Taxation and The Life Cycle of Firms

Andrés Erosa

Beatriz González *

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Abstract

The Hopenhayn and Rogerson (1993) framework of firm dynamics is extended to understand how different forms of taxing capital income affect investment and financial policies over the life cycle of firms. Relative to dividends and capital gains taxation, corporate income taxation slows down growth over the life cycle by reducing after-tax profits available for reinvesting in the firm. It also diminishes entry by negatively affecting the value of entrants relative to the that of incumbents firm. After a tax reform eliminating the corporate income tax in a revenue neutral way, output and capital increase by 13% and 35%. The large response of firm entry to the tax reform is crucial for our results.

Keywords Macroeconomics, Taxation, Firm Dynamics, Investment

JEL Codes D21, E22, E62, G12, G32, G35, H25, H32

*Universidad Carlos III de Madrid, Departamento de Economía, Calle Madrid 126, 28903 Getafe, Madrid.
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1 Introduction

The macroeconomic effects of the taxation of capital income have received a great deal of attention by economists and policy makers. Throughout modern economies the taxation of capital income takes many different forms: capital gains taxation, interest income taxation, dividend taxation, and corporate income taxation. In particular, the tax rate on corporate income in the US was until recently among the highest among OECD countries and this has raised concerns about its effects on job creation and investment. Policy advisors from the Obama and Trump administration have advocated for changes in the taxation of capital income and, indeed, the Trump administration has recently cut by nearly a half the corporate income tax rate. In this paper, we study how different forms of taxing capital income affect investment and financing decisions of firms over their life cycle, as well as the creation of new firms (firm entry), aggregate capital accumulation and output. We then evaluate the effects of a tax reform that eliminates the tax on corporate income and replace the lost revenue with a common tax rate on all other form of capital income.

Corporate profits distributed as dividends suffer the so-called 'double taxation', since they are taxed both at corporate and personal income levels (by the corporate income tax and the divident tax, respectively). The literature has long emphasized that corporate income taxation diminishes investment by firms by reducing the after tax return on capital. In this paper, we show that these distortions are much more severe when firms' growth over the life cycle is constrained by financial frictions. We also show that the impact of dividend taxation on firm investment decisions critically depend on the stage that firms are in their life cycle, as young firms are more likely to issue equity and old firms are more likely to issue dividends. Young firms behave according to the traditional view' in the finance literature that focuses on how raising the cost of equity finance (dividend taxation) negatively affects firms' investment.[1] However, as emphasized by the 'new view' in the finance literature, dividend taxation does not affect investment decisions of firms distributing dividends (mature firms) since the dividend tax leads to an equiproportional reduction in the return and costs of investment. More generally, our paper stresses that the various ways capital income can be taxed (whether corporate income, dividend, or capital gains taxation) have quite different effects on investment and payout policies over the life cycle of firms, and hence on the life cycle growth of firms. They also have different and asymmetric effects on the market valuation of new versus incumbent firms and thereby on firm entry.

Our paper is motivated by micro evidence on firm dynamics and the life cycle of

[1] See, for instance, (Auerbach, 2002) for a description of these views. Empirical findings on this issue are mixed. For instance, Poterba and Summers (1985) find evidence supporting the traditional view using British data. Kari et al. (2009) find evidence supporting more the new view using Finnish data. Auerbach and Hassett (2007) found that in the US, firms behave according to both views, which points at the coexistence of both regimes in the data.

firms. Haltiwanger et al. (2013) argue that start ups play a critical role for understanding US employment growth dynamics. The mass of firms entering the economy is large, most new businesses start as small but (conditional on survival) grow fast, and new entrants are important for understanding employment growth. Moreover, Hsieh and Klenow (2009) argue that the cross country differences in the life cycle growth of firms are important for understanding aggregate productivity differences across countries. The evidence indicates that firms face substantial equity issuance costs (see Hennessy and Whited (2007), Lee et al. (1996)). Using micro evidence from US and UK firms, Cloyne et al. (2018) show that financial frictions affect more strongly investment decisions of young firms than of mature firms. Campbell et al. (2013) empirically document heterogeneous investment responses across young and mature firms after the reduction on shareholder taxes in the US in 2003. Becker et al. (2013) study many tax reforms on 25 countries over a 20 year period, finding that changes in payout taxes affect firms differently depending on their financial regime. Overall, we believe that the evidence points to the importance of modeling the life cycle of firms for assessing the effects of taxation. A model with a representative firm, as in the standard Neoclassical Growth Model, implicitly focuses on mature firms (i.e. those distributing dividends where the 'new view' holds) disregarding the evidence that investment responses to tax changes vary over the life cycle of firms. Moreover, the empirical findings of Haltiwanger et al. (2013) suggest that it is important to consider the impact of taxation on business entry.

We extend the Hopenhayn and Rogerson (1993) framework of firm dynamics to understand how different forms of taxing corporate income affect the life cycle of firms. We start by analysing a simple version of the model with a deterministic fixed level of productivity determined upon entry. Companies need to raise equity to set the firm up, starting their life in the 'traditional view' regime (equity issuance phase). They grow by accumulating profits (growing phase), until they reach their optimal size and start distributing dividends (maturity phase). Consistently with the 'new view', dividend taxation does not distort investment decisions and dividends paid by mature firms. However, dividend taxation diminishes the optimal amount of initial equity issued by firms. Intuitively, firms can diminish the taxes paid by financing a larger portion of investments with retained earnings. Hence, dividend taxation reduces the initial size of firms, retarding the age at which they reach maturity, and diminishes entry. The taxation of capital gains have opposite effects from dividend taxation. First, the taxation of capital gains encourages firms to issue more equity at entry in order to avoid paying the taxes that would accrue with the accumulation of internal funds. Second, it distorts the optimal scale of the firm at maturity. Corporate income taxation impacts on capital accumulation through several channels. First, corporate income taxation distorts the optimal size and dividends paid by mature firms by decreasing the return on capital. Second, crucial to our analysis and results, the corporate income tax decreases after-tax earnings, making it harder for firms to finance investment with retained earnings and causing firms to grow at a slower pace over their life cycle. As a result, the market value of the firm decreases, leading to two additional effects of corporate income taxation on capital accumulation: Firms raise less equity at entry and the equilibrium mass of entry becomes smaller. While these effects are also present under dividend taxation, we find that they are stronger under corporate income taxation.

The baseline economy with firm dynamics (due to idiosyncratic productivity shocks at the firm level) is calibrated to moments on the micro data on firms' investment and financing decisions. We use the calibrated model economy to quantitatively assess the effects of a reform that eliminates the taxation of corporate income while keeping constant the tax revenue collected on capital. This is done by finding the common tax rate ($\bar{\tau}$) on all forms of capital income (dividends τ_d, interest income τ_r, and capital gains τ_g) that collects the same tax revenue as in the baseline economy. The purpose of the proposed policy reform is twofold. Firstly, by equating the three tax rates we would be treating symmetrically all forms of capital income from the household perspective. Secondly, by eliminating the corporate tax, we allow financially constrained firms to accumulate profits and to reach maturity (the dividend distribution stage) faster. Since under our proposed reform firms face higher taxes on dividend distribution, the tax burden shifts from constrained firms (firms with high marginal valuation of capital) to unconstrained firms (firms with low marginal valuation of capital). We find that the elimination of the corporate income tax in the baseline economy ($\tau_c = 0.34$) should be accompanied by an increase in the other capital income tax rates to 0.39 in order to keep government revenue constant (the dividend and capital gains tax in the baseline economy were set to 0.15 and the interest income tax was set to 0.25). This revenue neutral tax reform leads to an increase in aggregate output of 13.6%, which is accompanied by a large increase in the aggregate capital stock (35%) and in the number of firms (39.3%). Note that the fact that aggregate capital and output rise less than the number of firms indicates that the average size of firms is smaller after the tax reform. Hence, the large response of firm entry to the tax reform drives the large increase in aggregate output and capital.

At the heart of our results is that the tax reform increases more the expected value at entry than the value of incumbent firms, leading to a reallocation of resources from mature to younger firms, that operates through an increase in entry and in the equilibrium wage rate. The elimination of corporate income taxation allows financially constrained firms to retain a larger fraction of their earnings and increase their investments. The ability to retain earnings is particularly relevant for young firms, which are more likely to be constrained than the average incumbent firm in the economy. Since the value at entry is determined by the average value of age-0 firms, we find that the value of the average firm entering the economy increases more than that of incumbent firms when corporate inome taxation is eliminated. In general equilibrium, the increase in the value of entry requires the wage rate to rise, which reduces labor demand by incumbent firms. Labor market clearing requires a larger mass of firm entry, which rises by about 39.3%. Larger firm entry, together with a reallocation of resources to financially constraint firms, lead to an increase in aggregate TFP of 5.2%.

Our model economy builds on Gourio and Miao (2010), who study the impact of dividend taxation on firms investment and payout decisions. We contribute by comparing alternative forms of capital income taxation and by extending their analysis to incorporate three key features for our results: life cycle (endogenous entry), financial frictions, and corporate income taxes. In particular, we emphasize the importance of the life cycle of firms for understanding how taxation affects investment incentives of firms. Korinek and Stiglitz (2009) build a theory of the life cycle of firms for understanding the impact of dividend taxation but abstract from corporate income taxation and firm entry. McGrattan and Prescott (2005) and Atesagaoglu (2012) study how corporate income taxation affect the market valuation of firms in environments with a representative firm. Conesa and Domínguez (2013) advocate for the elimination of corporate income taxation in a Ramsey optimal taxation exercise with a representative firm, with no financial frictions and no firm entry/exit. Similar to us, Anagnostopoulos et al. (2015) evaluate the gains of eliminating corporate income taxation in a model with firm heterogeneity and household heterogeneity. We abstract from household heterogeneity but contribute by focusing on firm entry and the life cycle of firms, which turn out to be key for the large quantitative effects of our tax reform and which Haltiwanger et al. (2013) emphasize as crucial for understanding the dynamics of employment growth in the US. The financial crises has sparked the importance of the literature analyzing the role of financial frictions in business cycle fluctuations. Papers in this literature include Cooley and Quadrini (2001), Khan and Thomas (2013), Jermann and Quadrini (2012) (among many others). Our results suggest that the design of capital income taxation may affect the propagation of business cycle shocks.

An outline of the paper follows. In Section 2 we present and analyze simple version of our baseline model economy in which firms do not face idiosyncratic shocks to their productivity. We use it to illustrate how different forms of taxing capital income affect investment and payout policies over the life cycle of firms, the value of firms to its share holders, and firm entry. In Section 3 we present our baseline model economy of firm dynamics and taxation of capital income, calibrate it, and perform our main quantitative exercise. We evaluate a tax reform that eliminates corporate income taxes while keeping constant revenue from capital income. We analyze its impact on macroeconomic aggregates as well as on firms decisions on investment and payout policies over the life cycle. Section 4 concludes.

2 A Simple Deterministic Model Economy

Our baseline model extends the Hopenhayn and Rogerson (1993) framework of firm dynamics to study taxation of corporate capital income. Time is continuous. Each firm may exit the economy with some fixed probability. The entry of new firms is endogenous. Firms can finance investment with retained profits, equity issuance, and debt. Firms face adjustment costs in capital. Following Cooley and Quadrini (2001) and Gomes (2001), firms face financial frictions: borrowing is limited by a collateral constraint and equity issuance is costly. There is a representative household that owns all firms. There is a large number of firms so that the representative consumer does not face any uncertainty. As in Gourio and Miao (2010), households pay taxes on dividends (τ_d), interest income (τ_r), and capital gains taxes (τ_g).[2] In addition, corporations pay taxes on corporate profits (τ_c) so that capital income is taxed both at the firm and household level.

