency of net lending				
Small firms	0.215	0.178	0.546	0.581
Large firms	0.034	0.060	0.294	0.246
All firms	0.122	0.119	0.417	0.414
Median leverage ratio				
Small firms	0.755	0.214	-0.461	-0.059
Large firms	0.822	0.248	0.698	0.191
All firms	0.799	0.236	0.447	0.076
Std. dev. of leverage ratio				
Small firms	0.768	0.306	3.534	0.514
Large firms	0.293	0.180	0.905	0.294
All firms	0.599	0.251	2.768	0.430

Note: Firms are classified as small/large if total assets are smaller/greater than the median level of assets.

to 56.9% in 2012. Overall, while the model is less successful in matching this trend, it does match how equity issuance varies with firm size. In particular, in both 1980 and 2012, smaller firms tend to issue equity at a higher frequency. The same pattern is observed in the model.

The model is also successful in matching the changing borrowing patterns between 1980 and 2012. On the one hand, the model does match the increasing frequency of net lending (as this was a targeted moment). On the other hand, the model is also consistent with overall trends in both median leverage ratios and the standard deviation of leverage across firms. As discussed in Section 2, in our data, median leverage ratios have declined while dispersion has increased. While the model is able to match this trend qualitatively, it does generate higher leverage ratios and more dispersion than in the data.¹²

Furthermore, the model is successful in matching how leverage varies with firm size. On the one hand, smaller firms are more likely to be net lenders in both 1980 and 2012. The model does quite well matching the frequency of net lending for small and large firms. On the other hand, in the data, small firms tend to have lower median leverage ratios, and there is more variation in leverage across smaller firms. Again, the model is qualitatively able to

¹²One reason for this discrepancy may be the difference between total assets in our model and in the data. In the model, total assets is just physical capital. However, in the data, total assets includes not just physical capital, but also other assets such as cash, inventories, receivables, and intangible assets.

Figure 4: Size vs. Leverage

Note: We sort firms into five bins on the basis of their (net) leverage ratio. The first bin ($[0, 20]$) contains firms with leverage ratios below the 20th percentile, while the last bin ($[80, 100]$) contains firms with leverage ratios above the 80th percentile. In both 1980 (left panel) and 2012 (right panel), we plot the average size of firms in each bin. Size is measured by total assets and is normalized by the average economy-wide level of assets.

match this pattern, but it does generate too much variation in leverage across firms.

To further analyze the relationship between size and leverage, we sort firms into five bins on the basis of their (net) leverage ratio. The first bin ($[0, 20]$) contains firms with leverage ratios below the 20th percentile, while the last bin ($[80, 100]$) contains firms with leverage ratios above the 80th percentile. In Figure 4, we plot the average size of firms in each bin, where size is measured by total assets. We normalize total assets in each bin by the average economy-wide level of assets.

In Figure 4, it can be seen that there actually is a non-monotonic relationship between firm size and leverage.¹³ Firms with medium leverage ratios tend to be the largest, while firms with low or high leverage ratios tend to be smaller. Despite not being a target in the estimation, the model is successful in matching this empirical relationship in both 1980 and 2012. This is also consistent with Table 3, in which we reported that there is more dispersion in leverage ratios among small firms.

6 Quantitative Results

The model was then solved by iterating on the firm's Bellman equation and simulating the economy using Monte Carlo methods (for details, see Appendix B).

¹³This pattern is robust to different measures of firm size (e.g., sales, number of employees).

Figure 5: Capital, Dividend and Leverage Policy Functions

Note: This figure plots, as a function of internal equity e , three policy functions for a low level of productivity (left panel) and a high level of productivity (right panel): capital k' , dividends d and leverage qb'/k' .

6.1 Model Mechanics

Before comparing the results of the two models, we first highlight the mechanics of the model. For this purpose, Figure 5 plots, as a function of internal equity e , three policy functions for a low and high level of productivity: capital k' , dividends d and leverage qb'/k' . A key feature of this model (and models like it in the literature) is that the cost of external finance and dividend taxes induce firms to follow (S, s) decision rules with respect to dividends. In particular, a firm's optimal policies depend critically on its initial level of equity. There are three regions of interest: (1) low levels of internal equity, (2) medium levels of internal equity, and (3) high levels of internal equity.

