Taxing Firms Facing Financial Frictions*

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Abstract  
In the U.S. business income is taxed several times at different sources, including corporate income, dividends, capital gains, and interest payments. We investigate how the different rates above affect firm investment and the allocation of capital in the economy. To do so, we construct and calibrate a model with heterogeneous firms, borrowing constraints, costly equity issuance and endogenous entry and exit. Because of the financial frictions, the taxes mentioned are not perfect substitutes and distort different margins. In our model firms enter small and grow over time to reach an optimal size. Firms are borrowing constrained and rely on retained earnings to grow. The corporate income tax reduces net worth and with retained earnings available for investment, delaying capital accumulation. Taxes on dividends, capital gains and interest income do not reduce net worth. We use the model to quantitatively analyze the steady state consequences of a reform that replaces the corporate income tax by a common tax on shareholders. We find that such reform improves the allocation of capital in the economy, increasing total factor productivity by 1.7%.

JEL: E44, G11, H21, H25, O16  
Keywords: Taxation, Financial Frictions, Capital Misallocation

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1 Introduction

Most countries, including the United States tax business income more than once. First, they tax profits at the firm level as corporate income. Next, individuals pay taxes on dividends when distributed, and on capital gains when realized. If the business issues debt, bondholders pay taxes on interest at the personal income rate. Should all four taxes be levied? If the answer is yes, what should their relative levels be? Our objective in this paper is to provide a quantitative answer to these questions.

We investigate taxation of corporate income within the tools that exist in the current United States tax code, by examining the effects of these taxes on firm behavior in an environment where heterogeneous firms enter small and accumulate capital to reach an optimal size, subject to borrowing constraints. In our environment, the taxes levied on firms are not perfect substitutes and distort different margins. The corporate income tax decreases earnings and net worth, which decreases the amount of retained earnings available for investment. Firms are borrowing constrained and retained earnings are crucial to finance their investment during the growth process. As a result, the corporate income tax delays capital accumulation among growing firms. While growing, firms optimally choose not to pay dividends. Moreover, capital gains and interest taxes are paid at the household level and do not decrease firms’ net worth. Although all the taxes we consider introduce an intertemporal wedge, the corporate income tax adds a distortion above and beyond the intertemporal wedge by delaying the capital accumulation process.

Our paper relates to literature examining taxation and corporate financial policy.1 This literature has focused on the effect of taxes on firm behavior from a partial equi-

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1See Auerbach (2002) for a comprehensive review.
librium perspective. The key theoretical result from this literature, proved in Auerbach (1979), Bradford (1981) and King (1974), is that dividend taxes do not distort firm decisions when the firm uses retained earnings as the marginal source of investment. The literature refers to this result as the "new view". It contrasts with an alternative "traditional view" which assumes that equity serves as the marginal source of investment. Dividend taxes reduce the return on equity and hence affect capital accumulation. Thus, the existing literature takes the marginal source of investment as given and examines the implications of a set of taxes on firm behavior.

In an early contribution, Poterba and Summers (1984) test empirically these competing hypothesis and find evidence more consistent with the traditional view. However, Auerbach (2002) finds evidence of significant heterogeneity within their sample: some of the firms' behavior is consistent with the new view, and others behave according to the traditional view.

In this paper, we use a model where the marginal source of investment is endogenous. Our model builds on the structural corporate finance models of Cooley and Quadrini (2001), Gomes (2001), Hennessy and Whited (2005) and Hennessy and Whited (2007). In these models, external funds are costly and firms rely on retained earnings unless the benefit of investment is high enough to offset the costs of external financing. That is, endogenously, a fraction of the firms will behave according to the traditional view and another fraction will behave according to the new view.

Once calibrated, our model reproduces central features of the data including the investment rate, leverage, the frequency and average of equity issuances, and firm turnover. We then proceed to use the model to quantitatively assess the allocative consequences of shifting the tax burden from corporate income to the shareholder level.
Taxing at the shareholder level instead of the corporate income level improves the allocation of capital in the economy, increasing steady state total factor productivity (TFP) by 1.7%.

The closest papers to ours use structural corporate finance models to assess the economic impact of the Jobs and Growth Tax Relief Reconciliation Act of 2003, which substantially decreased taxes on dividends and capital gains. Gourio and Miao (2010) study the steady state effect of the reform, finding that the tax cuts reduce frictions in the reallocation of capital and increase steady-state capital by 4%. In a companion paper, Gourio and Miao (2011) use the same apparatus to predict the transitional dynamics triggered by the same reform. Glover et al. (2011) look at the effect of interest deductibility in a similar environment. They find that eliminating interest deductibility increases default frequency and credit spreads. However, the cited papers focus on mature firms and do not consider capital accumulation during the growth process. By contrast, we introduce entry and exit and financial frictions, which allows us to consider the entire firm lifecycle. In particular, in our model the firms go through a non-trivial growth process that is delayed by the corporate income tax.

Our exercise consists in quantifying the effect from removing the corporate income tax and replace it with a common tax on shareholders in a revenue neutral way. We find that in steady state TFP is 1.7% larger than in the benchmark economy. The general equilibrium feedback is important: under the counterfactual policy, the wage increases by 4.9%. Absent price adjustments, the higher allocative efficiency increases the value of entry substantially and the higher entry pushes wages up, which will reduce the production by incumbent firms. Ignoring this last effect will overestimate the welfare improvement.
The rest of the paper is organized as follows. In section 2, we present the model and define the equilibrium. Section 3 describes our calibration strategy the data used for calculating moments. Section 4 presents and discusses the quantitative results. Section 5 concludes.