In this section, we illustrate the key ideas in our paper in deterministic version of our baseline model economy that abstracts from adjustment costs in capital.

2.1 The problem of a firm.

We assume that when firms are created, they draw a productivity z that stays fixed over the lifetime of a firm. Firms exit exogenously the economy at a rate δ_d. The economy is a steady state with an after tax interest rate equal to $r(1-\tau_r)=\rho$, where ρ is the rate of time preference of the representative household (investor).

Each firm produce output with a decreasing returns to scale production function in capital and labor inputs: $f(z,k,n)=z^{1-\alpha-\eta}k^{\alpha}n^{\eta}$. Profits are given by

$$\pi(z,k)=\max_{n}\{f(z,k)-wn-\delta k\}$$

The flow constraint is

$$\dot{k}=(1-\tau_c)\pi(z,k)-d+(1-\xi)e,$$

where d and e denote dividend distribution and equity issued by firms. We assume that equity issuance is costly. There is a cost ξ per unit of equity issued, so the resources available are $e(1-\xi)$.

Consider a firm with fix z. The market value (V), the dividends(d) paid, and the equity issued e are deterministic functions of the age of the firm t. However, we do not

[2] While in the US capital gains are taxed upon realization, we follow standard practice in the literature by modeling capital gains taxation on an accrual basis. This modeling choice simplifies the analysis considerable and allow us to derive our results in a more transparent way.

explicitly index these variables with a subscript t to simplify the notation (unless there is some risk of confusing the reader). Taking as given investment and financial policies, the market value of the firm V satisfies that the after tax rate of return on equity equates the investor rate of discount ρ:

$$\rho = \frac{d(1-\tau_d)}{V} + \frac{\dot{V}-e}{V}(1-\tau_g) - \frac{\delta_d V}{V}(1-\tau_g), \tag{1}$$

where $\dot{V}$ represents the rate of change of V with respect to time (age of the firm). Note that increases in share values due to equity issuance are not taxable. Firm exit give rise to negative capital losses that are tax deductible. The above no-arbitrage equation can be re-arranged as

$$\left(\frac{\rho}{1-\tau_g} + \delta_d\right) V = \frac{1-\tau_d}{1-\tau_g} d - e + \dot{V}.$$

Denote $m = \frac{\rho}{1-\tau_g}$. Then, the solution to this first-order linear differential equation on V gives the integral in (2). The problem of the firm in state (k,z) is then to choose investment and financial policy to maximize:

$$\begin{aligned} V(k,z) \equiv \max \int_0^\infty e^{-(m+\delta_d)t} \left\{\frac{1-\tau_d}{1-\tau_g} d - e\right\} dt \\ \text{subject to:} \\ \dot{k} = (1-\tau_c)\pi(z,k) - d + (1-\xi)e \\ d \geq 0, e \geq 0, k_0 \ \text{ given} \end{aligned} \tag{2}$$

Associate the present-value multipliers $e^{-(m+\delta_d)}\lambda_t$ to the flow of funds constraint, $e^{-(m+\delta_d)}\mu_t^e$ to the non-negativity constraint on equity issuance, and $e^{-(m+\delta_d)}\mu_t^d$ to the non-negativity on dividend distribution. Then, the FOC from the Maximum Principle imply:

$$\lambda = \frac{1-\tau_d}{1-\tau_g} + \mu^d \tag{3}$$

$$(1-\xi)\lambda + \mu^e = 1 \tag{4}$$

$$\lambda\left[m + \delta_d - (1-\tau_c)\pi'(z,k)\right] = \dot{\lambda} \tag{5}$$

$$\dot{k} = (1-\tau_c)\pi(z,k) - d + e(1-\xi) \tag{6}$$

$$\mu^d \geq 0, \mu_t^d d \geq 0, d \geq 0 \tag{7}$$

$$\mu^e \geq 0, \mu_t^e e \geq 0, e \geq 0 \tag{8}$$

$$\lim_{t\to\infty} e^{-(m+\delta_d)t}\lambda_t k_t = 0 \text{ (transversality)} \tag{9}$$

Conditions (3) and (7), imply that the shadow value of funds $\lambda \geq \frac{1-\tau_d}{1-\tau_g}$, with equality if dividends are strictly positive. Conditions (4) and (8), imply that the shadow value of funds $\lambda \leq \frac{1}{1-\xi}$, with equality if equity issuance is strictly positive. In sum, the shadow value of funds satisfies $\lambda \in \left[\frac{1-\tau_d}{1-\tau_g}, \frac{1}{1-\xi}\right]$.

2.2 Entry, optimal initial equity, and time to maturity

As in Hopenhayn and Rogerson (1993), firms pay a fixed cost c_e to draw a productivity z from an exogenous probability density g_e. We assume that the firm decides the initial amount of capital $k_0(z)$ after observing the productivity draw z. The value of entry is then given by

$$V^e = \int_0^\infty V(k_0(z), z) g_e(z) dz = c_e, \tag{10}$$

where the second equality states that in a steady state equilibrium the value of entry should be equal to the entry cost. The wage rate adjusts to ensure that this is the case. The mass of firms entering the economy is determined by the labor market clearing condition:

$$\begin{aligned} &\int_0^\infty e^{-\delta_d t} \int_0^\infty n(z, k_t) g(k, z) dz dt = 1, \text{where g satisfies} \\ &0 = -\partial_k \left(s(k, z) g(k, z)\right) - \delta_d g(k, z) + M g_e(z) I_{k=k_0(z)}, \end{aligned} \tag{11}$$

where $n_t(z, k)$ and $g(k, z)$ denote the optimal labor demand and the mass of firms in state (k, z).

Consider a firm with productivity z that raises capital (equity) k_0 when newly created. The firm will accumulate capital until it reaches the optimal amount of capital $k^*(z)$ (for now we take $k^*(z)$ as given, but in the next subsection of the paper we determine the optimal scale of the firm). Once the firm reaches its optimal scale, it will start distributing dividends until it dies. The age (T) at which the firm starts distributing dividends solves the following equation:

$$(1 - \tau_c) \int_0^T \pi(z, k_t) dt + k_0 = k^*. \tag{12}$$

The above equation defines an implicit function $T(k_0, z)$ characterizing the age when a firm matures (starts distributing dividends) as a function of its net worth at entry (age 0). Since an increase in initial capital k_0 increases the profits accumulated by the firm over time, the firm takes a shorter period to reach maturity. Formally, differentiating (12) with respect to initial capital k_0 yields

$$\frac{dT}{dk_0} = -\frac{1 + (1-\tau_c)\int_0^T \pi'(z,k_t)\frac{dk_t}{dk_0}dt}{(1-\tau_c)\pi(z,k_T)} < 0. \tag{13}$$

In words, if initial capital k_0 is greater, everything else held constant, the time to reach maturity decreases.

We now focus on determining the optimal amount of initial equity. For a fixed value of k_0, we compute T from (12). Equations (3)- (7) imply that the shadow value of funds at age T satisfies $\lambda(T) = \frac{1-\tau_d}{1-\tau_g}$. Integrating (5) between 0 and $T(k)$ gives

$$\lambda(0) = \frac{1-\tau_d}{1-\tau_g} e^{\int_0^T [(1-\tau_c)\pi'(z,k_t)-(m+\delta_d)]dt} \tag{14}$$

The function inside the integral in (14) has a positive sign for all $t < T$, is equal to 0 at T, and is decreasing on k_0 (due to decreasing returns to capital accumulation). Moreover, T is a decreasing function of k_0 . As a result, it is easy to see that $\lambda(0)$ is a decreasing function of k_0. The optimal value of initial equity is obtained by solving $\lambda(0) = 1+\xi$.

The value of a firm with initial capital (equity) k_0 satisfies

$$V(k_0,z) = \int_{T(k_0,z)}^{\infty} \frac{1-\tau_d}{1-\tau_g} e^{-(m+\delta_d)t} d^*(z)dt = \frac{1-\tau_d}{1-\tau_g} d^*(z) \frac{e^{-(m+\delta_d)T(k_0,z)}}{m+\delta_d} \tag{15}$$

where $m = \frac{\rho}{1-\tau_g}$ is determined by the capital gains tax rate. Note that another way of solving for the optimal amount of initial equity is

$$\max_{k_0} V(k_0,z) - \frac{1}{1-\xi}k_0, \tag{16}$$

which implies

$$V'(k_0,z) = \frac{1-\tau_d}{1-\tau_g} d^*(z) e^{-(m+\delta_d)T(k_0,z)}(-1)\frac{dT}{dk_0} = \frac{1}{1-\xi} \tag{17}$$

Since V is a concave function of net worth, it follows that the solution for initial equity is unique.

2.3 The life cycle of a firm

The previous discussion highlights that, as in Korinek and Stiglitz (2009), firms in our simple model firms face three distinct phases during their life cycle: equity issuance phase, growth phase, and dividend distribution phase.

- **Equity issuance phase.** The first stage occurs when firms are created. Firms start with zero net worth. In order to operate they need to raise equity at age 0 so that $e_0 > 0$. The Kuhn Tucker complementarity slackness condition (8) imply that $\mu_0^e = 0$ so that (4) implies that the shadow value of assets at age 0 is given by $\lambda_0 = \frac{1}{1-\xi}$. The non-negativity constraint on dividend distribution binds ($\mu_0^d > 0$) so that firms do not distribute dividends. The amount of initial equity raised is such that:

$$(1 - \tau_c)\pi'(z, k_0) > m + \delta_d \tag{18}$$

  By equation (5), once the firm is set up and $\lambda_0 = \frac{1}{1-\xi}$, the next instant the value of the multiplier is decreasing,i.e.$\lim_{t\to 0^+} \lambda_t < \frac{1}{1-\xi}$. Otherwise, condition (18) implies that $\lim_{t\to 0^+} \lambda_t > \frac{1}{1-\xi}$, which violates the non-negativity of μ_t^e (see equation (4)). This phase would fall within the so-called 'traditional view', where firms are using equity issuance as the marginal source of financing.

- **Growth phase.** When firms start operation (immediately after age 0), the continuity of λ_t together with (18) imply that the shadow value of net worth decreases since $(1 - \tau_c)\pi'(z, k_t) > m + \delta_d$ for $t > 0$ in the right neighborhood of $t = 0$ ($\dot{\lambda}_t$). Newly created firms start operation and retain earnings in order to increase their net worth. As net worth grows, the shadow value of funds decreases relaxing the non-negativity constraint on dividends (its multiplier decreases).