First, consider firms with low levels of internal equity (for either low or high productivity). From Figure 5, it can be seen that dividends $d < 0$, investment k' is low and the leverage ratio qb'/k' is high. Since these firms have very little internal equity, they choose to issue external equity. Since $1 - \Lambda'(d) = 1 + \lambda$ for these firms, they are in a region where the marginal benefit of debt issuance is high (see Equation (14)). As a result they choose higher leverage ratios to substitute away from costly external equity. Furthermore, because they have low internal equity, they choose a smaller k' than they would have if they were less constrained. Given small increases in internal equity e , these firms would not change k' or their leverage ratio qb'/k' . Instead, they will reduce one-for-one their reliance on external equity.

Second, consider firms with medium levels of equity. Some of these firms choose a level of dividends exactly equal to zero ($d = 0$). Other firms with a little bit more internal equity

choose positive dividends, but near zero.¹⁴ Since these firms have more internal equity, they do not issue any external equity (i.e., $d \geq 0$). Instead, they rely only on internal funds and debt to finance investment, while making zero or small distributions to shareholders. However, firms in this region will use any additional internal equity to increase capital k' and reduce leverage qb'/k' .

Third, consider firms with high levels of internal equity. These firms have so much internal equity that they choose a relatively large value for k' , while also distributing funds to shareholders ($d > 0$). These firms choose a higher level of capital k' and a lower leverage ratio qb'/k' . For firms in this region, increases in internal equity e will have no effect on capital k' or leverage qb'/k' . Instead, these firms will distribute the extra internal equity as dividends to shareholders. Furthermore, notice that when internal equity is high enough, firms will choose to be a net lender (i.e., $qb'/k' < 0$). The possibility of needing to issue external equity in the future, combined with a low marginal corporate tax rate, will encourage some firms to be a net lender rather than distribute more funds to shareholders.

Furthermore, notice that the slope of the dividend policy function is approximately one for low and high levels of internal equity. As a result, there will be an incentive for firms to live in the middle region. Firms with very low levels of internal equity will raise a lot of external equity (i.e., $d < 0$). As a result, these firms will have much more internal equity (on average) next period. Similarly, firms with very high levels of internal equity will distribute a lot of funds to shareholders. As a result, they will have much less internal equity (on average) next period. Within this middle region, firms will generally avoid issuing large dividends to shareholders, allowing them to accumulate internal equity.

Finally, consider the effect that productivity has on the firm's policy functions. Comparing the left and right panels of Figure 5, it can be observed that productivity has little direct effect on the firm's dividend policy. However, for a given level of internal equity, the higher-productivity firm will, on average, borrow more and choose a larger level of capital. Furthermore, the difference in leverage is larger for high internal equity.

6.2 Accounting for the Empirical Trends

By construction, the two models match both the increasing frequency of net lending and the decreasing frequency of zero net equity issuance between 1980 and 2012. We now consider an accounting exercise whereby we evaluate which parameters best explain these trends between 1980 and 2012. First, we consider the effect of changes in the tax parameters (i.e., for corporate, personal, and dividend taxes). Second, we separately consider the effect

¹⁴The progressive dividend tax helps generate the slow increase in dividend issuance.

Table 4: Effect of Taxes

	Model (1980s)	Model (1980s) $+\Delta\tau_c$	Model (1980s) $+\Delta\tau_i$	Model (1980s) $+\Delta\tau_d$	Model (1980s) $+\Delta\tau$	Model (2000s)
<i>Parameters:</i>						
2000s corporate tax	No	Yes	No	No	Yes	Yes
2000s personal tax	No	No	Yes	No	Yes	Yes
2000s dividend tax	No	No	No	Yes	Yes	Yes
2000s other parameters	No	No	No	No	No	Yes
<i>Statistics:</i>						
τ_c , 25th percentile	0.226	0.075	0.204	0.241	0.037	0.048
τ_c , 75th percentile	0.448	0.348	0.447	0.449	0.305	0.318
Freq. ($b' \leq 0$)	0.122	0.685	0.002	0.187	0.502	0.417
Freq. ($d = 0$)	0.133	0.433	0.155	0.113	0.396	0.022
Exit rate	0.062	0.020	0.097	0.058	0.020	0.082
Total Factor Productivity	1.000	0.984	1.014	0.999	0.984	1.024

Note: This table shows the effect of taxes on the model's predictions. Model (1980s) corresponds to the model estimated using data from the first half of our sample (early 1980s) and Model (2000s) uses the end of our sample (late 2000s). We then separately consider parameterizations in which the corporate income tax, personal income tax and dividend tax parameters are changed from their initial (1980s) value to their final (2000s) value. All other parameters are held fixed at their original (1980s) values.

of the equity issuance cost, productivity parameters and the fixed operating cost. In each case, we hold fixed all other parameters at their original values.