2 The Model

2.1 Economic environment

We now describe the model, which builds on the industry dynamic literature pioneered by Hopenhayn (1992), but features endogenous investment and financing decisions on the firms side. Time is discrete and the horizon infinite. The model economy consists of representative household, a continuum of ex-post heterogenous firms, and a government who needs to finance an exogenous stream of (constant) expenditures.

2.1.1 Preferences and endowments

The preferences over consumption and labor are given by,

$$\sum_{t=0}^{\infty} \beta^t u(C_t, L_t)$$  \hspace{1cm} (1)

The households own all the firms in the economy. Denote by $\Phi(s)$ the measure of stocks of type $s$ in the household’s portfolio. The firm type $s$ is its state, which will be described in more detail in the next subsection. Since for each type of firm, the total number of shares outstanding is normalized to 1, in equilibrium $\Phi(s)$ is also the total measure of firms of type $s$ in the economy (by market clearing). Let $E(s)$ the cum-dividend price of a firm of type $s$ and $D(s)$ the payout to its shareholders.

Besides dividends, payouts could take the form of equity repurchases. Although
modeling share repurchases is beyond the scope of this paper, when firms make share repurchases regularly, the Internal Revenue Service (IRS) treats these as dividends. The same will be assumed in the context of the model. For calibration purposes $D(s)$ will be mapped to the sum of common and preferred dividends and equity repurchases. Throughout the paper, for simplicity, we refer to $D(s)$ as “dividends”.

2.1.2 Technology

Firms are heterogenous in their idiosyncratic productivity $z_t$, which they observe at the beginning of the period, and as in Hopenhayn (1992) the production technology features decreasing returns to scale and a fixed cost of operation. A firm with productivity $z_t$, $k_t$ units of capital and $l_t$ units of labor produces $F(z_t, k_t, l_t)$ units of final good. We define operating profits as

$$\pi(k, z) = \max_l F(z_t, k_t, l_t) - wl$$

(2)

The investment technology is standard: one unit of final good invested at time $t$ increases the capital stock at $t+1$ by one unit, and the capital stock depreciates at rate $\delta$. There are no adjustment costs or irreversibilities in capital accumulation: $k_{t+1} = i_t + (1 - \delta)k_t$.

2.1.3 Entry and exit

After productivity is observed and before undertaking production, a firm can exit the market. In such case, the firm liquidates its assets and pays its debts. The remaining funds -always positive because of the collateral constraint- are distributed back to households as dividends. The constraint on borrowing guarantees that default is never a possibility.
If profitable, a positive mass of firms enters in every period. An entrant firm has no capital or debt, and as a result its output is zero on the first period. It is forced to issue equity to pay for the fixed cost of operation. After paying the fixed cost, the entrant observes its productivity shock.

### 2.1.4 Market structure

Households, firms and the government can trade one period risk free bonds $b_t$, subject to financial frictions. In this sense, financial markets are incomplete and firms cannot insure against idiosyncratic productivity shocks. Bonds are in zero net supply.

Following the corporate finance literature we constrain the use of debt and of equity in a reduced form way. As first used by Kiyotaki and Moore (1995), debt is subject to a collateral constraint, $b_t \leq \theta(1 - \delta)k_t$. Following Hennessy and Whited (2005) and Hennessy and Whited (2007), issuing equity is costly. In particular, for a firm to raise $e$ units of equity it requires an investment of $\lambda_0 + \lambda_1 e$. The parameters $\lambda_0, \lambda_1 > 0$ are meant to capture technological underwriting and flotation costs incurred when issuing equity. They will be calibrated to match the frequency and average of equity issuances.

### 2.1.5 Government policy

The government needs to finance an exogenous stream of expenditures $G$. It can do so by using linear taxes at four different levels. First, it can tax firms at the corporate income level, at rate $\tau_c$. The corporate income tax is charged on operating profits and allows for depreciation and interest deductions. Total collections from an individual firm are given by $\tau_c(\pi(k, z) - \delta k - rb)$.

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2 Although firms are risk neutral, because of the financial frictions, they value cash flows more in certain states of the world.
In addition, the government can tax dividends at rate $\tau_d$ and interest payments at rate $\tau_i$. Following the literature, (see Gourio and Miao (2010), Gourio and Miao (2011)) capital gains can be taxed on accrual at rate $\tau_g$. In particular, capital losses are fully deductible.\(^3\) This will be important for equity issuances: in the context of our model, when a firm issues equity, its current shareholders are subject to a capital loss on the shares outstanding before the issuance, as their position is diluted. We also allow for a tax on labor income $\tau_l$. Although we will hold the tax on labor income constant in our policy analysis, its presence is important because the wage is endogenous: a better allocation of capital results in higher wages, and tax collections increase. As in Krueger and Ludwig (2016) the labor income tax allows for a deduction $\Delta$. The deduction allows to match both the base of the labor income tax and its the marginal rate in a simple way. Total collections from the labor income tax are therefore given by $\tau_l(w_tL_t) = \tau_l w_t L_t - \Delta$.

We constrain the government to have a balanced budget in steady state.

### 2.2 Competitive Equilibrium

In this subsection we formulate the recursive problem for firms and households and characterize the aggregate variables. The subsection finishes with the definition of a recursive competitive equilibrium.

#### 2.2.1 Timeline

In the interest of clarity, before formulating the agents’ maximization problems, we briefly describe the decisions within a period in a timeline.