- **Dividend distribution phase.** Firms reach the dividend distribution phase (maturity) when the shadow value of funds reaches the value $\frac{1-\tau_d}{1-\tau_g}$. At this stage, the marginal source of funds is retained earnings, and its marginal cost equals the marginal benefit of distributing dividends. Growth ceases when firms reach a steady state with a constant capital (k^*) and constant dividend distribution d^* satisfying

$$(1 - \tau_c)\pi'(z, k^*) = m + \delta_d \tag{19}$$

$$(1 - \tau_c)\pi(z, k^*) = d^* \tag{20}$$

2.4 Discussion on taxation and the life cycle of firms.

We now discuss, for a fixed wage rate, the effects of taxes on the life cycle of firms. To analyze the effects of taxes on mature firms we use that in steady state $m = \frac{r(1-\tau_r)}{1-\tau_g}$ and

$r = \frac{\rho}{1-\tau_r}$, (19)-(20) to obtain:

$$(1-\tau_c)\pi'(z,k^*) = \frac{\rho}{1-\tau_g} + \delta_d \tag{21}$$

$$(1-\tau_c)\pi(z,k^*) = d^*, \tag{22}$$

Equations (21) and (22) determine the optimal level of capital (k^*) and dividends (d^*) by mature firms. The value of a mature firm with productivity z is

$$V^{mature}(z) = \frac{1-\tau_d}{\rho + \delta_d(1-\tau_g)} \;\; d^*. \tag{23}$$

Using (15), $m = \rho/(1-\tau_g)$ implies that the value of an age-0 firm with productivity z satisfies

$$V^{new}(z) = \frac{1-\tau_d}{\rho + \delta_d(1-\tau_g)} e^{-(\frac{\rho}{1-\tau_g}+\delta_d)T(k_0,z)} \;\; d^* \tag{24}$$

Below we use (21)-(24) to evaluate the impact of capital income taxation on mature firms and on the market value of mature firms relative to that of age-0 firms.

Dividend taxation (τ_d) The tax rate on dividend distribution does not affect equations (21) and (22). It is then immediate that dividend taxation has no impact on capital and dividends paid by mature firms, a that result is consistent with the "new view" of the public finance literature. When the firm is indifferent between using its marginal unit of funds as dividend or investment, a change in the dividend tax rate has proportional effects in the benefits and cost of investment. As a result, investment decisions and dividend payouts of mature firms are unaffected by the dividend tax rate. However, the dividend tax reduces the market value of mature firms (it changes proportionally with the term $1-\tau_d$, as shown in (23)).

Paradoxically, the dividend tax rate affects capital accumulation when firms are not paying dividends. This is because the lower value of the firm to shareholders reduces the optimal amount of initial equity (see equation (17)), retarding the age at which firms reach maturity. Intuitively, the firm can effectively diminish the taxes paid by reducing (initial) equity issuance and by financing investment with retained earnings. The fact that the firm reaches maturity at a later age, implies that dividend tax rate decreases the market value of firms at entry more than at maturity (in (24) the increase in T caused by dividend taxation further reduces the value of entry).

In sum, while dividend taxation does not distort the optimal scale and payouts of mature firms, it distorts the initial scale of operation of firms, diminishing capital accumulation along the life cycle and the age at which firms reach maturity. Moreover, in general equilibrium dividend taxation negatively affects the creation of businesses (entry).

Taxation of capital gains (τ_g) Taxation of capital gains (τ_g) reduces capital and dividend distribution of mature firms since it increases the cost of equity financing ($\frac{\rho}{1-\tau_g}$). As a result, the optimal amount of capital at maturity decreases (see equation (21)) and so does the dividends distributed (see equation (22)). The decrease in dividends imply a decrease in the market value of mature firms.[3]

Relative to mature firms, the tax rate on capital gains τ_g has an additional effect on the market value of new firms (see (24)): It increases the rate of discount of dividends ($\frac{\rho}{1-\tau_g} + \delta_d$). As a result, the taxation of capital gains incentivize firms to issue more equity at entry so that the time to maturity diminishes and the firm value rises.[4] Intuitively, by raising more equity at entry, they avoid paying taxes on capital gains that would accrue with the accumulation of internal funds. Hence, the capital gains tax encourages new firms to finance investment with external funds. Note that this result is the opposite of what we found for dividend taxation. Recall that, in order to minimize taxes on dividends, dividend taxation encourages young firms to finance investment with internal funds.

Corporate income taxation (τ_c) Corporate income taxation reduces capital accumulation and dividends paid by firms. Intuitively, corporate income taxation reduces the after tax benefit to capital (see left hand side of equation (21)) but without reducing the cost of funds to the firm. This effect reduces the optimal size (k^* decreases) and distributions (d^*) by mature firms (see equation (22)). Lower dividends imply a decrease in the market value of mature firms (see equation (15)) which, in turn, decreases the optimal amount of initial equity (equation (17)). Hence, firms start their life with a smaller scale. Moreover, the firm grows at a slower pace since the corporate income tax reduces the fraction of earnings that the firm accumulates during its growth face in the life cycle (see equation (12)). The time to reach maturity may increase or not with corporate income taxation since there are two opposite forces at work: While the firm grows more slowly, the optimal scale of the firm at maturity is smaller. In our computational experiments, we shall find that the first effect is stronger so that firms take a longer time to mature.

It is important to note that the decrease in d^* associated with corporate income taxation

[3]Note that τ_g enters in the denominator of (23). This expression represents that the market value of mature firms increase with τ_g because the tax code in our model ecomnomy allows for a tax credit associated to the death of the firm. Quantitatively, this effect will likely have a small effect on the market value of firms if the death rate is small. As a result, we should expect the market value of mature firms to move together with d^*. This will always be the case if we assume that there are no tax credit associated to the capital losses upon death of firms.

[4]The time to reach maturity diminishes because of a second effect: The optimal amount of capital diminishes with the capital gains tax rate.

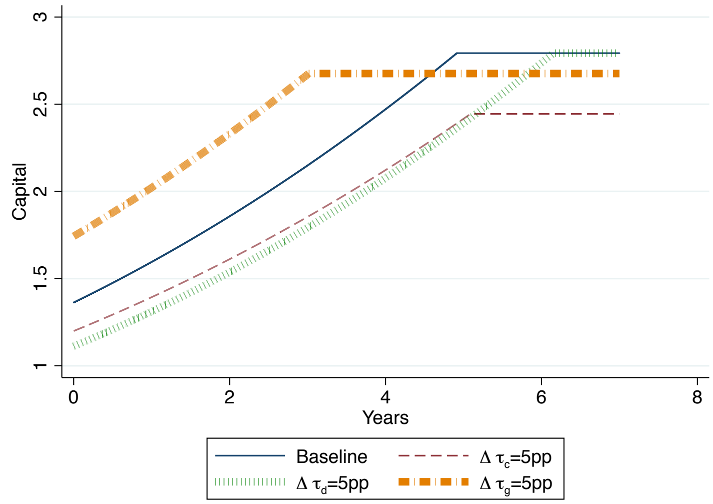
reduces proportionally the market value of firms at entry and at maturity. In addition, for a fixed amount of initial equity, the corporate income tax makes it harder for firms to accumulate retained earnings, retarding the age at which firms reach maturity. This additional effect implies that corporate income taxation affects more negatively the market value of firms at entry than at maturity. The asymmetric effect on market valuations at entry and at maturity implies that the corporate income tax discourages entry, an effect that will play an important role in the tax reform that we analyze in the next section of the paper.

Quantitative illustration We parameterize the simple model in order to illustrate the discussion on how various forms of taxing capital income affect the life cycle of firms.[5] We simulate in partial equilibrium (e.g. fixed wage rate) the life cycle of a firm in three different scenarios: under the baseline parametrization, and after an increase of 5 percentage points of each of the tax rates, maintaining everything else constant. Figure 1 plots the life cycle profile of capital for the four cases considered. Consistent with our discussion above, we find that firms start their life cycle with a lower amount of capital when they are subject to dividend or corporate income taxation. The initial level of capital is slightly below under dividend taxation than corporate income taxation. While the level of capital at maturity is not affected by dividend taxation, it is negatively affected by corporate income taxation. This is the key factor explaining why it takes the firm about one more year to reach maturity under dividend taxation, despite the fact that the firm is able to accumulate capital faster under dividend taxation than corporate income taxation. The latter explains why the age profile of capital in the figure is steeper under dividend taxation than corporate taxation.

It is interesting to compare the effects of dividend taxation with those of capital gains taxation. While dividend taxation does not distort capital accumulation of mature firms, it has a large negative impact on the initial amount of equity at entry. In this way the firm finance a larger portion of its investment over the life cycle with internal funds, diminishing the present value of taxes paid on dividends. Capital gains taxes do precisely the opposite. They encourage firms to finance a bigger fraction of their investment with external equity, diminishing firm growth over the life cycle, and the present value of taxes paid on capital gains. In terms of capital accumulation, the tradeoff is between distorting investments prior to becoming mature (dividend taxation) versus distorting the optimal scale at maturity (capital gains taxation). The corporate income tax distorts investments all over the life cycle.

[5] We set the following parameters for the production function $\alpha = 0.3 \times 0.85, \eta = 0.7 \times 0.85$. The depreciation of capital is fixed as $\delta = 0.05$ and the rate of time preference is set so that the steady state interest rate is 4% ($r = 0.04$). The equity issuance cost is set to 0.10. The wage rate is fixed at 1. Taxes in baseline are $\tau_c = 0.34$, $\tau_d = 0.15$, $\tau_g = 0.15$ and $\tau_r = 0.25$

Figure 1: Life Cycle of Firm



Life cycle of three identical firms in equilibriums with different taxes. Blue is the baseline: $\tau_c = 0.34$, $\tau_d = 0.15$, $\tau_g = 0.15$ and $\tau_r = 0.25$. Changes after an increase of 5pp of each of the tax rates, maintaining everything else constant.

General equilibrium Changes in the taxation of capital income also have general equilibrium effects that involve changes in the mass of entry of firms and the wage rate. Consider the effects of corporate income taxes on entry. Since corporate income taxation makes it hard for firms to retain earnings, it makes the impact of financial frictions on new firms more severe that the one of dividend taxation. As a result, a switch from corporate income to dividend taxation increases the value of the firm at entry more than the ones of mature (or incumbent) firms. In general equilibrium, the free entry condition implies that the wage should increase, leading incumbent firms to hire less workers. Equilibrium in the labor market then requires an increase in the number of firms that is attained through higher entry of firms. This mechanism points that, in general equilibrium, the corporate income tax acts as a barrier to entry . We will quantitatively analyze these effects in the next section of the paper.

3 The Stochastic Model Economy

We extend the simple model as follows. Time is still continuous[6]. Following the standard theory of investment, we introduce adjustment costs in capital and uncertainty in productivity.

[6] Achdou et al. (2017) advocate the use of continuous time models for analyzing heterogeneous agent models. We extend their methods to a model of firm dynamics with financial frictions.

Physical capital evolves according to

$$\dot{k} = x - \delta k.$$

and the resource cost of investing x is given by $x + \Psi \frac{x^2}{2k}$, where the second term reflects the presence of adjustment costs in capital.

The productivity z of a firm follows a geometric Brownian Motion

$$dz = \mu z dt + \sigma z dW, \tag{25}$$

where μ determines the drift and dW is a Wiener process. Since productivity follows a geometric Brownian motion, large firms in our model follow Gibrat's Law and growth rates are independent of firm size. Empirical research, such as Hall (1987), suggests that Gibrat's law is a good approximation for firms that are not too small (see also Gabaix (2009)). Similar specification of the productivity shocks has been widely used in the literature on firm dynamics (see Atkeson and Kehoe (2005), Luttmer (2007), Da-Rocha et al. (2017), among many others). Nonetheless, in Appendix C of the paper we consider the robustness of our results to an alternative specification in which productivity follows an autoregressive process.