We start by considering the effect of all taxes, which is reported in Table 4. The change in taxation largely explains the increase in net lending. When only marginal corporate income tax rates fall, the frequency of net lending (i.e., $b' \leq 0$) increases from 12.2% to 68.5% (compared to the increase from 11.9% to 41.4% in the data). When only the personal income tax rate falls, the frequency of net lending falls to 0.2%. When only marginal dividend tax rates increase, the frequency of net lending increases to 18.7%. All three taxes together cause the frequency of net lending to increase to 50.2%. Overall, the effect of corporate taxes and dividend taxes dominate the effect of personal income taxes. The increasing frequency of net lending seen in the data can thus be attributed to a lower tax advantage for debt.

To further understand the mechanism behind this result, consider Figure 6, which plots how the change in all the tax parameters (τ_c, τ_i, τ_d) affects the policy functions for leverage qb'/k' , dividends d , and capital k' (for a medium level of productivity s). Notice that the effect is stronger on firms with higher internal equity. Firms with low internal equity substitute away from external equity (i.e., $-d$ decreases) and towards debt (i.e., qb'/k' increases), while increasing k' . Meanwhile, high equity firms reduce dividend issuance and reduce leverage

Figure 6: Effect of Change in Taxes on Firm Policies

Note: Panel A plots the policy functions for leverage (qb/k') as a function of internal equity given a medium level of productivity. Panel B plots the dividend (d) policy function and Panel C plots the capital (k') policy function. We plot the policy functions for two scenarios: (1) our benchmark economy in the 1980s (i.e., “1980s taxes”) and (2) the economy in which all taxes are set to their final (2000s) values but all other parameters are set at their initial (1980s) values (i.e., “2000s taxes”).

ratios, with a smaller effect on capital k' .

Lower marginal corporate income taxes (relative to personal income taxes) reduce the incentive for these firms to borrow. Therefore, given the possibility of needing to issue equity in the future, high equity firms choose to reduce payments to shareholders and instead save more (through more negative leverage ratios). Furthermore, consistent with the data, dispersion in leverage ratios should increase, and the increase in dispersion will come from an increase in net lending behavior.

Higher marginal dividend taxes (through ϕ_d) also helps generate an increase in net lending behavior. Intuitively, a higher dividend cost ϕ_d creates an incentive for firms to decrease dividends and decrease debt issuance (see the discussion in Section 4). To see this more clearly, we repeat the firm’s budget constraint (defined in Equation (2)):

$$d + k' = e(s, k, b) - c_f + q(s, k', b')b'$$

Consider a firm with some internal equity e that wishes to choose a level of capital k' . If the firm decreases d because of a higher ϕ_d , it will necessarily have to decrease b' . Overall, the effect of the higher ϕ_d is to increase the frequency of net lending.

While the change in taxation has been one explanation in the literature for the increased frequency of net lending (e.g., [Armenter and Hnatkovska, 2017](#)), our model shows that this

Table 5: Effect of Equity Issuance Cost, Productivity, and Operating Cost

	Model (1980s)	Model (1980s) + $\Delta\lambda$	Model (1980s) + Δc_f	Model (1980s) + $\Delta\rho_s, \sigma_{\varepsilon s}$	Model (2000s)
<i>Parameters:</i>					
2000s equity issuance cost	No	Yes	No	No	Yes
2000s fixed operating cost	No	No	Yes	No	Yes
2000s productivity parameters	No	No	No	Yes	Yes
2000s tax parameters	No	No	No	No	Yes
<i>Statistics:</i>					
τ_c , 25th percentile	0.226	0.215	0.364	0.224	0.048
τ_c , 75th percentile	0.448	0.447	0.460	0.452	0.318
Freq. ($b' \leq 0$)	0.122	0.115	0.000	0.238	0.417
Freq. ($d = 0$)	0.133	0.086	0.017	0.259	0.022
Exit rate	0.062	0.053	0.346	0.038	0.082
Total Factor Productivity	1.000	0.997	1.089	1.008	1.024

Note: This table shows the effect of other parameters on the model's predictions. Model (1980s) corresponds to the model estimated using data from the first half of our sample (early 1980s) and Model (2000s) uses the end of our sample (late 2000s). We then separately consider parameterizations in which the equity issuance cost λ , fixed operating cost c_f , and productivity parameters ($\rho_s, \sigma_{\varepsilon s}$) are changed from their initial (1980s) value to their final (2000s) value. All other parameters are held fixed at their original (1980s) values.

also produces the counterfactual prediction that the rate of zero net equity issuance should increase. Notice that in Figure 6, the region where firms choose $d = 0$ is much wider after taxes change. When all three taxes change, the frequency of zero net equity issuance increases from 13.3% to 39.6% (see Table 4). This is in contrast to the decrease from 13.1% to 2.0% observed in the data. As we discuss below, our model is able to reconcile these predictions through a lower estimated cost of external finance and a higher fixed operating cost.

