# Taxing Firms Facing Financial Frictions[*]

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## Abstract

What is the effect of replacing the corporate income tax by a tax on business owners? To answer this question we construct a model with heterogeneous firms, borrowing constraints, costly equity issuance and endogenous entry and exit. Calibrating the model to the U.S. economy, we find that replacing the corporate income tax with a revenue-neutral common tax on shareholders, steady-state output would increase by 6.8% and total factor productivity (TFP) by 1.7%. Due to financial frictions, taxes levied at the corporate income level and at the shareholder level are not perfect substitutes because they distort different margins. In our model, firms are hit by productivity shocks and aim to adjust their capital stock in pursuit of optimal size. Optimal firm behavior often dictates reliance on retained earnings for growth. The corporate income tax reduces retained earnings available for investment, thereby delaying capital accumulation. As the retained earning are not paid back to shareholders, the friction just described does not occur when taxes are levied at the dividend level. The mechanism is amplified by endogenous entry and exit and by general equilibrium feedback.

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**Keywords:** Taxation, Financial Frictions, Capital Misallocation

# 1  Introduction

Many countries, including the United States, tax business income more than once. First, they tax profits at the firm level as corporate income. Next, business owners 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.

Major tax reforms in the United States and elsewhere have sought to alleviate this "double taxation." For instance, the Jobs and Growth Tax Relief Reconciliation Act of 2003 under the George W. Bush administration, and the Tax Reform Act of 1986 under the Reagan administration both decreased capital taxes at the shareholder level in order to alleviate double taxation. In this paper we will discuss how the allocation of capital in the economy can be improved by alleviating double taxation in the other direction. Namely by decreasing the corporate income tax and replacing the forgone income by a tax on shareholders.

Specifically we ask what is the effect of replacing the corporate income tax by a tax on shareholders, in a revenue neutral way. To answer this question we construct a model with heterogeneous firms, borrowing constraints, costly equity issuance, and endogenous entry and exit. After calibrating the model to the U.S. economy, we find that when the corporate income tax is replaced by a tax on shareholders (to be described in more detail later), steady-state output increases by 6.8% and total factor productivity (TFP) increases by 1.7%.

We compute steady states for all corporate income tax rates between the current statutory rate of 35% and 0, and in each case set the tax on shareholders such that government revenue is unchanged. As predicted by the neoclassical growth mode, we find that output, total factor productivity, and steady state welfare all peak when the

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corporate income tax rate is zero.

The mechanism behind the efficiency gain is as follows. Firms randomly receive idiosyncratic investment opportunities (modeled as idiosyncratic persistent productivity shocks). When hit by a shock, firms seek to adjust its capital stock in pursuit of optimal size. Due to financial frictions, optimal firm behavior often dictates reliance on retained earnings for growth. The corporate income tax reduces retained earnings available for investment, thereby delaying capital accumulation. As the retained earnings are not paid back to shareholders, the friction just described is absent when taxes are levied only at the dividend level.

The general equilibrium feedback and endogenous entry and exit play an important role in the quantification of the mechanism. The revenue neutral tax reform triggers an increase in the demand for capital and labor. In turn, the higher demand increases the wage, and as a result less productive firms no longer find it optimal to remain active. Firm turnover increases, and more importantly, in steady state, the average productivity of active firms increases. The higher wage also increases the households labor supply, contributing to the increase in output.

Our paper relates to literature examining taxation and corporate financial policy from a theoretical perspective.[1] This literature has focused on the effect of taxes on firm behavior from a partial equilibrium 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." The new view is in contrast with an alternative "traditional view," which assumes that equity serves

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[1]See Auerbach (2002) for a comprehensive review.

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 funding for investment as given and examines the implications of a set of taxes on firm behavior.

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.

Our work also relates to an empirical literature which estimates the elasticity of capital taxes on investment. The estimates (for publicly traded firms) range between -1 and -0.5 (see Hassett and Hubbard (2002) ). However, recent studies have used novel data from tax returns finding different results. Zwick et al. (2014) exploits variation in eligibility for bonus depreciation allowances, which are effectively reductions on the corporate income tax base. They find a much larger elasticity: -1.6. Moreover, they find that small firms respond 95% more than big firms. Using the same data, Yagan (2015) exploits the different incidence of a recent tax reform on S-corporations versus C-corporations.[2] He finds no effect of the dividend tax on firm investment. Our model can theoretically rationalize the apparently contradictory results. Firms facing financial frictions will decrease

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[2]See Yagan (2015) for a detailed explanation about the differences between S-corporations and C-corporations and the resulting tax treatment.