The flow of a firm at time t in state (k, z) with investing expenditures x is given by

$$d - e(1-\xi) = (1-\tau_c)\pi(k,z) - x - \Psi_k \frac{x^2}{2k}, \tag{26}$$

where

$$\pi(k,z) = \max_n \{y(k,n,z) - wn\}.$$

The firm in state (k, z) solves the following optimal control problem:

$$v(k,z) = \max E_0 \int_0^\infty \left\{ \frac{1-\tau_d}{1-\tau_g} d - e \right\} e^{-(m+\delta_d)t} dt \tag{27}$$

subject to:

$$dz = \mu z dt + \sigma z dW \tag{28}$$

$$\dot{k} = x - \delta k \tag{29}$$

$$d - e(1-\xi) = (1-\tau_c)\pi(k,z) - x - \Psi_k \frac{x^2}{2k} + \tau_c \delta k. \tag{30}$$

where $m + \delta_d$ is the rate at which the firm discount future payments to/from shareholders when acting in their interest (see Appendix A).

Then, the Hamiltonian-Jacobi-Bellman equation of a firm satisfies:

$$(m+\delta_d)v(k,z) = \max \frac{1-\tau_d}{1-\tau_g}d - e + \partial_k v(k,z)\dot{k} + \mu_z z \partial_z v(k,z) + \frac{(z\sigma)^2}{2}\partial_{zz}v(k,z). \tag{31}$$

We assume that upon entry firms draw the initial productivity z_0 from a Pareto distribution:

$$g_e(z_0) = \begin{cases} \epsilon \frac{1}{z_0^{\epsilon+1}} \text{ if } z_0 > 1 \\ 0 \text{ otherwise.} \end{cases} \tag{32}$$

The initial amount of equity raised by a firm that draws z solves the following problem:

$$\hat{k}_0(z_0) = \arg\max_{k_0}\{v(k_0, z_0) - \frac{1}{(1-\xi)}k_0\} \tag{33}$$

Then, the value of entry for a firm that draws z can be expressed as

$$v^e(z_0) = v(\hat{k}_0(z_0), z_0) - \frac{1}{(1-\xi}\hat{k}_0 \tag{34}$$

In equilibrium the free entry condition requires

$$V^e \equiv \int_1^\infty v^e(z_0)g^e(z_0)dz_0 = \int_1^\infty v^e(z_0)\epsilon\frac{1}{z_0^{\epsilon+1}} \leq c_e, \tag{35}$$

with strict equality if there is positive entry.

The distribution of firms depends on firms investment and entry decisions. The measure g of firms in state (k,z) satisfies:

$$0 = -\partial_k\left(s(k,z)g(k,z)\right) - \partial_z\left(\mu_z z g(k,z)\right) + \frac{\sigma_z^2}{2}\partial_{zz}g(k,z) - \delta_d g(k,z) + M g_e(z) I_{k=k_0(z)}, \tag{36}$$

where $s = \dot{k} = x - \delta k$ and M denotes the mass of firms entering the economy.

We assume that there is a representative household that owns the market portfolio of firms. Households supply labor to firms, receive dividends, buy/sell shares of firms, and trade bonds. Since households do not face uncertainty on their savings, in equilibrium there is a no arbitrage condition (see Appendix A for its derivation) that equates the after-tax return in bonds to the expected after-tax return in each firm.

The representative household maximizes discounted lifetime utility subject to the intertemporal budget constraint

$$\max_{\{c_t\}} \int_0^\infty e^{-\rho t} u(c_t) dt \tag{37}$$

subject to: (38)

$$\int_0^\infty e^{-r(1-\tau_r)t}(c - w - T) = a_0, \tag{39}$$

$$a_0 = \int v(k,z) g(k,z) dkdz \tag{40}$$

where a_0 is the period-0 market value of all firms. In steady state equilibrium, $r_t(1-\tau_r) = \rho$ and $c_t = c \; \forall t$. Note that given that firms can't borrow, the assumption of a representative consumer implies that bonds are in zero net supply $b_0 = 0$ and households make zero interest income.

Definition of steady state equilibrium Given a fiscal policy $(\tau_r, \tau_c, \tau_g, T)$, a steady state equilibrium is given by value functions for incumbent firms $(v(k,z))$, value of entry V^e, prices (w, r), firms policy functions on employment (n), investment in physical (x) and financial policies (d,e) , initial equity k_0, mass of entry M, measure of firms $g(k,z)$, consumption c and initial household assets a_0 such that:

1. Given prices, the value function $v(k,z)$ satisfy the HJB equation of the firm and firm decisions (n, x, d, e) are optimal.

2. V^e satisfy the free entry condition (35).

3. The government budget constraint is satisfied (all tax revenue is rebated back to consumers as a lump sum transfer).

4. Household maximize utility taking as given government transfer, prices, and initial wealth, which implies that steady state consumption is equal to permanent income: $c = \rho a_0 + w + T$

5. Labor, bonds, and goods market clear

$$\int n(k,z) g(k,z) dkdz = 1$$

$$c + c_e M + \int \left[x + \psi \frac{x^2}{k} \right] g(k,z) dkdz = \int z^{1-\alpha-\gamma} k^\alpha n^\gamma g(k,z) dkdz \tag{41}$$

3.1 Firms' Policies and its Life Cycle

The financial and investment policy of firms can be characterized using the FOC from the HJB. The Lagrangean associated to the maximization problem in the HJB equation can be written as:

$$\mathcal{L} = \frac{1-\tau_d}{1-\tau_g}d - e + \partial_k v(k,z)(x-\delta k) + \partial_z v(k,z)\mu z + \frac{(z\sigma)^2}{2}\partial_{zz}v(k,z) + \lambda_d d + \lambda_e e + ...$$
$$\lambda_k \left\{(1-\tau_c)\pi(k,z) - x - \Psi\frac{x^2}{2k} - d + (1-\xi)e\right\},$$

where λ_k represents the shadow price of capital (Tobin's marginal q), λ_d and λ_e are the multipliers on the non-negativity condition on dividends and equity issuance. The optimal decisions on dividend distribution, equity issuance and investment should satisfy the following conditions:

$$d : \frac{1-\tau_d}{1-\tau_g} + \lambda_d - \lambda_k = 0 \tag{42}$$

$$e : -1 + \lambda_e - \lambda_k(1-\xi) = 0 \tag{43}$$

$$x : \partial_k v(k,z) - \lambda_k\left[1 + \Psi\frac{x}{k}\right] = 0 \tag{44}$$

$$KT : \lambda_d d = 0, \lambda_e e = 0, \lambda_d, \lambda_e, d, e \geq 0, \tag{45}$$

where (45) are the complementarity slackness conditions from Kuhn-Tucker.

The shadow price of capital (λ_k) determines the financial policy of the firm. It is easy to see that λ_k is bounded above by the cost of raising external funds ($\frac{1}{1-\xi}$) and bounded below by the after tax dividends received by the shareholder. In the former case the firm issues equity and in the latter case it distributes dividends. Tax policy (e.g. when $\tau_d \neq \tau_g$) and financial frictions create a wedge between these two bounds leading to an inaction region. Indeed, when the shadow value of capital is in between these two bounds the firm does not distribute dividends nor does it issue equity. In this case, the firm finances all of its investment with retained earnings and all earnings are used to finance investment. Optimal investment satisfy:

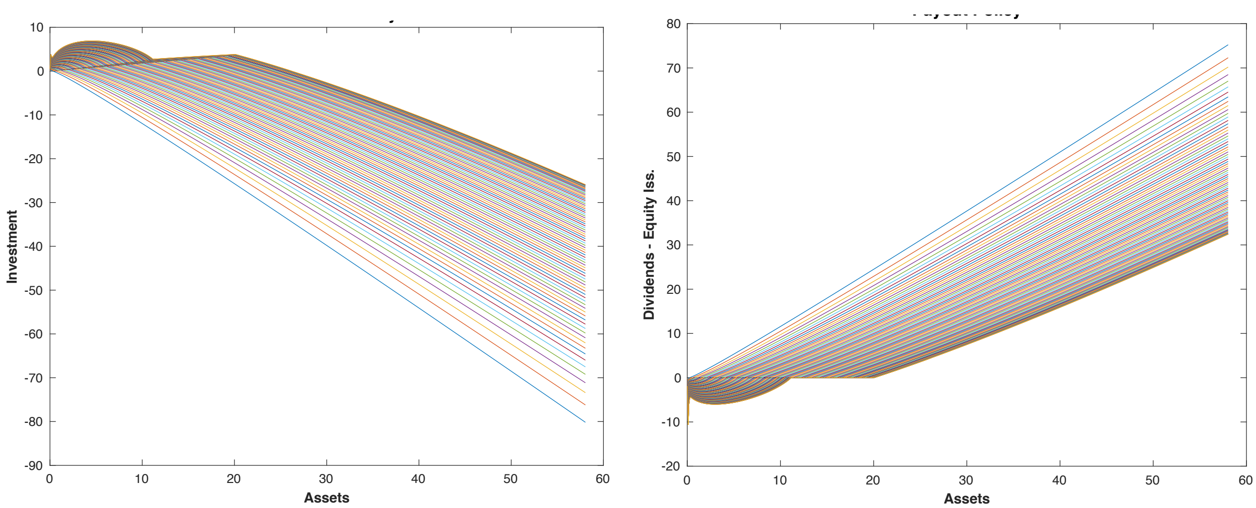
$$x = \left[\frac{\partial_k v(k,z)}{\lambda_k} - 1\right]\frac{k}{\Psi} \quad \text{where} \quad \lambda_k \in \left[\frac{1-\tau_d}{1-\tau_g}, \frac{1}{1-\xi}\right] \tag{46}$$

As in modern q theory, investment is an increasing function of the marginal value of installed capital. Financial frictions imply that investment is also affected by the shadow price of capital (λ_k). The rate of investment or disinvestment depends on the ratio between the marginal value of capital and the shadow cost of funds. If this ratio is above 1, investment rate is positive. If its below 1, the firm disinvests. For a fixed, marginal value of installed capital,the concavity of the value function implies that investment is a decreasing function of the shadow price of capital λ_k. The shadow cost of funds depends on the financial regime of the firm. When equity issuance is the marginal source of funds, $\lambda_k = \frac{1}{1-\xi}$. When the firm distributes dividends, $\lambda_k = \frac{1-\tau_d}{1-\tau_g}$ and the firm is indifferent between using the last unit of earnings to finance dividend distribution or investment. When $\lambda_k \in \left(\frac{1-\tau_d}{1-\tau_g}, \frac{1}{1-\xi}\right)$ firms do not issue equity nor distribute dividends. In this case, all available funds are used to finance investment.

Figure 2: Policy functions for different Z

A: Investment

B: Net Payout (Dividends-Equity)



Investment and payout policy (y-axis) by level of assets (x-axis) for different levels of productivity. Each parallel line corresponds to a level of productivity.