As discussed in Section 5.2, the estimated equity issuance cost is estimated to have declined from 23.5% to 6.4%. In Table 5, we report the effect of the lower equity issuance cost. Intuitively, the lower equity issuance cost causes the frequency of zero net equity issuance to decline (from 13.3% to 8.6%). This still is less than the decline observed in the data. However, notice also that the frequency of net lending actually decreases slightly (from 12.2% to 11.5%). As discussed in Section 4, a lower equity cost λ does not necessarily imply that firms will decrease their use of debt. On the one hand, lower equity issuance costs create an incentive for firms to substitute away from debt and towards external equity. On the other hand, lower equity issuance costs decrease the precautionary motive of firms to accumulate internal equity and reduce debt issuance. In our quantitative analysis, it is the second effect which dominates.

Furthermore, the increase in the fixed operating cost c_f also tends to affect both borrowing and equity issuance (see Table 5). Absent changes in the other parameters, a higher c_f significantly increases the exit rate. The higher exit rate reduces the marginal cost of servicing the debt (see Equation (14)). This increases the incentive of firms to borrow. In fact, the effect is so strong that the frequency of net lending falls to zero. Furthermore, the frequency of zero net equity issuance also falls as the higher exit rate decreases the precautionary motive to save.

The higher idiosyncratic uncertainty (through $\sigma_{\varepsilon s}$) also, to a smaller extent, generates an increased frequency of net lending. Increasing $\sigma_{\varepsilon s}$ from 0.113 to 0.128 almost doubles the frequency of net lending. The higher uncertainty strengthens the precautionary motive, whereby firms have an incentive reduce dividend issuance and decrease borrowing so as to avoid future financial constraints. While this is a common explanation for the increase in cash holdings (Bates, Kahle, and Stulz, 2009; Boileau and Moyen, 2016; Armenter and Hnatkovska, 2017; Zhao, 2017), it also generates the counterfactual prediction that the rate of zero net equity issuance should increase. Again, we highlight how our model is able to reconcile these trends. Overall, we can conclude that the higher frequency of net lending is mostly driven by changes in taxation, and to a smaller extent, higher uncertainty. Meanwhile, the reduced frequency of zero net equity issuance, is driven by the reduction in equity issuance costs λ but also the increase in the fixed operating cost c_f .

And finally, we consider the broader implications of these changes for the aggregate economy. Specifically, we focus on the overall level of total factor productivity (TFP). In Table 4, we can see that the overall effect of the change in taxes is to decrease aggregate productivity. The main mechanism for this result is the exit rate. When only taxes change, the overall exit rate declines. As a result, more (relatively) less-productive firms are able to survive, and overall TFP declines by 1.6% relative to the 1980s economy. The overall effect of all parameters, however, increases TFP by 2.4%. The main mechanism here is through the higher fixed operating cost (see Table 5). With a higher fixed operating cost, overall exit rates are higher in the 2000s economy. As a result, less-productive firms exit at a higher frequency, and the average productivity of surviving firms increases.

6.3 Alternative Equity Issuance Cost

In our benchmark model, the equity issuance cost was assumed to be proportional to the amount issued. Under this specification, the estimated equity issuance cost was estimated to be quite large in the 1980s (23.5%). We now consider an alternative specification for the equity issuance cost. Instead of a variable cost, we consider the effect of a fixed cost to issue

equity.¹⁵ Under this specification, the overall dividend/equity cost $\Lambda(d)$ is summarized by the following function:

$$\Lambda(d) = \begin{cases} \lambda & \text{if } d < 0 \\ T_d(d) & \text{if } d \geq 0 \end{cases}$$

When firms issue positive dividends ($d > 0$), firms pay the dividend tax as before. However, when firms raise external equity ($d < 0$), the equity issuance cost does not depend on d .

We then repeat our estimation, following the same approach as before. Table 6 reports the resulting parameters along with the targeted moments. Notice that the estimates for the other six parameters are quite similar to our benchmark estimates (see Table 2). Furthermore, as in our main analysis, we find that there has been a decline in the equity issuance cost. The fixed issuance cost is estimated to have declined from 0.0043 to 0.00094. However, as the units of the fixed cost are now specific to the model, these numbers are not directly interpretable. To interpret these numbers, we report also report the average equity issuance cost as a percentage of the amount issued (see Panel C of Table 6).¹⁶ Using this measure, equity issuance costs have declined from 11.4% in the 1980s to 4.0% in the 2000s. While not as large a decline as our benchmark specification, it is still a significant decline.