\(^3\) According to the U.S. tax code capital losses are deductible as long as they are offset by capital gains. This is consistent with our model because in steady state the value of the portfolio is constant.
1. The period begins. Households have assets $A$, incumbent firms arrive to the period with capital $k$ and debt $b$.

2. Before the shocks $z$ are observed, a mass $M$ of firms choose to enter.

3. For each form, the shock $z$ is realized. Incumbents choose to continue or exit.\footnote{Entrants commit to operate during the first period.}

4. Production takes places. Wages, taxes and debt are paid.

5. Firms make investment and borrowing decisions by choosing $k'$ and $b'$.

6. The corporate sector distributes dividends and issues equity.

7. Households collect dividends, interest payment and labor income, and uses them for consumption or savings.

### 2.2.2 Recursive problem of households

The households are subject to the following budget constraint,

\[
C + B' + \int E(s)\phi'(s)ds = B(1 + (1 - \tau_i)r)
+ \int \left( E(s) + (1 - \tau_d)D(s) - \tau_g(E(s) - E^-(s)) \right) \phi(s)ds + wL - \tau_l(wL)
\]

We define assets $A$ as,

\[
A = B(1 + (1 - \tau_i)r) + \int \left( E(s) + (1 - \tau_d)D(s) - \tau_g(E(s) - E^-(s)) \right) \tilde{g}_t(s)ds
\]

In equilibrium, the household will only hold assets yielding the same return and hence it is enough to only keep track of the total value of the assets.

The recursive formulation of the household problem is,
\[ V(A) = \max_{B', \phi'(s)} u(C, L) + \beta V(A') \quad (5a) \]

s.t: \[ C + B' + \int E(s)\phi'(s)ds = A + (1 - \tau_l)wL - \tau_l(wL) \quad (5b) \]

s.t: \[ A' = B'(1 + (1 - \tau_i)r) \quad (5c) \]

\[ + \int \left( E'(s) + (1 - \tau_d)D'(s) - \tau_g(E'(s) - E(s)) \right) \tilde{\phi}'(s)ds \]

s.t: \[ B' \geq B \tag{5d} \]

Here \( B \) is the natural borrowing limit.

To gain intuition about the way our model works and how taxes affect agents decisions, we summarize here the optimality conditions of the household problem.

First, the Euler equation is

\[ u'(C, L) = (1 + (1 - \tau_i)r)\beta u'(C', L') \quad (6) \]

We refer to \( \frac{\beta u'(C', L')}{u'(C, L)} \) as the household discount factor.

Second, the no-arbitrage condition implies,

\[ (1 - \tau_i)r = (1 - \tau_g)\frac{E' - E}{E} + (1 - \tau_d)\frac{D}{E} \quad (7) \]

Third, labor supply

\[ -u_l(C, L) = (1 - \tau_l)w\psi_c(C, L) \quad (8) \]

The no-arbitrage equation allows to derive the firms’ market value. Define the cum-dividend price of the firm \( P(s) \) to be the ex-dividend price plus after-tax dividends and net of equity dilutions, \( N(s) \):

\[ P(s) = E(s) + \frac{1 - \tau_d}{1 - \tau_g} D(s) - N(s) - \Lambda(N(s)). \]
Iterating on the no-arbitrage equation 7, the cum-dividend value of the firm satisfies the following recursion,

\[ P(s) = (1 - \tilde{\tau}_d)D(s) - N(s) - \Lambda(N(s)) + \tilde{\beta} P'(s) \]  \hspace{1cm} (9)

We defined the effective tax on dividends by \( 1 - \tilde{\tau}_d = \frac{1 - \tau_d}{1 - \tau_g} \), and the firm’s discount factor by \( \tilde{\beta} = \left(1 + \frac{1 - \tau_i}{1 - \tau_g} r\right)^{-1} \). In particular when \( \tau_g = 0 \), the effective tax on dividends is equal to the dividend tax rate and the firm’s discount factor is equal to the household’s discount factor.

### 2.2.3 Recursive problem of firms

In our environment, the incentives between firms’ managers and shareholders are aligned, and the objective of the firms is to maximize its market value as stated in equation 9 above.

Firms never it find optimal to issue equity and distribute dividends in the same period. For simplicity, we denote by \( d \) net distributions, and refer to it as dividend payments when \( d > 0 \) and equity issuance when \( d < 0 \). It will prove useful to introduce the indicator function \( j = 0 \) if \( d \geq 0 \) and \( j = 1 \) otherwise.

For each individual firm, the uses and sources of funds need to be equal according to,

\[ \pi(z, k) + b' - (1 + r)b = d + k' - (1 - \delta)k + \tau_c(\alpha z - f - \delta k - rb) \] \hspace{1cm} (10)

The equation above states that operating profits and net borrowing are used to pay for (net) distributions, investments and taxes.

Define net worth as, \( \omega = \pi(k, z) - \tau_c(\pi(k, z - \delta k - rb)) + (1 - \delta)k - (1 + r)b \). This is
a sufficient statistic for the firms dynamic decisions.

The problem of a firm be written recursively as,

$$P(\omega, z) = \max_{k', b'} \omega - k' + b' - (1 - j)\bar{\tau}_d(\omega - k' + b') - j\Lambda(k' - \omega - b')$$  \hspace{1cm} (11a)

$$+ \beta \mathbb{E}_{z'} \left[ \max \left\{ (1 - \tau_d)((1 - (1 - \tau_c)\delta)k' - (1 + (1 - \tau_c)\tau)b'), P(\omega', z') \right\} \right]$$  \hspace{1cm} (11b)

s.t: $\omega' = \pi(k', z') - \tau_c(\pi(k', z') - \delta k' - \tau b') + (1 - \delta)k' - (1 + \tau)b'$  \hspace{1cm} (11c)

s.t: $\theta(1 - \delta)k' \geq b'$  \hspace{1cm} (11d)

Once again, optimality conditions allow to built intuition about the way the model works.