Figure 2 plots the investment and financial policy as a function of the capital installed by firms in our calibrated model economy. Each line in the figures correspond to a firm with different a level of productivity. It is instructive to consider the life cycle of a firm that enters the economy with a fixed productivity level z . If the initial level of installed capital is low enough, optimal investment is an inverted U-shaped function of capital (see Panel A). An increase in installed capital has two opposite effects on optimal investment (see equation (46)). On the one hand, the marginal value of capital to the firm decreases ($\partial_k v(k, z) \downarrow$), thereby pushing investment down. On the other hand, the presence of adjustment costs imply that the cost of investment decreases with the level of installed capital. This effect explains why the optimal level of investment initially rises with capital (as reflected by the positive effect that the term k outside the straight bracket in (46) has on x). The first force dominates at low levels of capital and the second force at high levels of capital, explaining the inverted U-shaped of investment as a function of capital. Note that a (young) firm with low level of capital finance investment by issuing equity (see Panel B). As capital increases, the firm makes more profits and can finance a bigger fraction of investment with retained earnings. The firm fully finance investment with retained earnings when installed capital becomes sufficiently large, thereby avoiding external financing costs. Once firms finance all investment with internal funds, the investment policy becomes an increasing function of installed capital (and earnings) until the firm reaches its optimal level of capital. This occurs when the level of capital is such that the shadow price of capital equates the after-tax value of dividend distribution to the shareholders. At this point, the firms starts distributing dividends. Higher values of installed capital then lead to higher dividend distribution and to lower investment. When installed capital is large enough, investment becomes negative as the firm finds it optimally to disinvest in order to finance dividend distribution.

In the presence of uncertainty, shocks to firms productivity may change their financial and investment policies. A firm that is increasing its capital and issuing equity, may stop doing so if productivity decreases. When productivity decreases by a large amount, the firm may even start distributing dividends and disinvesting. Conversely, an increase in productivity may move back the firm to the equity issuance and investment regime.

3.2 Quantitative Analysis

3.2.1 Calibration

The calibration targets aggregate and firm level data from the US economy. In principle, our goal is to target all US businesses that pay corporate income taxes. The calibration requires targeting "dynamic moments" from US firms, such as average firm growth, volatility and autocorrelation of investment rates over time. We follow Gourio and Miao (2010) in using Compustat data to pin down these calibration targets. Nonetheless, we should keep in mind that the Compustat data covers publicly traded firms that only represent a small subset of US corporations. We thus also target cross-sectional data on the size distribution of businesses from US Census Bureau. Now, the universe of US businesses include private pass-through businesses that are not subject to the US corporate income tax (S corporations, partnerships).[7] Since most of these businesses tend to be small, as a compromise we target data on the size distribution of businesses that includes businesses with more than 50 employees. We divide the set of parameters to be calibrated in two groups.

Parameters assigned without solving the model. We use data from the Internal Revenue Service for the year 2015 to set the tax parameters. We set the corporate income tax

[7] Developing a theory of organizational choice (pass through entities versus C corporations) is outside the scope of the current paper. See Dyrda and Pugsley (2018) for a theory of organizational choice.

rate to 34% ($\tau_c = 0.34$)[8] We set the capital gains tax rate to 0.15 ($\tau_g = 0.15$), the dividend tax rate to 0.15 ($\tau_d = 0.15$), and the interest income tax rate to 0.25 ($\tau_r = 0.25$) to the marginal Federal taxes faced by a married couple with the average household income in the US. We assume that households discount future utility at an annual rate of 0.0375 ($\rho = 0.0375$) so that the (before tax) steady state return on capital is 5%, consistent with the estimates of the return on capital by Cooley and Prescott (1995). The parameters on the production function are set to standard values in the literature: the profit share is set to 0.15, with 70% of the remaining share going to labor and 30% to capital ($\alpha = 0.85 * 0.3, \eta = 0.85 * 0.7$), as in Midrigan and Xu (2014). The depreciation rate of capital is set at 0.05 per year ($\delta_k = 0.05$). Based on data from US Census Bureau's Business Dynamic Statistics (BDS), the average annual exit rate of firms with more than 50 employees is 4.6% so we set $\delta_d = 0.046$. Using data from Thomson Reuter's Securities Data Company (SDC) Platinum, we find that during the period 1995-2015 the total costs of equity issuance as a percentage of proceeds is about 7%[9]. This is computed following closely the procedure of Lee et al. (1996) for IPO firms. It is somewhat smaller than the ones reported by Hennessy and Whited (2007), who estimated equity issuance cost in the range of 8.3% to 10.1%. We thus set the cost of raising external fund to 0.07 ($\xi = 0.07$). Nonetheless, we assume that firms raising their initial capital at entry face a higher equity issuance cost ξ_e. This parameter will be determined later by simulating the model economy. As we shall see our calibration requires that $\xi_e > 0.07$ in order to match the equity issuance by incumbent firms.

Parameters assigned by solving the model. It remains to assign the parameters driving the stochastic process on productivity (μ_z, σ_z), the parameter Ψ driving adjustments costs, the productivity distribution of firms that enter the economy and their cost of raising external capital. We assume that firms that enter draw the initial productivity from a Pareto distribution with tail parameter η_p and a location parameter 1 (the lowest possible productivity is one). We normalize the wage rate to 1 and set the fixed cost of entry equal to the value of entry.

Targeted moments. Although the endogenous equilibrium outcomes of interest will be jointly determined by all of these parameters, each of these parameters is intuitively connected with a particular moment of interest. The parameter μ_z will be closely connected with firm growth and σ_z with the variance of investment. The parameter Ψ is closely related to the correlation of investment rates across two consecutive years and the parameter determining the Pareto tail with the size distribution of businesses. Finally, the cost of raising initial equity is closely connected to the amount of external finance by incumbent firms. With

[8]The progressive rate structure of the Federal corporate tax in the US is designed such that it produces a flat 34% tax rate on incomes from \$335,000 to \$10,000,000, gradually increasing to a flat rate of 35% on incomes above.

[9]See Appendix B.2 for more details on the data and computation.

these connection in mind we target the following statistics:

1. An average annual employment growth of 2.1%.
2. The volatility of the investment rate (x/k) among firms of 0.059.
3. The autocorrelation of investment rates between two consecutive years of 0.57.
4. The ratio of equity issuance by incumbent firms to investment of 12.6%.
5. The size distribution of businesses, computed using data from BDS and reported in Table 2.

The first 4 targets were computed using Compustat data from over the period 1995-2015.[10] For the reasons previously discussed, in computing the size distribution of businesses we abstracted from small businesses in the BDS and focused on businesses with more that 50 employees. Tables 1 and 2 show the parameter values and the calibration results.

Table 1: Calibration Baseline Economy

Parameter	Description	Value
ψ	Capital adjustment cost	0.09
μ	Productivity drift	-0.00325
σ	Volatility of prod. shock	0.15
ξ_e	Financing cost at entry	0.30
η_p	Distribution of businesses	1

Parameter values and discussion. The model accounts well for the targeted moments. We now discuss how some key parameters help attaining the calibration targets. The baseline economy matches the average employment growth of 2.1 percent in the data. Recall that productivity in our model economy follows a geometric Brownian Motion with a drift given by $\mu = \mu_z + \frac{\sigma_z^2}{2}$[11]. Hence, the variance of shocks is a force driving firm growth.[12] We find that the model economy accounts for the 2.1% in average employment growth with $\mu_z = -0.00325$. To measure the volatility of the investment rate and its autocorrelation over time in our baseline economy, we first solve the model to compute the stationary distribution of firms. Then, we draw firms from this distribution and simulate them over the year to compute annual investment rates. The annual volatility of the investment rate in

[10]See Appendix B.1 for more information about the data and variable construction.

[11]This follows from Ito's lemma, and the specification of the process of productivity growth in our model, i.e. $dlnz = \mu_z dt + \sigma_z dW$

[12] Moreover, the distribution of productivity at entry is such that most businesses in our baseline economy start their life with a low productivity level, not far from the minimum value of 1 which represents a low barrier on z.

Table 2: Calibration Results

	Data	Model
Target		
Avg. employment growth	0.02	0.02
Volatility investment rate	0.059	0.054
Autocorrelation invest. rate	0.57	0.59
Eq. issuance incumbents/investment	0.13	0.13
Size Distribution of Businesses		
No. of Employees	Fraction Data	Fraction Model
$[50, 99)$	0.53	0.50
$[100, 249)$	0.29	0.22
$[250, 499)$	0.089	0.13
$[500, 999)$	0.0429	0.07
$[1000, 2499)$	0.0265	0.047
$[2500, 4999)$	0.0099	0.018
$[5000, \infty)$	0.0115	0.0057

Targeted moments in the data, and their respective counterpart in the model. Data comes from Compustat, and BDS for the size distribution of businesses.

the baseline economy is 0.054, which is close to the value of 0.059 in the data. Matching this target requires a significant variance in productivity since $\sigma_z = 0.15$[13]. The parameter $\psi = 0.07$ is set to match the autocorrelation of annual investment rates over two years across the stationary distribution of firms. This parameter is between the 0.049 estimated by Cooper and Haltiwanger (2006) and the 1.08 value obtained by Gourio and Miao (2010). The size distribution of businesses in the baseline economy is determined by the distribution of businesses at entry and by the stochastic growth in productivity over the life cycle of firms. The model accounts reasonably well for the size distribution of businesses, although the match is not perfect. The model implies that 50 percent of business have less than 100 workers, and 22 percent of businesses employed between 100 workers and 250 workers. The corresponding fractions in the data are 53 precent and 29 percent. The fraction of businesses with more than 5000 employees are about 0.6 percent in the model economy and 1% in the data[14].

A crucial parameter in our model economy is given by the cost of external financing. As in Korinek and Stiglitz (2009), financial frictions matter for the different financial regimes

[13]Nonetheless, recall that z in the production function is raised to the power of 0.15 so that the variance of TFP is much smaller than the one in z. For instance, Gourio and Miao (2010) estimate a variance in TFP of 0.2, though in their model TFP follows an autoregressive process with persistence of about 0.8

[14]In the data, most large firms are multi-establishment, a fact that our model cannot account for. This is the main reason our model underpredicts mass in largest size category.

that firms go over their life cycle[15]. In particular, we want our model economy to be consistent with data on firm growth, investment rates, and the fraction of investment financed raising capital on the equity market. Recall, that the cost of external finance was set exogenously at 7 percent using data from SDC Platinum. The model economy matches the 13 percent target for the fraction of investment financed by equity issuance among incumbent firms. To match this statistic the model requires that firms that entry face substantial financial frictions. The baseline economy assumes that when firms enter the economy face equity issuance costs of 0.30. Lower values of equity issuance costs at entry, will imply that firms will raise a substantial amount of equity when they enter in order to invest a large amount and avoid on expected adjustments costs in capital as they grow (in expectations) over their life cycle. While we do not have data on the cost of raising external funds when firms are created, we find that the cost of raising external funds in initial public offerings in the SDC data is about 12%. Presumably, the cost of raising external funds when businesses are actually created should be much larger. Moreover, our model assumes that firms learn their productivity before making the initial investment in capital. Firms in our model would invest less when they enter if they face some uncertainty on their initial productivity and learn it over time. Hence, our calibrated equity issuance cost at entry may be capturing the effects of information frictions that our model abstracts from.

Other non-targeted moments. The aggregate investment rate (x/k) in the model economy is 0.096 somewhat above the 0.086 value from the National Income Accounts. The model economy overstates the ratio of aggregate dividends to aggregate earnings in Compustat (0.45 versus 0.098). This also happens in the model by Gourio and Miao (2010). Perhaps, this should not be surprising since both model economies abstract from share repurchases which is another way of dividend distribution. The model does a decent job in matching the ratio of aggregate equity issuance to aggregate investment in the data (0.15 versus 0.19). Moreover, the share of equity issuance by entrants relative to aggregate investment is 0.037 in the data and 0.067 in the model.[16]

In Figure 3, we plot age profile of employment growth by firms [17] in the model and the data. Although being an untargeted moment, the model captures quite well the sharp decline in employment growth as firms age. In our model economy young firms are small

[15] Gourio and Miao (2010)'s model abstracts from financial frictions and life cycle. Firms in their model go through different financial regimes because of the differential tax treatment on dividends and capital gains during the year 2003.