Both the fixed and the variable equity issuance cost create an incentive for firms to choose zero net equity issuance. However, the fixed cost creates an additional incentive for firms to issue large amounts of equity, relatively infrequently. Therefore, the fixed-cost specification will tend to reduce the frequency of equity issuance. Under the fixed-cost specification, the frequency of equity issuance is 9.7% and 15.6% in the 1980s and the 2000s, respectively. While this was an untargeted moment, the corresponding frequencies in our benchmark specification were 19.0% and 17.5%, respectively. However, in our Compustat data, equity issuance was relatively frequent (31.9% in 1980 and 56.9% in 2012). At the very least, this suggests a declining role for fixed equity issuance costs.

7 Conclusion

In this paper, we build a model in which heterogeneous firms finance investment with equity and debt, to explain both the increasing frequency of net lending and the decreasing frequency of zero net equity issuance. Structurally estimating the model using firm-level data on equity issuance, debt issuance and marginal tax rates, we conclude that there has

¹⁵With a fixed equity issuance cost, the firm's problem is no longer globally concave, and thus there may be multiple local minima.

¹⁶With the variable-cost specification, this particular statistic was directly estimated as parameter. With the fixed-cost specification, this statistic is no longer an estimated parameter, but depends also on firm behavior (e.g., how much equity firms choose to issue at a time).

Table 6: Model with Fixed External Equity Issuance Cost

		1980s		2000s	
Panel A: Parameters	Notation	Value	Std. Err.	Value	Std. Err.
Productivity persistence	ρ_s	0.633	(0.026)	0.631	(0.020)
Std. dev. of shock to productivity	$\sigma_{\varepsilon s}$	0.113	(0.005)	0.128	(0.005)
Corp. tax shift parameter	$\bar{x}_c$	0.055	(0.001)	0.157	(0.003)
Corp. tax progressivity parameter	ϕ_c	32.62	(1.43)	24.41	(0.37)
Div. tax progressivity parameter	ϕ_d	33.58	(4.74)	48.66	(35.56)
Fixed equity issuance cost	λ	0.0043	(0.0016)	0.00094	(0.00041)
Fixed operating cost	c_f	0.067	(0.0002)	0.096	(0.0005)

		1980s		2000s	
Panel B: Moments		Model	Data	Model	Data
Autocorrelation of log sales		0.728	0.728	0.741	0.731
Std. dev. of innovation to log sales		0.365	0.365	0.409	0.412
Marginal corp. tax rate, 25th percentile		0.228	0.229	0.053	0.093
Marginal corp. tax rate, 75th percentile		0.448	0.448	0.318	0.331
Frequency of net lending		0.118	0.119	0.415	0.414
Frequency of zero net equity issuance		0.131	0.131	0.018	0.020
Exit rate		0.061	0.061	0.079	0.080

		1980s		2000s	
Panel C: Additional Statistics		Model	Data	Model	Data
Average equity issuance cost		0.114		0.040	
Frequency of positive net equity issuance		0.097	0.319	0.156	0.569

Note: In this table, we repeat the estimation but assume a fixed cost to issue equity (λ). Panel A reports the estimated parameters, while Panel B reports the moments in the model and the data. Panel C reports some additional statistics from the model. The average equity issuance cost is the average of the equity issuance cost as a percentage of the amount issued.

been a significant reduction in the cost of external equity. Overall leverage ratios have fallen and an increasing fraction of firms are net lenders mainly because of a lower tax advantage of debt and, to a smaller extent, higher idiosyncratic uncertainty. While these two factors, by themselves, would generate an increasing frequency of zero net equity issuance, the cost of external equity in our model is estimated to have fallen from 23.5% in 1980 to 6.4% in 2012. As a result, the model is able to match the decreasing frequency of zero net equity issuance observed in the data.