We start by discussing exit. Using standard dynamic programing arguments, it can be shown that $P(\cdot)$ is strictly increasing in $z$. Hence there is a unique threshold $z^*(k', b')$ such that the firm is indifferent between staying active and exiting,

$$(1 - \bar{\tau}_d)((1 - (1 - \tau_c)\delta)k' - (1 + (1 - \tau_c)\tau)b')$$

$$= P((1 - \tau_c)\pi(k', z^*) + (1 - (1 - \tau_c)\delta)k' - (1 + (1 - \tau_c)\tau)b', z^*)$$  \hspace{1cm} (12)

As described above, when a firm exits it liquidates its capital stock, pays its debts and distributes the differences as dividends. Notice that upon exit, capital depreciation and interest payments are deductible are still deductible.

To the extent that taxes decrease firm value $P$, they decrease the value of remaining active vis a vis exiting. Everything else equal (including prices and distributions) a higher $\tau_c$ is associated with lower exit rates. However when liquidations are taxed, $\bar{\tau}_d$ decreases the value of exit. As it will be clear later, in an economy where equity issuances
aren’t allowed, the effective dividend tax does not distort the exit margin. When equity issuances are allowed and the cost of equity capital is not deductible, a higher effective tax is associated with higher exit, because the effective dividend tax is not paid in every state of the world. When capital gains and dividends are taxed at the same rate, equity issuances are tax deductible via capital losses. Under such a tax system, the common dividend - capital gains tax does not distort the exit margin.

Then next step is to consider capital accumulation. We first discuss the case when firms optimally distribute dividends in the current period. Using Leibniz rule, the first order condition with respect to $k'$ (when the objective is differentiable\(^5\)) is,

\[
(1 - \tilde{\tau}_d) \tilde{\beta} = (1 - \tilde{\tau}_d)(1 - (1 - \tau_c)\delta) \Pr(z' < z^*(k', b')) \\
+ \int_{z^*(k', b')} z' P_{\omega}(\omega', z') \left( ((1 - \tau_c)\pi_k(k, z) - \delta) + 1 \right) \Pr(z'|z) dz' \\
+ \theta(1 - \delta) \mu \tag{13}
\]

The left hand side of the equation above is the marginal cost of investment, namely not distributing the marginal dollar to shareholders. The right hand side is the marginal benefit. If the firm chooses to exit -with probability $\Pr(z' < z^*(k', b'))$- it gets the after-tax, un-depreciated value of capital. If instead it chooses to stay active, in addition it gets the marginal product of capital, weighted by the value of internal funds on that period: $P_{\omega}(\omega', z')$. This value satisfies,

\(^5\)The value function has kinks at the point where dividends are zero, and at the exit threshold.
\[ P_{\omega}(\omega', z') = 1 - \tilde{\tau}_d \]

\[ = 1 + \lambda_1 \]

\[ \in [1 - \tilde{\tau}_d, 1 + \lambda_1] \]

\[ \text{if } d(\omega', z') > 0 \]

\[ = 1 + \lambda_1 \]

\[ \text{if } d(\omega', z') < 0 \]

\[ \text{if } d(\omega', z') = 0 \]  

(14)

The marginal benefit also includes the term \( \theta(1 - \delta)\mu \), where \( \mu \) is the Lagrange multiplier on the collateral constraint. Since the capital stock relaxes the borrowing constraint. Since debt offers a debt shield, in this model there will be over-investment.

We now provide some intuition of how taxes change capital accumulation decisions. For this discussion, we assume that prices do not respond to changes in tax policy. If a firm never were to issue equity, or alternatively all costs of equity issuance, including the opportunity cost of capital are deducted, the choice of \( k' \) is not distorted by \( \tilde{\tau}_d \). This is the “new view”, first introduced by Auerbach (1979), Bradford (1981) and King (1974).

In this model, firms endogenously avoid to issue equity, but do so in some states of the world. A firm that is distributing dividends will invest more than a firm facing the same prices but no effective dividend taxes.

Firms that are hit by a very high productivity shock will find it optimal to issue equity. In such case, the marginal cost of investing one dollar is \( (1 + \lambda_1)\beta^{-1} \), and -fixing prices- \( \tilde{\tau}_d \) decreases investment.

By contrast, the corporate income tax decreases investment in all states of the world: even firms using exclusively retained earning to finance investment invest less than they would in a world with the same prices but no corporate income taxes.

Last, the firm discount factor \( \tilde{\beta} \) decreases the marginal cost of investment in every state of the world and regardless of the current liquidity regime.
Besides exit and investment, firms choose the value of debt to be issued. The first
order condition with respect to \( b' \) is given by,

\[
(1 - \tilde{\tau}_d) + \mu = \tilde{\beta}(1 + (1 - \tau_c)r) \left( (1 - \tilde{\tau}_d) \Pr(z' < z^*(k', b')) + \int_{z^*(k', b')}^{\bar{z}} P_{\omega'}(\omega', z') \Pr(z' \mid z) dz' \right)
\]

Before discussing the equation above, consider a government policy such that equity
has a tax benefit over debt, \((1 - \tau_i) < (1 - \tau_c)(1 - \tau_g)\). In such a case, the household
like to borrow infinite amounts from firms, and no equilibrium exists. The reason is
the following: when the household holds debt, she gets a tax subsidy on her interest
payments that is higher than the tax paid by firms on the interests. As a result, the
household gets a subsidy proportional to the value of its debt and would demand an
infinite amount of it. To rule out such “loophole”, we restrict taxes to satisfy \((1 - \tau_i) \geq (1 - \tau_c)(1 - \tau_g)\). The last inequality implies \( \tilde{\beta}(1 + (1 - \tau_c)r) \leq 1 \).