[16] To measure the share of equity issuance by new entrants and by incumbents in Compustat, we sum up the equity issuance of all firms that report doing an IPO in that same year on one side, and the rest of the firms operating in that year on the other, and divide both by the sum of investment in capital expenditures of all firms.

[17] Unfortunately, age is not a variable available in Compustat, so we construct a proxy with the available data, and define age as years since their IPO.

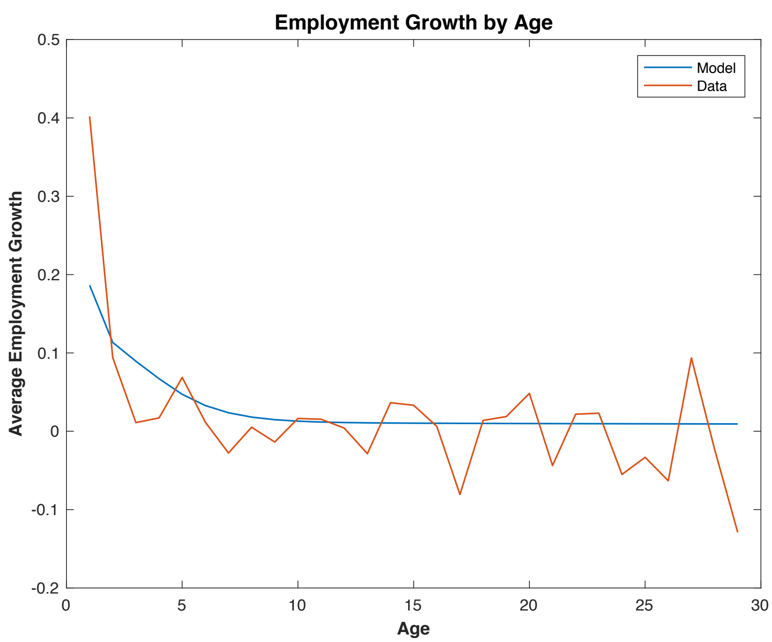
Table 3: Non-targeted Moments

Variable	Data	Model
Investment rate	0.086	0.096
Dividends/Earnings	0.098	0.45
Agg. eq. issuance/ agg. investment	0.15	0.19
Eq issuance entrants/agg. investment	0.037	0.067

Non-targeted moments in the data, and their respective counterpart in the model. Data moments from Compustat.

and constrained, so they grow fast at the beginning. As they age and accumulate internal funds, they are likely to become less constrained and progressively reach their optimal size. As a result, the age-profile of employment growth of firm is expected to decrease with age. The fact that the baseline economy matches reasonably well the decline in the growth rate of employment with age suggests that the model is not exaggerating the impact of financial frictions on firm growth.

Figure 3: Employment growth by age in the model and the data.



Average employment growth by age. Data from Compustat, where age is computed in the as years since IPO (see Appendix B.1).

3.3 Aggregate effects of reforming the taxation of capital income.

We now consider the long run effects of a tax reform that eliminates the taxation of corporate income while keeping constant the tax revenue collected on capital income. This is done by finding the common tax rate ($\bar{\tau}$) on all forms of capital income (dividends τ_d, interest income τ_r, and capital gains τ_g) that collects the same tax revenue as in the baseline economy. The purpose of the proposed policy reform is twofold. Firstly, by equating the three tax rates we would be treating symmetrically all capital income from the household perspective. Secondly, by eliminating the corporate tax, we allow financially constrained firms to accumulate profits and to reach maturity (the dividend distribution stage) faster (in expectations).

We emphasize that the key insights from our simple model apply to the current stochastic model. Financial frictions imply that firms start their life constrained. For fixed productivity, firms build internal equity over time, becoming less constrained and eventually will start distributing dividends. Stochastic shocks imply that firms distributing dividends might become liquidity constrained again if their productivity grows sufficiently over time, so that the "life cycle process" is initiated again. By reducing the corporate tax and increasing the dividend tax, our proposed tax reforms intends to shift the tax burden from liquidity constrained firms (with high marginal valuation of capital) to firms distributing dividends (with low marginal valuation of capital). However, the effects of the reform are more involved than it seems at first sight. This is because firms react to the higher dividend taxes by diminishing initial equity, rising the likelihood that firms become liquidity constrained, and (partly) reversing the gains pursued with the elimination of corporate income taxation (see Section 2.4).[18] To minimize these effects, our proposed tax reform involves raising capital gains taxes *together* with dividend taxes. The rise in capital gains taxes encourages firms to issue more equity in order to minimize taxes paid on capital gains, (partly) undoing the distortions of dividend taxation on initial equity decisions (see discussion in Section 2.4).

To check for potential non-linearities in our results, we also consider a tax reform that reduces the tax rate on corporate income to a half relative to the baseline economy (τ_c is reduced from 0.34 to 0.17), again keeping aggregate revenue from capital income taxation constant. To isolate the role of capital gains taxation from dividend taxation, we consider a tax reform in which the corporate income tax is set at 0.17, but we only increase dividend taxes to clear the government budget, while maintaining the other tax rates equal to their baseline value.

Tax reform 1: Eliminate corporate income taxes

The results are shown on Table 4. We find that the elimination of the corporate income taxes in the baseline economy ($\tau_c = 0.34$) should be accompanied by an increase in capital income taxes to 0.39 to keep government revenue constant (recall that in the baseline economy the dividend and capital gains tax was set to 0.15 and the interest income tax was set to 0.25). This revenue neutral tax reform leads to an increase in aggregate output of 13.6%, which

[18] By financing a larger fraction of investments with internal funds, they reduce the cost of capital.

Table 4: Effects of Tax Reforms

Panel A: Aggregate Effects.

	Output	Capital	TFP	Mass Entry	Wage	Revenue Neutral Tax
1.- $\tau_c = 0$	13.6	35.2	5.2	39.3	13.6	$\tau_d = \tau_g = \tau_r = 0.39$
2.- $\tau_c = 0.17$	8.1	20.1	3.1	22.7	8.1	$\tau_d = \tau_g = \tau_r = 0.28$
3.- $\tau_c = 0.17$	0.34	15.5	-3.3	-17.3	0.34	$\tau_d = 0.41$, $\tau_g = 0.15$, $\tau_r = 0.25$

Panel B: Effects on Initial Size and Firm Value

	Average k_0	Average Value Entrants	Average Value Incumbents	Revenue Neutral Tax
1.- $\tau_c = 0$	5.1	1.1	-1.4	$\tau_d = \tau_g = \tau_r = 0.39$
2.- $\tau_c = 0.17$	1.3	0.3	-1.0	$\tau_d = \tau_g = \tau_r = 0.28$
3.- $\tau_c = 0.17$	-10.2	-2.2	4.8	$\tau_d = 0.41$, $\tau_g = 0.15$, $\tau_r = 0.25$

Percent changes from the baseline. Value of entrants is gross of initial equity payment. In each experiment, we decrease corporate tax, but change other taxes such that the government revenue is constant. First row corresponds to Tax Reform 1 ($\tau_c = 0, \tau_d = \tau_g = \tau_r = 0.39$). Second row corresponds to Tax Reform 2 ($\tau_c = 0.17, \tau_d = \tau_g = \tau_r = 0.28$). The third row corresponds to Tax Reform 3 ($\tau_c = 0.17, \tau_d = 0.41, \tau_g = 0.15, \tau_r = 0.25$).

is accompanied by a large increase in the aggregate capital stock (35.2%), in the number of firms (39.3%), and in aggregate TFP (5.2%). Note that the fact that aggregate capital and output rise less than the number of firms, indicates that both capital per firm and output per firm decrease. The large response of firm entry to the tax reform is crucial for the large increase in aggregate output and aggregate TFP.

It is interesting that the tax reform rises firm entry and wages at the same time. The tax reform benefits constrained firms (firms with low capital relative to productivity), regardless of their absolute level of productivity. Note that in Melitz (2003), the trade reform benefits mostly large firms who are the ones that export due to the presence of fixed costs of exporting. This asymmetric effect leads to a labor reallocation from small to large firms, raising the equilibrium wage rate and *reducing* the number of firms. On the contrary, in our model economy the tax reform affects symmetrically firms with different productivity levels (z) at entry and leads to a large increase in entry.

Crucially for our results, the tax reform increases more the expected value of entry (for all firms) than the value of incumbent firms, which leads to a reallocation of resources from mature to younger firms, and hence to an increase in entry and in the equilibrium wage rate. In understanding this result note that corporate income taxation has asymmetric effects across firms depending on their financial regime. The elimination of corporate income taxation allows financially constrained firms to retain a larger fraction of their earnings and increase their investments. The ability to retain earnings is particularly relevant for young firms, which are more likely to be constrained than the average incumbent firm in the economy. Since the value of entry is determined by the average value of age-0 firms, this observation explains why we find that, keeping fixed the wage of the baseline economy, the value of the average firm entering the economy increases more than that of incumbent firms (67% versus 62%) when corporate income taxation is eliminated. In general equilibrium, the increase in the value of entry requires the wage rate to rise by about 13.6% in order to restore the free entry condition. As a result, the value of entry does not change (it is fixed by the cost of entry) but the value of incumbent firms decreases by 1.4%. The rise in wages reduces labor demand by incumbent firms. Labor market clearing requires a larger mass of firm entry, which rises by about 39.3%. Larger firm entry together with a reallocation of resources to financially constraint firms explain the large increase in aggregate TFP.

In sum, we find that in general equilibrium corporate income taxation raises the market value of incumbent firms relative to entrants, depressing the equilibrium wage rate and business entry, shifting resources from young to mature businesses and reducing aggregate output and TFP.

Tax reform 2: $\tau_c = 0.17$ increasing all other capital income taxes

The corporate income tax rate is set as $\tau_c = 0.17$ while all other capital income taxes are set to 0.28 ($\tau_g = \tau_d = \tau_r = 0.28$). We find that output increases by 8.1% and entry increases by 23% (see Table 4). The results are somewhat more than a half the ones obtained when the corporate income taxation was eliminated (13.6% increase in output and 39% increase in entry). Hence, the effects on output and entry of reducing the taxation of corporate income are non-linear but not too far from linearity.

Tax reform 3: $\tau_c = 0.17$ increasing only dividend tax

The corporate income tax rate is set as $\tau_c = 0.17$, and we increase $\tau_d = 0.41$ so that the reform is revenue neutral. Capital gains tax and income tax are kept fixed at their value in the baseline economy. The results in Table 4 show that the output gain diminishes dramatically relatively to the previous reform (0.34% versus 8.7%). Hence, the output gains of equating the tax rates on capital gains and dividends are substantial. Why is this the case? When τ_g is substantially below τ_d, firms have strong incentives to accumulate capital internally (see discussion in Section 2.4). As a result, firms enter the economy with a small size. The average initial equity is reduced by 10% relative to the baseline economy (while in tax reform 2 is slightly higher than in the baseline economy). Firms take more time to grow which reduces the value of entrants. As a result, relative to the baseline economy entry is reduced by 17.3%. The fact that aggregate capital rises by 15.5% while the number of firm decreases implies that the average firm is much bigger than in the baseline economy. In sum, higher dividend taxes act as a financial frictions that hurt entry and make incumbents firms much larger.