References

- Almeida, Heitor, Murillo Campello, and Michael S. Weisbach. 2004. “The Cash Flow Sensitivity of Cash.” *Journal of Finance* 59 (4):1777–1804.
- Altinkilic, Oya and Robert S. Hansen. 2000. “Are There Economies of Scale in Underwriting Fees? Evidence of Rising External Financing Costs.” *Review of Financial Studies* 13 (1):191–218.
- Arellano, Cristina, Yan Bai, and Patrick J. Kehoe. 2018. “Financial Frictions and Fluctuations in Volatility.” *Journal of Political Economy* Forthcoming.
- Arellano, Cristina, Yan Bai, and Jing Zhang. 2012. “Firm Dynamics and Financial Development.” *Journal of Monetary Economics* 59 (6):533–549.
- Armenter, Roc and Viktoria Hnatkovska. 2017. “Taxes and Capital Structure: Understanding Firms’ Savings.” *Journal of Monetary Economics* 87:13–33.
- Bates, Thomas W., Kathleen M. Kahle, and René M. Stulz. 2009. “Why Do U.S. Firms Hold So Much More Cash than They Used To?” *Journal of Finance* 64 (5):1985–2021.
- Begenau, Juliane and Juliana Salomao. 2018. “Firm Financing over the Business Cycle.” *Review of Financial Studies* Forthcoming.
- Blouin, Jennifer, John E. Core, and Wayne Guay. 2010. “Have the Tax Benefits of Debt Been Overestimated?” *Journal of Financial Economics* 98 (2):195–213.
- Boileau, Martin and Nathalie Moyen. 2016. “Corporate Cash Holdings and Credit Line Usage.” *International Economic Review* 57 (4):1481–1506.
- Bolton, Patrick, Hui Chen, and Neng Wang. 2011. “A Unified Theory of Tobin’s q , Corporate Investment, Financing, and Risk Management.” *Journal of Finance* 66 (5):1545–1578.
- Burnside, Craig, Martin Eichenbaum, and Sergio Rebelo. 1995. “Capital Utilization and Returns to Scale.” *NBER Macroeconomics Annual* 10:67–110.
- Chen, Peter, Loukas Karabarbounis, and Brent Neiman. 2017. “The Global Rise of Corporate Saving.” *Journal of Monetary Economics* 89:1–19.
- Cooley, Thomas F. and Vincenzo Quadrini. 2001. “Financial Markets and Firm Dynamics.” *American Economic Review* 91 (5):1286–1310.

- Covas, Francisco and Wouter J. Den Haan. 2011. "The Cyclical Behavior of Debt and Equity Finance." *American Economic Review* 101 (2):877–899.
- . 2012. "The Role of Debt and Equity Finance Over the Business Cycle." *Economic Journal* 122 (565):1262–1286.
- Curtis, Chadwick C., Julio Garín, and M. Saif Mehkari. 2017. "Inflation and the Evolution of Firm-Level Liquid Assets." *Journal of Banking and Finance* 81:24–35.
- DeAngelo, Harry, Linda DeAngelo, and Toni M. Whited. 2011. "Capital Structure Dynamics and Transitory Debt." *Journal of Financial Economics* 99 (2).
- Eisfeldt, Andrea L. and Tyler Muir. 2016. "Aggregate External Financing and Savings Waves." *Journal of Monetary Economics* 84:116–133.
- Falato, Antonio, Dalida Kadyrzhanova, Jae W. Sim, and Roberto Steri. 2018. "Rising Intangible Capital, Shrinking Debt Capacity, and the US Corporate Savings Glut." Working Paper.
- Fama, Eugene F. and Kenneth R. French. 2004. "New Lists: Fundamentals and Survival Rates." *Journal of Financial Economics* 73 (2):229–269.
- . 2005. "Financing Decisions: Who Issues Stock?" *Journal of Financial Economics* 76 (3):549–582.
- Foley, C. Fritz, Jay C. Hartzell, Sheridan Titman, and Garry Twite. 2007. "Why Do Firms Hold So Much Cash? A Tax-Based Explanation." *Journal of Financial Economics* 86 (3):579–607.
- Gamba, Andrea and Alexander Triantis. 2008. "The Value of Financial Flexibility." *Journal of Finance* 63 (5):2263–2296.
- Gomes, Joao F. 2001. "Financing Investment." *American Economic Review* 91 (5):1263–1285.
- Gomes, Joao F. and Lukas Schmid. 2010. "Levered Returns." *Journal of Finance* 65 (2):467–494.
- Graham, John R. 2000. "How Big Are the Tax Benefits of Debt?" *Journal of Finance* 55 (5):1901–1941.
- Green, Richard C. and Burton Hollifield. 2003. "The Personal-Tax Advantages of Equity." *Journal of Financial Economics* 67 (2):175–216.