Whenever \( \tilde{\beta}(1 + (1 - \tau_c)r) < 1 \), the tax advantage of debt pushes firms to borrow up
to the constraint. If the correlation of shocks is high enough, firms will always be at the
collateral constraint. However, when the correlation of shocks if low enough, reducing
the stock of debt allows firms to insure against low productivity shocks, and they trade-
off the tax advantage with precautionary saving motives.

2.2.4 Entry

At the beginning of every period, an unbounded mass of potential entrants with zero
net worth is available. Potential entrants will enter as long as it is profitable to do so.
However, entry is costly. Before observing productivity shocks, entrants have to pay
an entry cost \( c_e \). Upon entry, firms will draw a productivity shock from its ergodic
distribution and pay the fixed cost of operation. In particular, entrants are forced to issue equity. The actual mass of entrant $M$ satisfies,

$$\mathbb{E}P(0, z) = c_e, \text{ if } M > 0$$

$$\mathbb{E}P(0, z) < c_e, \text{ if } M = 0$$

The entry margin is distorted to the extent that taxes reduce firm value. Both $\tilde{\tau}_d$ and $\tau_c$, but the later has a larger effect: $\left| \frac{\partial P}{\partial \tilde{\tau}_d} \right| < \left| \frac{\partial P}{\partial \tau_c} \right|$. Since $\tilde{\tau}$ is increasing in $\tau_d$, the dividend tax decreases firm value. The firm discount factor decreases firm value as well, meaning that $\tau_i$ increases firm value. Notice that if $\tau_i, \tau_g, \tau_d$ are set equal, any change the the common rate does not distort the entry margin.

Having discussed the behavior of each firm in isolation, in the next section we describe the aggregate variables.

### 2.2.5 Aggregation

Since each firm is characterized by its state $s = (\omega, z)$, in this section we describe the law of motion for the measure $\Phi$ over the space of feasible net worth and productivity shocks.

Let $\otimes$ and $\mathcal{Z}$ be measurable sets. The probability of going from $\omega, z$ into the set of states $\otimes \times \mathcal{Z}$, is given by,

$$Q(\omega, z, \otimes, \mathcal{Z}) = \int_{\{\omega'(z', \omega, z) \in \otimes\}} x(z', \omega, z) d\Gamma(dz'|z) \tag{16a}$$

where, $x(z', \omega, z) = 1$ if $z' > z^*(k'(\omega, z), b'(\omega, z))$ and $\Gamma$ denotes the distribution of productivity shock. That is, a firm with state $\omega, z$ goes into $\otimes \times \mathcal{Z}$ if its realized next
worth, given its optimal choices of investment and borrowing is in $\otimes$ with probability
\[ \int_Z d\Gamma(dz'|z), \] provided that under the realization of $z'$ the firm doesn’t want to exit.

Using the Markov transition function $Q$, the measure of firms is evolves according to,

\[
\begin{align*}
\Phi'(\otimes, Z) &= \int Q(\omega, z, \otimes, Z) d\Phi(\omega, z) & \text{if } 0 \notin \otimes \\
\Phi'(\otimes, Z) &= \int Q(\omega, z, \otimes, Z) d\Phi(\omega, z) + M \int d\Gamma^e(z) & \text{otherwise (16b)}
\end{align*}
\]

Where $\Gamma^e(z)$ is the ergodic distribution of productivity shocks. Notice that the distribution $\Phi$ is associated with a distribution $\tilde{\Phi}$ over $(k, b, z)$ by $\tilde{\Phi}(k, b, z) = \Phi(\pi(k, z) - \tau_c(\pi(k, z - \delta k - rb)) + (1 - \delta)k - (1 + r)b, z)$

Next we use the measure $\tilde{\Phi}$ to define the aggregate quantities in the corporate sector. These are the (net) aggregate supply of final goods, total profits, the aggregate investment, and total financial costs, defined respectively as,

\[
\begin{align*}
Y_t &= \int (z_t k_t^{\alpha_k} l_t^{\alpha_l} - f) d\tilde{\Phi}_t(k_t, b_t, z_t) \\
\Pi_t &= \int \pi(z_t, k_t) d\tilde{\Phi}_t(k_t, b_t, z_t) \\
I_t &= \int (k_t + 1 - (1 - \delta)k_t) d\tilde{\Phi}_t(k_t, b_t, z_t) \\
\Lambda_t &= \int (\lambda_0 + \lambda_t d_t) j_t d\Phi_t(\omega_t, z_t)
\end{align*}
\]
2.2.6 Definition of equilibrium

Given an initial stock of assets in hands of the household $A_0$, an initial distribution of firm $\Phi_0()$ and a government spending requirement $G$ and tax on labor $\tau_l$, a recursive competitive equilibrium is a sequence of value and policy functions for the household $\{V_t, C_t, B_t', L_t\}_{t=0}^\infty$, a sequence of value and policy functions for the firms $\{P_t, k_t', b_t', l_t, x_t\}_{t=0}^\infty$, sequences of masses of entrants $M_t$ and measures $\Phi_t$, sequences of prices $\{w_t, r_t\}$ and sequences of government policies $\{\tau_{d,t}, \tau_{c,t}, \tau_{i,t}, \tau_{g,t}\}$ such that,