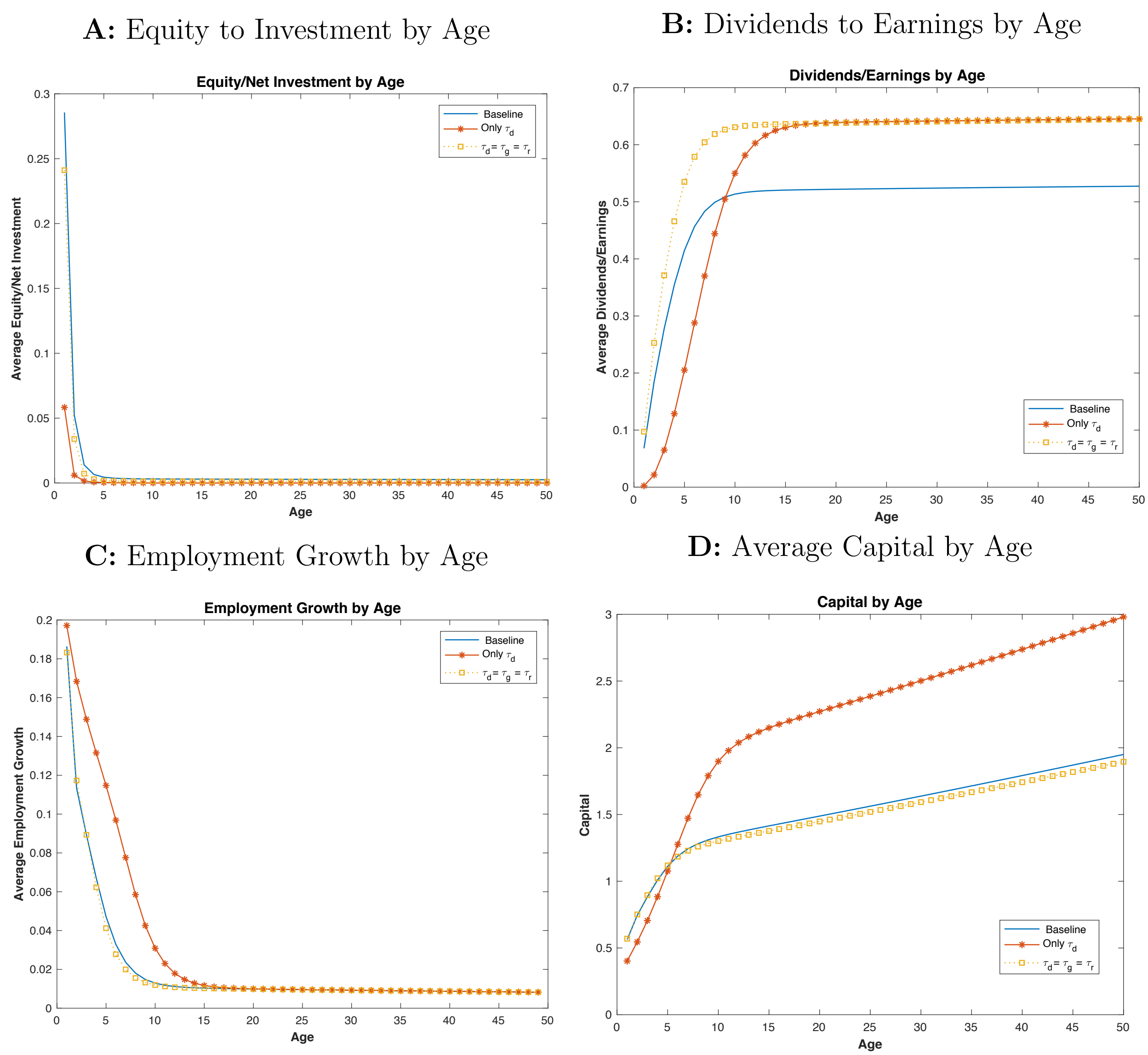
3.3.1 Taxation and the life cycle of firms

It is interesting to compare the average life cycle behavior of firms across the model economies. Panel A of Figure 4 shows the average equity to investment ratio for the baseline economy and the economies with the Tax Reforms 2 and 3. When the capital gains tax is smaller than the dividend tax (Tax Reform 3), firms are much more reluctant to finance investment with equity issuance. Moreover, as shown in Panel B of the same Figure, firms distribute much less dividends when young in Tax Reform 3 because they are (slowly) building internal equity. Nonetheless, when firms mature there are no differences in the dividends to earnings ratio under the Tax Reforms 2 and 3. Mature firms in the baseline economy distribute a lower fraction of their earnings because they are paying higher corporate taxes than in the other two economies. Panel C of Figure 4 shows that the mean employment growth rate of firms is much higher under Tax Reform 3. Again, when capital gains taxes are lower than dividend taxes, firms start small and grow fast by retarding dividend payments and accumulating internal equity. Since firms discount future payouts at a low rate when capital gains taxes are low, they have a strong incentive to grow over their life cycle. Even though the average firm size at entry is the smallest under Tax Reform 3, the average size late in the life cycle is the largest across all economies. The large dispersion in business size over the life cycle and the low entry under Tax Reform 3 explain why this economy features the lowest TFP among all the economies considered.

4 Conclusions

In this paper, we use a model of firm dynamics with endogenous entry to analyze the impact of different forms of taxing capital income on investment over the life cycle of firms and on firm entry. We use the calibrated model economy to quantitatively assess the effects of a reform that eliminates the taxation of corporate income while keeping constant the tax revenue collected on capital. This is done by finding the common tax rate ($\bar{\tau}$) on all forms of capital income (dividends τ_d, interest income τ_r, and capital gains τ_g) that collects the same tax revenue as in the baseline economy. The purpose of the proposed policy reform is twofold. Firstly, by equating the three tax rates we would be treating symmetrically all forms of capital income from the household perspective. Secondly, by eliminating the corporate

Figure 4: Life Cycle of Firms



Average age profiles for equity to investment, dividends to earnings, employment growth and capital. Blue solid line (Baseline) corresponds to the baseline calibration. Dotted yellow line ($\tau_d = \tau_g = \tau_r$) corresponds to Tax Reform 2, i.e. $\tau_c = 0.17$, and $\tau_d = \tau_g = \tau_r = 0.28$ to keep the governement budget constraint balanced. Starred orange line (Only τ_d) corresponds to Tax Reform 3, i.e. $\tau_c = 0.17$, and $\tau_d = 0.41$ to keep the governement budget constraint balanced, while the other taxes are set to their baseline values ($\tau_g = 0.15$, $\tau_r = 0.25$).

tax, we allow financially constrained firms to accumulate profits and to reach maturity (the dividend distribution stage) faster. We find that the this revenue neutral tax reform leads to an increase in aggregate output of 13.6%, which is accompanied by a large increase in the aggregate capital stock (35%) and in the number of firms (39.3%). Note that the fact that aggregate capital and output rise less than the number of firms indicates that the average size of the firm is smaller after the tax reform. Hence, the large response of firm entry to the tax reform drives the large increase in aggregate output and capital.

At the heart of our results is that the tax reform increases more the expected value of entry than the value of incumbent firms, leading to a reallocation of resources from mature to younger firms that operates through an increase in entry and in the equilibrium wage rate. The elimination of corporate income taxation allows financially constrained firms to retain a larger fraction of their earnings and increase their investments. The ability to retain earnings is particularly relevant for young firms, which are more likely to be constrained than the average incumbent firm in the economy. Since the value of entry is determined by the average value of age-0 firms, we find that the value of the average firm entering the economy increases more than that of incumbent firms when corporate inome taxation is eliminated. In general equilibrium, the increase in the value of entry requires the wage rate to rise, which reduces labor demand by incumbent firms. Labor market clearing requires a larger mass of firm entry. Larger firm entry together with a reallocation of resources to financially constraint firms lead to an increase in aggregate TFP of 5.2%.

Our paper abstracts from many effects of corporate income taxation. In particular, the corporate income is likely to affect the organizational form of firms, the incentives of firms to borrow and to invest in intangibles capital. While these issues are out of the scope of the current paper, they are important for having a complete assessment of the impact of corporate income taxation.

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Appendix

Appendix A. Asset Pricing

We derive some useful results on asset prices by considering a discrete time version of the model with $\delta_d = 0$[19]. Consider a small time interval Δ. In equilibrium the following no arbitrage condition must hold:

$$\Delta R_t = \frac{1}{P_t} E_t \left[(1-\tau_d) d_{t+\Delta}\Delta + (1-\tau_g)(P_{t+\Delta} - e_{t+\Delta}\frac{1}{(1-\xi)}\Delta - P_t) \right], \tag{47}$$

where $R = r(1-\tau_r)$ denote the returns on bonds.

Dividing by Δ in both sides yields:

$$R_t = \frac{1}{P_t} E_t \left[(1-\tau_d) d_{t+\Delta} - (1-\tau_g) e_{t+\Delta} + (1-\tau_g)\frac{P_{t+\Delta} - P_t}{\Delta} \right] \tag{48}$$

Taking the limit as $\Delta \to 0$, yields expression (1) in the text.

To obtain the HJB equation satisfied by the firm value function, use (47) to solve for P_t:

$$P_t = \frac{E_t \left\{ \left[\frac{1-\tau_d}{1-\tau_g} d_{t+\Delta} - e_{t+\Delta} \right] \Delta + P_{t+\Delta} \right\}}{1 + \frac{\Delta R_t}{1-\tau_g}} \tag{49}$$

Define the cum-dividend value of equity net of taxation on dividends and capital gains as: (for every t):

$$V_t = \left[\frac{1-\tau_d}{1-\tau_g} d_t - e_t \right] \Delta + P_t \tag{50}$$

Combining (50) and (49) yields:

$$V_t = \left[\frac{1-\tau_d}{1-\tau_g} d_t - e_t \right] \Delta + E_t \left(\frac{V_{t+\Delta}}{1 + \frac{\Delta R_t}{1-\tau_g}} \right). \tag{51}$$

The date-0 value of the firm is obtained as follows:

$$V_0 = E_0 \sum_{t=0}^{\infty} \left[\frac{1-\tau_d}{1-\tau_g} d_t - e_t \right] \Delta \frac{1}{\Pi_{j=0}^{t} \left(1 + \frac{\Delta R_j}{1-\tau_g} \right)}, \tag{52}$$

[19] The analysis in Appendix A builds on Gourio and Miao (2010).

which taking the limit $\Delta \to 0$ yields:

$$V_0 = E_0 \int_0^\infty \left[\frac{1-\tau_d}{1-\tau_g} d_t - e_t\right] e^{-\frac{\int_0^t R_s ds}{1-\tau_g}}, \tag{53}$$

which gives the objective function in the problem of the firm stated in the text.[20]

To derive the HJB equation, re-arrange equation **??** to get

$$R_t \Delta V_t = [(1-\tau_d)d_t - (1-\tau_g)e_t]\, \Delta \left(1 + \frac{R_t \Delta}{1-\tau_g}\right) + (1-\tau_g)E_t(V_{t+\Delta} - V_t) \tag{54}$$

Dividing by Δ and taking the limit $\Delta \to 0$ gives

$$R_t V_t = (1-\tau_d)d_t - (1-\tau_g)e_t + (1-\tau_g)E_t(dV_t) \tag{55}$$

Applying Ito's Lema, $E(dV) = \frac{\partial V}{\partial t} + \frac{\partial V}{\partial z}\mu z + \frac{1}{2}\frac{\partial^2 V}{\partial z^2}(\sigma_z z)^2$

Hence,

$$R_t V_t = (1-\tau_d)d_t - (1-\tau_g)e_t + (1-\tau_g)\left\{\frac{\partial V}{\partial t} + \frac{\partial V}{\partial z}\mu z + \frac{1}{2}\frac{\partial^2 V}{\partial z^2}(\sigma_z z)^2\right\} \tag{56}$$

Dividing both sides of the above equation by $1-\tau_g$ yields:

$$\frac{R_t}{1-\tau_g} V_t = \frac{1-\tau_d}{1-\tau_g} d_t - e_t + \frac{\partial v}{\partial t} + \frac{\partial v}{\partial z}\mu z + \frac{1}{2}\frac{\partial^2 v}{\partial z^2}(\sigma_z z)^2, \tag{57}$$

which coincides with the HJB equation in the paper.