- Guner, Nezih, Remzi Kaygusuz, and Gustavo Ventura. 2014. "Income Taxation of U.S. Households: Facts and Parametric Estimates." *Review of Economic Dynamics* 17 (4):559–581.
- Han, Seungjin and Jiaping Qiu. 2007. "Corporate Precautionary Cash Holdings." *Journal of Corporate Finance* 13 (1):43–57.
- Hennessy, Christopher A. and Toni M. Whited. 2005. "Debt Dynamics." *Journal of Finance* 60 (3):1129–1165.
- . 2007. "How Costly Is External Financing? Evidence from a Structural Estimation." *Journal of Finance* 62 (4):1705–1745.
- Hopenhayn, Hugo A. 1992. "Entry, Exit and Firm Dynamics in Long Run Equilibrium." *Econometrica* 60 (5):1127–1150.
- Jo, In Hwan and Tatsuro Senga. 2018. "Aggregate Consequences of Credit Subsidy Policies: Firm Dynamics and Misallocation."
- Karabarbounis, Marios, Patrick Macnamara, and Roisin McCord. 2014. "A Business Cycle Analysis of Debt and Equity Financing." *Economic Quarterly* 100 (1):51–85.
- Katagiri, Mitsuru. 2014. "A Macroeconomic Approach to Corporate Capital Structure." *Journal of Monetary Economics* 66:79–94.
- Khan, Aubhik, Tatsuro Senga, and Julia K. Thomas. 2016. "Default Risk and Aggregate Fluctuations in an Economy with Production Heterogeneity."
- Khan, Aubhik and Julia K. Thomas. 2013. "Credit Shocks and Aggregate Fluctuations in an Economy with Production Heterogeneity." *Journal of Political Economy* 121 (6):1055–1107.
- Kim, Dongcheol, Darius Palia, and Anthony Saunders. 2008. "The Impact of Commercial Banks on Underwriting Spreads: Evidence from Three Decades." *Journal of Financial and Quantitative Analysis* 43 (4):975–1000.
- Lucas, Robert E., Jr. 1978. "On the Size Distribution of Business Firms." *The Bell Journal of Economics* 9 (2):508–523.
- Lyandres, Evgeny and Berardino Palazzo. 2016. "Cash Holdings, Competition, and Innovation." *Journal of Financial and Quantitative Analysis* 51 (6):1823–1861.

- Ma, Liang, Antonio S. Mello, and Youchang Wu. 2018. “First Mover Advantage, Time to Finance, and Cash Holdings.”
- Modigliani, Franco and Merton H. Miller. 1958. “The Cost of Capital, Corporation Finance and the Theory of Investment.” *American Economic Review* 48 (3):261–297.
- Morellec, Erwan, Boris Nikolov, and Francesca Zucchi. 2013. “Competition, Cash Holdings, and Financing Decisions.”
- Nikolov, Boris, Lukas Schmid, and Roberto Steri. 2018. “Dynamic Corporate Liquidity.” *Journal of Financial Economics* Forthcoming.
- Nikolov, Boris and Toni M. Whited. 2014. “Agency Conflicts and Cash: Estimates from a Dynamic Model.” *Journal of Finance* 69 (5):1883–1921.
- Opler, Tim, Lee Pinkowitz, René Stulz, and Rohan Williamson. 1999. “The Determinants and Implications of Corporate Cash Holdings.” *Journal of Financial Economics* 52 (1):3–46.
- Palazzo, Bernardino. 2012. “Cash Holdings, Risk, and Expected Returns.” *Journal of Financial Economics* 104 (1):162–185.
- Riddick, Leigh A. and Toni M. Whited. 2009. “The Corporate Propensity to Save.” *Journal of Finance* 64 (4):1729–1766.
- Rosen, Sherwin. 1982. “Authority, Control, and the Distribution of Earnings.” *The Bell Journal of Economics* 13 (2):311–323.
- Sánchez, Juan M. and Emircan Yurdagul. 2013. “Why Are U.S. Firms Holding So Much Cash? An Exploration of Cross-Sectional Variation.” *Federal Reserve Bank of St. Louis Review* 95 (4):293–325.
- Strebulaev, Ilya A. and Toni M. Whited. 2012. “Dynamic Models and Structural Estimation in Corporate Finance.” *Foundations and Trends in Finance* 6 (1-2):1–163.
- Townsend, Robert M. 1979. “Optimal Contracts and Competitive Markets with Costly State Verification.” *Journal of Economic Theory* 21 (2):265–293.
- Zhao, Jake. 2017. “Accounting for the Corporate Cash Increase.”