1. Given prices and government policies $\{V_t, C_t, B_t', L_t\}_{t=0}^\infty$ solves the household problem (5).
2. Given prices and government policies $\{P_t, k_t', b_t', l_t, x_t\}_{t=0}^\infty$ solves the individual firm problem (11).
3. $M_t$ is consistent with the free entry condition (15).
4. The government policy satisfies the budget constraint

$$G_t + (1 + r_t)B_t^G - B_{t+1}^G$$
$$= \tau_{i,t}r_tB_t + \tau_{d,t}D_t + \tau_{c,t}(\Pi_t - \delta K_t - \tau_iB_t - f) + \tau_{g,t}(E_t - E_{t-1})$$ (17)

5. Markets clear in every period:

$$L_t = \int l_t(w_t) dG_t(\omega_t, z_t)$$ (18)

$$Y_t = C_t + I_t + \Lambda_t + G_t$$ (19)

6. The law of motion of the measure $\Phi_t$ is consistent with firms’ policy functions according to (16)
\[ B' = \int q'(\omega, z) d\Phi(\omega, z) \quad L = \int l'(\omega, z) d\Phi(\omega, z) \]

A stationary equilibrium is a competitive equilibrium in which all functions and aggregate variables are constant over time.

3 Data and Calibration

In this section we calibrate the model. A first subset of parameters is chosen to match steady state moments to their data counterparts. Those include the parameters ruling the financial frictions, the productivity process and the amount of turnover in the economy. We will argue that those are the most important parameters to quantify the mechanism. A second set of parameters is fixed following estimates typically found in the literature.

3.1 Functional forms and fixed parameters

We use the same production technology as Gomes (2001), namely \( F(z, k, l) = z k^\alpha l^{1-\alpha} - f \). We set the labor share of output \( \alpha_l = 0.64 \) as in Prescott (1986). Using plant-level data, Lee (2007) finds that returns to scale in manufacturing vary from 0.83 to 0.91, depending on the estimator. We fix \( \alpha_k = 0.23 \) so that total returns to scale fall in the midpoint of the reported range. The fixed cost of operation \( f \) will be included among the estimated parameters. We assume free entry and set the cost of entry, \( c_e \) to zero. Firm level idiosyncratic productivity follows \( \log z_{t+1} = \rho_z \log z_t + \sigma_z \varepsilon_t \), where \( \varepsilon \) is a standard normal innovation.

As first introduced by Greenwood et al. (1988), in our economy household preferences are given by

\[
  u(C, L) = \frac{1}{1-\sigma} \left( C - \frac{H}{1+\frac{1}{\gamma}} L^{1+\frac{1}{\gamma}} \right)^{1-\sigma}
\]
Underlying this preference specification is the assumption of no wealth effects on the labor-leisure trade-off. This is done for computational simplicity, but it may overestimate the efficiency gains of the reforms. We assume log utility and choose an elasticity of labor supply $\gamma = 0.5$ as in Chetty et al. (2011). The discount rate $\beta$ is fixed at 0.972 to match a (before tax) interest rate of 4% in the benchmark steady state.

**Tax system**

We argue that flat tax rates are a good approximation to the actual tax system. Although the tax rate are actually progressive, the rate structure 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 $18,333,333. Moreover the marginal rate already hits 34% for income above 75,000. In our sample, 99% of firms report a pretax income above 128,000 (conditional on reporting profits). We set the corporate income tax to the top statutory rate $\tau_c = 0.35$.

Since the Jobs and Growth Tax Relief Reconciliation Act of 2003 was enacted, dividend and capital gains are tax at 15% for all incomes falling on or above the third tax bracket$^6$. Accordingly we set $\tau_g = \tau_d = 15\%$.

For personal income taxes, the rate structure is more progressive and a linear tax is less of a good approximation. As described in section 2.1.5 we model this in a parsimonious way by allowing for a constant marginal rate and a deduction. We follow Krueger and Ludwig (2016) and calibrate the deduction to match 35% of the household income. This matches the sum of standard deductions and exemptions from the tax code. Krueger and Ludwig (2016) choose the marginal rate to balance the government budget and find 27.5%. This is consistent with the 28% rate reported by Mendoza et al.

$^6$For instance in 2013, the 15% rate applied for incomes above $36,250 for single taxpayers and above $72,500 for those filing jointly.
We set $\tau_1 = \tau_1 = 0.28$.

### 3.2 Targeted Parameters

Our environment is in between two benchmarks. On the one hand, in an economy where $\lambda_0$ or $\lambda_1$ and $\theta$ are infinite, households cannot finance firms. In such economy firms only use internal funds to finance investment and dividends can be thought as an endowment to households. The taxation of such endowment is not distortive. On the other extreme is an economy in which $\lambda_0 = \lambda_1 = \theta = 0$ and the economy is similar to the neoclassical benchmark, where household finance investment and are indifferent to do so using equity or debt. Because of their importance we include those parameter in the vector to be calibrated. In addition we include in the vector of calibrated parameters, the fixed cost of operation $f$, the parameters ruling the process of productivity $\rho_z, \sigma_z$, the depreciation rate of physical capital $\delta$ and the disutility of effort $H$.