Appendix B. Data Variables

Appendix B.1. COMPUSTAT North America

We use data from COMPUSTAT North America obtained via WRDS. We use an unbalanced panel of firms from 1995-2015. We exclude all Canadian and foreign firms. We also exclude firms whose industry classification is in utilities (SIC codes between 4900 and 4949) or the financial sector (SIC code between 6000 and 6999), following the literature[21]. We also exclude observations reporting a value of acquisitions to assets larget than 5%, since these firms might behave differently. We finally exclude firms reporting negative employment, sales, wages or investment. All dollar values are in million dollars (1999 real terms, deflated

[20] The discount rate in the paper is denoted by $m = \frac{R}{1-\tau_g} = \frac{r(1-\tau_r}{1-\tau_g}$. When exogenous death of the firm is allowed, firms discount future payout at a rate $m + \delta_d$, where δ_d is the death rate. The value of the firm in the deterministic problem is just a special case of the stochastic case.

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

using the GDP deflator from the U.S. Bureau of Economic Analysis[22]), and all firm-level measures are winsorized at the 1st and 99th percentile. The raw variables we are going to use are the following:

- **Dividends.** Total amount of dividends, other than stock dividends, declared on all equity capital of the company, based on the current year's net income (DVT item). We restrict the analysis to those reporting DVT greater or equal to 0.
- **Equity Issuance.** Funds received from issuance of common and preferred stock (SSTK item). We restrict the analysis to those reporting SSTK greater or equal to 0.
- **Capital.** It represents the cost, less accumulated depreciation, of tangible fixed property used in the production of revenue, which is a component of total assets (PPENT item).
- **Age.** Computed as current year minus year of their IPO (IPODATE item)[23].
- **Employees.** Number of company workers as reported to shareholders. This is reported by some firms as an average number of employees and by some as the number of employees at year-end (EMP item).
- **Earnings.** Measured as Operating Income Before Depreciation (OIBDP item).

Table 5 presents the summary statistics of the variables over the period.

Table 5: Summary Statistics Compustat

Variable	Mean	Median	Std. Dev.	N
Dividends	44.43	0	195.71	104381
Equity Issuance	21.81	.68	68.71	103368
Capital	863.10	23.52	3056.73	105516
Age	7.10	6	6.65	113580
Employment	8.36	.65	24.07	96425
Earnings	455.90	10.94	2429.87	104864

Source: Compustat North America

We construct the variables used in the calibration as follows. The calibration targets are the average of these variables over the sample.

- **Employment growth**. Computed as $\frac{emp_{i,t}-emp_{i,t-1}}{(emp_{i,t}+emp_{i,t-1})/2}$.

[22] Accesed at https://www.bea.gov/iTable/iTable.cfm?ReqID=9step=1reqid=9step=1isuri=1

[23] Though an imperfect measure of firms' age, it is the only one available in Compustat database. This variable presents a high correlation with actual age, so that can be used as a proxy.

- **Aggregate Investment rate**. Computed from NIPA table 1.1.5 and FAT table 1.1.
- **Aggregate Dividends to Earnings**. Measured as the sum of dividends of all firms alive in one period, divided by the sum their earnings (OIBDP).
- **Aggregate Equity to Investment**. Measured as the sum of equity issuance of all firms alive in one period, divided by the sum their earnings (OIBDP). Equity issuance of incumbents is the sum of equity issuance of all firms alive in one period that are not doing an IPO, and equity issuance of entrants the sum of equity issuance reporting to do an IPO in the period.
- **Aggregate Employment Growth by Age**. Computed as the sum of all labor of firms of age j at time t ($sum\_emp_{j,t}$) for all ages and years in our data. Then, compute the growth rates by age as $\frac{(sum\_emp_{j+1,t+1} - sum\_emp_{j,t})}{((sum\_emp_{j+1,t+1} + sum\_emp_{j,t})/2)}$, and averaging by age j across all years t in our sample.

Appendix B.2. SDC Global New Issues database

We use the Thompson's Securities Data Corporation (SDC) Global New Issues database. We only use the subset of observations from SDC that we can match to the previous Compustat observations through their CUSIP. We keep only those observations trading in main stocks markets: NYSE, Amex and NASDAQ (EXCHC codes NYSE Alter, NYSE Amex, NYSE Arca, NYSE MKT, Nasdaq). We use only primary offerings, since these are the ones linked to inflows of capital to the firm[24]. Following Lee, Lochhead, Ritter and Zhao (1996), we compute the total costs of an issue as a percentage of the proceeds as follows:

$$\text{total cost} = GPCTP + EXPTH * 10/PROCDS \tag{58}$$

where the first item ($GPCTP$) is gross spreads (management fees, underwriting fees, and selling concession); and the second item ($EXPTH*10/PROCDS$) are other direct expenses (registration fee, printing,legal and auditing costs) as percentage of the proceeds .

Appendix C. Robustness

Our baseline economy assumes that productivity follows a geometric Brownian Motion. We now evaluate the robustness of our results by assessing the output gains of eliminating corporate income taxes in an economy in which productivity follows an AR(1) process. This specification is the one used by Gourio and Miao (2010) in their study of the effects of dividend taxation. In the next draft of the paper, we plan to further sensitivity analysis.

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

Table 6: Summary Statistics SDC Platinum

		Mean	Median	Std Dev.	N
IPO	Gross Spreads	7.1	7	.16	1218
	Other Costs	4.0	3.0	2.9	994
	Total Costs	11.0	10.1	3.3	994
SEO	Gross Spreads	5.5	5.6	.2	1468
	Other Costs	1.5	0.8	2.2	1279
	Total Costs	7.0	6.6	3.0	1279

Calibration

The logarithm of productivity follows a diffusion process of the form:

$$dlnz_t = -\theta lnz_t dt + \sigma dW \tag{59}$$

which is the continuous time analog of an AR(1), where θ controls the mean reversion. From Ito's lemma, we obtain that

$$dz_t = z_t \left(-\theta lnz_t + \frac{\sigma^2}{2} \right) dt + \sigma z_t dW. \tag{60}$$

We assume that entrants draw productivity from the invariant distribution implied by the process above, which follows a lognormal distribution with $\mu = exp(-\theta lnz_t + \sigma^2/2)$ and variance σ^2.[25] We fix all parameters to the values in the baseline economy but for the following parameters: (i) ψ, determining the magnitude of capital adjustment costs; (ii) θ, determining the mean reversion of productivity; (iii) σ, determining the volatility of productivity shocks; (iv) ξ_e, determining equity issuance cost when firms enter the economy. We set $\theta = -log(0.76) = 0.2485$ to match the an autocorrelation of shocks of 0.76, as estimated in the Compustat data by Gourio and Miao (2010). The other three parameters are calibrated by targeting (i) the volatility of the investment rate x/k across firms of 0.059, (ii) the ratio of equity issuance by incumbent firms to investment of 12.6%, (iii) the fraction of businesses with less than 100 employees of 53%.

The calibrated model economy with AR shocks matches well the calibration targets (see Table 8). Relative to our baseline economy, the calibration requires higher variance of shocks (0.50 instead of 0.15) and higher capital adjustment costs (0.18 instead of 0.09) to match the volatility of investment rates and the fraction of small businesses. These results are as expected: given that shocks are transitory we require a higher variance of shocks to match the heterogeneity in business size; and given the higher variance of shocks

[25] Since Gourio and Miao (2010) do not model entry and exit of firms, the distribution of productivity in their model economy is given by the invariant distribution of schocks.

Table 7: Calibration Baseline Economy with AR(1) growth

Parameter	Description	Value
ψ	Capital adjustment cost	0.18
θ	Mean reversion parameter	0.2485
σ	Volatility of prod. shock	0.5
ξ_e	Financing cost at entry	0.40

adjustment costs should also be larger in order to match the volatility of investment rates. Moreover, the higher adjustment costs calibrated implies that the model economy requires higher equity issuance costs at entry than in the baseline economy (0.40 instead of 0.30) to match the fraction of investment financed with equity by incumbent firms. The intuition is simple: when adjustment costs are large, firms want to do more investment at entry in order to minimize adjustment costs after entry. Table 8 presents data in some non-targeted dimensions showing that the economy with mean-reverting shocks performs worse than our baseline economy. Relative to the data, the former model economy has a too low employment growth of firms (0.01 instead of 0.02), a too high autocorrelation of (annual) investment rates (0.71 instead of 0.57), and has almost no businesses with size bigger than 500 (while in the data they represent about 10% of the total mass of businesses).

Results

Table 9 presents the aggregate long-run effects of replacing the corporate income tax with a common tax on capital all forms of capital income (dividends, capital gains, interest income) that raises the same amount of government revenue. We also report results for an experiment in which the corporate income tax is reduced by a half (from 34% to 17%). The quantitative findings are quite close to the ones in our baseline economy. Output increases by 15.5% and capital by 39%, while in the baseline economy these figures were slightly lower (13.6% and 35.2%). The elimination of corporate income taxation leads to a large increase in entry 47.7%, larger than the 39.3% increase in the baseline economy. The results are quite similar when we consider reducing corporate income tax rates by a half. We thus conclude that are key findings are robust to modeling productivity shocks as a mean reverting process.

Table 8: Calibration Results

	Data	Model
Targets		
Volatility investment rate	0.059	0.057
Eq. issuance incumbents/investment	0.13	0.13
Fract. bussinesses employees $\in [50, 99)$	0.53	0.52
Non-targeted dimensions		
Avg. employment growth	0.02	0.01
Autocorrelation invest. rate	0.57	0.71
Agg. eq. issuance /agg. investment	0.13	0.13
Dividend/ Earnings	0.098	0.46
Size Distribution of Businesses		
No. of Employees	Fraction Data	Fraction Model
$[50, 99)$	0.53	0.52
$[100, 249)$	0.29	0.45
$[250, 499)$	0.089	0.03
$[500, 999)$	0.0429	8e-7
$[1000, 2499)$	0.0265	0
$[2500, 4999)$	0.0099	0
$[5000, \infty)$	0.0115	0

Targeted moments in the data, and their respective counterpart in the model. Data comes from Compustat, and BDS for the size distribution of businesses.

Table 9: Aggregate Effects of Eliminating Corporate Income Taxation under AR(1) of shocks to growth of z.

	Output	Capital	TFP	Mass Entry	Wage	$\bar{\tau}$
$\bar{\tau}_c = 0$	15.5	39.0	6.2	47.7	15.5	0.38
$\bar{\tau}_c = 0.17$	9.1	22.0	3.7	26.4	9.1	0.27