A Data

The data are from Standard and Poor's Compustat industrial files. We use annual fundamental data from 1980 to 2012. Marginal corporate tax rates are taken from the Marginal Tax Rate database, where marginal tax rates are estimated using a non-parametric procedure detailed in [Blouin, Core, and Guay \(2010\)](#). We impose the following restrictions. We exclude financial firms (SIC 6000-6999), utilities (SIC 4900-4999) and public administration (SIC 9000-9999). We drop any firm-year observations without any information on assets, stockholder's equity, liabilities, debt, capital, cash holdings, or marginal corporate tax rates. We drop any firm-year observations with non-positive assets or capital. We also drop any observations with where assets minus cash is non-positive, and observations where stockholder's equity plus net debt is non-positive. And finally, we drop observations that violate the accounting identity of assets equal to equity plus debt by more than 10%.

Data variables are defined as follows. Total debt consists of debt in current liabilities (item 34) plus long-term debt (item 9). Cash is item 162. Net debt is total debt minus cash. Total assets is item 6. Total liabilities is item 181. The capital stock is total property, plant and equipment (item 8). Stockholder's equity is item 216. Sales is item 12. Retained earnings is item 36. Cash dividends is item 127. Net equity issuance is computed as $\Delta(SEQ - RE)$ minus cash dividends. $\Delta(SEQ - RE)$ is the annual change in $(SEQ - RE)$ where SEQ is stockholder's equity and RE is retained earnings.

B Numerical Algorithm

To solve for the steady state equilibrium given wage w , the algorithm proceeds as follows. First, solve for the firm's value function, $V(s, e)$, by value function iteration. Second, simulate the model for N firms and T periods, using Monte Carlo methods.

The firm's value function is solved by iterating on the Bellman equation defined in Equation (13) until convergence. To construct the grid, 30 equally-spaced (in logs) grid points are used for productivity s and 400 equally spaced grid points are used for internal equity e . For each combination of (s, e) on the grid, we search for the optimal (k', b') using the Nelder-Mead unconstrained multi-dimensional minimization algorithm. For robustness, we occasionally use grid search over (k', b') to determine a better initial guess for the Nelder-Mead algorithm. To compute the default cutoff $s'_d(k', b')$, we use the one-dimensional Brent root finding routine from the GNU Scientific Library (GSL) to search for the value of s'_d satisfying Equation (8).

To calculate the bond price $q(s, k', b')$, we first compute the re-negotiation equity thresh-

old, $e'_r(s')$ for every possible value of s' on the grid. This threshold $e'_r(s')$ is computed using the Brent one-dimensional root finding algorithm from the GSL. To compute values of $e'_r(s')$ off the grid, we use linear interpolation. We then compute the integral $\int_0^{s'_d} R(s', k') h(s'|s) ds'$ using a non-adaptive Gauss-Kronrod integration routine from the GSL. Given the default threshold s'_d and $\int_0^{s'_d} R(s', k') h(s'|s) ds'$, we can easily compute the bond price $q(s, k', b')$ using Equation (12).

To calculate the continuation value, which is defined in Equation (7), note that given $s'_d(k', b')$, the continuation value in Equation (7) can be written as:

$$CV(s, k', b') = \int_{s'_d(k', b')}^{\infty} \max(V_c(s', e(s', k', b')), V_x(e(s', k', b'))) h(s'|s) ds'$$

To compute the continuation value, we first define an additional productivity cutoff, $s'_x(k', b')$, which is the value of productivity s'_x such that

$$V_c(s'_x, e(s'_x, k', b')) = V_x(e(s'_x, k', b'))$$

When $s'_d(k', b') < s'_x(k', b')$, the continuation value can be re-written as:

$$CV(s, k', b') = \int_{s'_d(k', b')}^{s'_x(k', b')} V_x(e(s', k', b')) h(s'|s) ds' + \int_{s'_x(k', b')}^{\infty} V_c(s', e(s', k', b')) h(s'|s) ds' \quad (15)$$

When $s'_d(k', b') \geq s'_x(k', b')$, the continuation value can be written as:

$$CV(s, k', b') = \int_{s'_d(k', b')}^{\infty} V_c(s', e(s', k', b')) h(s'|s) ds' \quad (16)$$

As with s'_d , the cutoff productivity s'_x is computed using the Brent one-dimensional root finding routine from the GSL. Then, given the cutoffs (s'_d, s'_x) , the integrals in Equations (15) and (16) are approximated using a non-adaptive Gauss-Kronrod integration routine from the GSL.

We then simulated the economy for $N = 10,000$ firms for $T = 2,000$ periods, using Monte Carlo methods. The policy functions for $k'(s, e)$ and $b'(s, e)$ were interpolated using linear interpolation. Only the final 25 periods were saved for analysis.