#### 3.2.1 Selection of moments

We choose moment that are a priori informative about the parameters we seek to calibrate. First, in steady state, aggregate investment is given by $\delta K$. In order to pin down $\delta$ we include the average investment rate $\int i(\omega, z)/kd\Phi(k, b, z)$. In order to pin down $\lambda_0$ and $\lambda_1$ we include the frequency of equity issuance, $\int j(\omega, z)d\Phi(\omega, z)$, and the average of equity issuance as a fraction of total capital, $\int d(\omega, z)j(\omega, z)d\Phi(\omega, z)/\int kd\Phi(k, b, z)$. In order to identify $\rho_z$ and $\sigma_z$ we include the serial autocorrelation and the standard deviation of the profits to capital ratio $\pi/k$\(^8\). The turnover rate defined as the mass of

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\(^7\)The disutility of effort is sensitive to changes in the wage, and the equilibrium wage turns out to be very responsive to the value of the fixed cost of operation $f$. Hence we include $H$ in the calibrated parameters.

\(^8\)Following the literature, for the computation of second moments, we remove fixed effects from the data. Accordingly, the variance of profits to assets is computed after substracting the average for each
entrants over the mass of incumbents, $M/\int d\Phi$, should be informative about the cost of entry $c_e$. Average leverage $\int b/k \ d\Phi(k, b, z)$ is associated with the value of $\theta$. The fixed cost of operation is related to the ratio of dividends to profits. Last, the scale parameter $H$ is chosen to match one third of time spent at market work. All the moments were computed using the dataset described in the next subsection except for two. The first is time spent at market work, which we set at 0.33 as is standard in the literature. The second is turnover. Firms appear and disappear from Compustat for several reasons other than entry and exit. Consequently, we target the turnover value of 6% reported by Lee and Mukoyama (2015) using the Annual Survey of Manufactures from the US Census Bureau.

3.2.2 Data Description

We use data from the Compustat Monthly Updates - Fundamentals Annual File, North America from WRDS. Following the literature, we discard all regulated utilities (SIC 4900-4999), financial firms (SIC 6000-6999) and quasi-governmental and non-profit firms (SIC 9000-9999) because our model is not well suited for the analysis of such firms. Next we drop Canadian and foreign ADRs, as the American tax system does not apply for those firms.

We define capital as Compustat variable total assets (AT); investment as the difference between capital expenditures and sales of property, plant and equipment (CAPX-SPPE); dividends (total payouts) include common and preferred dividends, and equity repurchases (DVC + DVP + PRSTKC); debt as long term debt plus short term debt (DLTT + firm. For the autocorrelation, we fit a panel autoregression using the method by Arellano and Bond (1991). Assuming that the variance of profits is constant over time, the slope coefficient corresponds to the autocorrelation of profits.
DLC), equity issuances as sales of common and preferred equity (SSTK)\(^9\); and operating profits as earnings before interest, taxes, depreciation and amortization (EBITDA). All variables are winsorized at the top and bottom 5%.

Our model abstracts from unobserved heterogeneity in firms’ characteristics. To be consistent, we use firm (and time) fixed effects when computing second moments.

The dataset covers fiscal years between 2003 and 2015. This correspond to the period since the last major tax reform, for which the statutory rates used are relevant. After dropping observation with missing or inconsistent information for any of the variables used, we end up with 42,546 observations. The number of firms ranges between a minimum of 2,711 in 2015 and a maximum of 3,955 in 2003.

The following table presents the data estimated parameters and the model counterparts.

<table>
<thead>
<tr>
<th></th>
<th>Data</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average investment rate</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Standard deviation of profits</td>
<td>0.11</td>
<td>0.09</td>
</tr>
<tr>
<td>Average leverage</td>
<td>0.17</td>
<td>0.21</td>
</tr>
<tr>
<td>Average equity issuances</td>
<td>0.09</td>
<td>0.11</td>
</tr>
<tr>
<td>Frequency of equity issuances</td>
<td>0.19</td>
<td>0.23</td>
</tr>
<tr>
<td>Autocovariance of profits</td>
<td>0.39</td>
<td>0.61</td>
</tr>
<tr>
<td>Turnover (Lee, Mukoyama 2015)</td>
<td>0.06</td>
<td>0.05</td>
</tr>
<tr>
<td>Time at work</td>
<td>0.33</td>
<td>0.33</td>
</tr>
<tr>
<td>Average dividends to profits</td>
<td>0.48</td>
<td>0.43</td>
</tr>
</tbody>
</table>

\(^9\)We use the filter proposed by McKeon (2015) to clean the Compustat reported data from employee’s exercise of options.
3.2.3 Parameter values

We find a collateral constraint parameter value $\theta = 0.23$. This is lower than the 0.36 estimate found by Li et al. (2016) in an environment without equity issuances. The fix cost of equity issuances $\lambda_0 = 0.025$ and the fixed cost of operations is $f = 1.44$. For the marginal cost of equity issuances we find $\lambda_1 = 0.24$. This value is in between 0.028 reported by Gomes (2001) and 0.059 found by Hennessy and Whited (2005). The deprecation rate is $\delta = 0.08$.

We end this section by summarization all parameter values and their respective targets in the following table,
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Interpretation</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Calibrated Parameters</strong></td>
<td></td>
</tr>
<tr>
<td>θ</td>
<td>collateral constraint</td>
<td>0.23</td>
</tr>
<tr>
<td>λ₀</td>
<td>fixed cost of equity issuance</td>
<td>0.025</td>
</tr>
<tr>
<td>λ₁</td>
<td>linear cost of equity issuance</td>
<td>0.24</td>
</tr>
<tr>
<td>ρ₂</td>
<td>autocorrelation of productivity shocks</td>
<td>0.75</td>
</tr>
<tr>
<td>σ₂</td>
<td>std. deviation of productivity shocks</td>
<td>0.1</td>
</tr>
<tr>
<td>δ</td>
<td>depreciation rate</td>
<td>0.08</td>
</tr>
<tr>
<td>H</td>
<td>disutility of labor</td>
<td>3.4</td>
</tr>
<tr>
<td>f</td>
<td>fixed cost of operation</td>
<td>1.44</td>
</tr>
<tr>
<td>cₑ</td>
<td>cost of entry</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td><strong>Fixed Parameters</strong></td>
<td></td>
</tr>
<tr>
<td>β</td>
<td>discount rate</td>
<td>0.972</td>
</tr>
<tr>
<td>γ</td>
<td>labor supply elasticity</td>
<td>0.5</td>
</tr>
<tr>
<td>σ</td>
<td>intertemporal elasticity of substitution</td>
<td>1</td>
</tr>
<tr>
<td>αₖ</td>
<td>capital share</td>
<td>0.21</td>
</tr>
<tr>
<td>α₁</td>
<td>capital share</td>
<td>0.64</td>
</tr>
<tr>
<td></td>
<td><strong>Taxes</strong></td>
<td></td>
</tr>
<tr>
<td>τₑ</td>
<td>corporate income tax</td>
<td>0.35</td>
</tr>
<tr>
<td>τₓ</td>
<td>dividend tax</td>
<td>0.15</td>
</tr>
<tr>
<td>τₓ</td>
<td>tax on capital gains</td>
<td>0.15</td>
</tr>
<tr>
<td>τᵢ</td>
<td>interest income tax</td>
<td>0.28</td>
</tr>
<tr>
<td>τₓ</td>
<td>labor income tax</td>
<td>0.28</td>
</tr>
</tbody>
</table>
4 Thought Experiment

In this section we use the model to explore computationally the effects of different tax regimes on economic outcomes, focusing particularly on TFP.

Our first exercise consists of decreasing the corporate tax rate from benchmark rate of 35% to 0%, in revenue neutral way. In the baseline model, the value of $G$ is 13.3% of GDP. By comparison, between 2003 and 2015, the average revenue from corporate and personal income taxes was 9.05% of GDP in the U.S. In order to hold $G$ constant, we replace the revenue from the corporate income tax by increasing a common tax on shareholders $\tau_d = \tau_g = \tau_i = \hat{\tau}$.

We do so in two steps. The first step consists on finding the common rate $\hat{\tau}$ achieving budget balance when the corporate income tax is at its benchmark level of 35%. Such reform increases TFP and output by decreasing over-accumulation of capital: since debt provides a tax-shield, and firms are borrowing constrained, they over-accumulate capital as long as the benefit from relaxing the borrowing constraint to exploit the tax shield is higher than the cost, a lower marginal product of capital.

The effect of the first step of the reform is quantitatively very small. Steady-state TFP increases by 0.07%, output by 0.6% and the wage by 0.35%.

The second step consists on decreasing the corporate income tax gradually from 35% to 0%, and adjusting $\hat{\tau}$ such that,

$$G = \hat{\tau}rB + \hat{\tau}D + \tau_c (\Pi - \delta K - rB - f) + \hat{\tau} (E' - E) + \tau_l (wL)wL$$

Figure 4 depicts the effect of the described change in government policy on several variables of interest. As shown by the first panel, the corporate income tax can be re-
Figure 1: Effects of Tax Reform
placed by a common tax of shareholders of 34.6%. The rate is comparatively low and suggest substantial efficiency gains. In fact, the second panel shows that TFP increases from 0.568 to 0.577, that is 1.7%. Both output and consumption increase substantially: 6% and 6.5% respectively. The wage increases by 4.9%. This increase in the wage combined with the 2.4% in labor displayed in the last panel are important because they substantially increase labor income tax collections, explaining why they 35% corporate income tax can be replaced increasing dividend and corporate income rates by 20 percentage points.

Behind the increase in TFP is an improvement in the capital allocation: the elimination of the corporate income tax allows growing firms to accumulate capital more rapidly. The acceleration in the capital accumulation process is depicted in figure 5. The figure shows the sequence of capital, starting at entry, for a firm hit every period by the same productivity shock. In the benchmark economy, it takes 11 periods for such a firm to grow up to its unconstrained optimal level. When the corporate income tax is eliminated, the same firm reaches its optimal level of capital in 9 periods. As a result, for each level of productivity, the distribution gets more compressed closer to the optimal size, which reduces capital misallocation in the economy.

5 Conclusion

In this paper we use a model of heterogenous firms subject to borrowing constraints, costly equity issuances and endogenous entry and exit to study the effects of corporate income taxation and compare them with the effects of taxation at the shareholder level. We argued that total factor productivity is 1.7% higher in a steady state where the corporate income tax is replaced by a higher common tax on shareholders in a revenue neutral
Figure 2: Capital Accumulation Before and After Reform
For our tax experiments we assumed that capital gains are taxed on accrual. Under that assumption, when a firm issues equity, the value of the current shareholders stock decreases and the capital loss is tax deductible. In reality, in the U.S. capital gains are taxed upon realization, not on accrual. Relaxing the former assumption requires a richer model that is out of the scope of this paper. We leave that for future research.

References