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investment in response to an increase in the corporate income tax, as the latter decreases their net worth. The effect is particularly important for smaller firms that are more likely to be constrained. On the other hand, as firms endogenously rely on retained earnings to finance investment, increases in the dividend tax rate won't decrease investment.

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. 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 use to consider the entire firm life-cycle. In particular, in our model the firms go through a non-trivial growth process that is delayed by the corporate income tax. Considering the full life-cycle of firms is crucial to quantifying the mechanism described above.

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 dynamics 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 a 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,

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

The households own all the firms in the economy. Denote by $\Phi(s)$ the measure of shares of firms 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

$$\pi(k, z) = \max_l \ F(z, k, l) - wl \tag{2}$$

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.[3] 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, $b_t \leqslant \theta(1-\delta)k_t$. 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 floatation costs incurred when issuing equity. They will be calibrated to match the frequency and average value 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 $\tau_c\big(\pi(k,z) - \delta k - rb\big)$.

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.[4] This will be important for equity issuances: in the context of our model,

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[3] Although firms are risk neutral, because of the financial frictions, they value cash flows more in certain states of the world.

[4] According to the U.S. tax code capital losses are deductible as long as they are offset by capital gains.

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 $\tau_l(w_t L_t) = \tau_l w_t L_t - \Delta$.

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.

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 firm, the shock $z$ is realized. *Incumbents* choose to continue or exit.[5]

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

This is consistent with our model because in steady state the value of the portfolio is constant.

[5]Entrants commit to operate during the first period.

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,

$$
\begin{aligned}
C + B' + \int E(s)\phi'(s)ds &= B(1 + (1-\tau_i)r) \\
&+ \int \Big( E(s) + (1-\tau_d)D(s) - \tau_g(E(s) - E^-(s)) \Big)\phi(s)ds + wL - \tau_l(wL)
\end{aligned}
\tag{3}
$$

Where $E^-(s)$ is last period's value of a firm of type $s$. We define assets $A$ as,

$$
A = B(1 + (1-\tau_i)r) + \int \Big( E(s) + (1-\tau_d)D(s) - \tau_g(E(s) - E^-(s)) \Big)\tilde{g}_t(s)ds
\tag{4}
$$

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,

$$V(A) = \max_{B', \phi'(s)} u(C, L) + \beta V(A') \tag{5a}$$

$$\text{s.t: } C + B' + \int E(s)\phi'(s)ds = A + (1 - \tau_l)wL - \tau_l(wL) \tag{5b}$$

$$\text{s.t: } A' = B'(1 + (1 - \tau_i)r) \tag{5c}$$

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

$$\text{s.t: } B' \geqslant \underline{B} \tag{5d}$$

Here $\underline{B}$ 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

$$u'(C, L) = (1 + (1 - \tau_i)r)\beta u'(C', L') \tag{6}$$

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

Second, the no-arbitrage condition implies,

$$(1 - \tau_i)r = (1 - \tau_g)\frac{E' - E}{E} + (1 - \tau_d)\frac{D}{E} \tag{7}$$

Third, labor supply

$$-u_l(C, L) = (1 - \tau_l)wu_c(C, L) \tag{8}$$

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,

$$P(s) = (1 - \tilde{\tau}_d)D(s) - N(s) - \Lambda(N(s)) + \tilde{\beta}P'(s) \tag{9}$$

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 $d \geqslant 0$ and $j = 1$ otherwise.

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

$$\pi(z, k) + b' - (1 + r)b = d + k' - (1 - \delta)k + \tau_c \left(zk^\alpha - f - \delta k - rb\right) \tag{10}$$

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

Define net worth as, $\omega = \pi(k, z) - \tau_c \left(\pi(k, z - \delta k - rb)\right) + (1 - \delta)k - (1 + r)b$. This is

a sufficient statistic for the firms dynamic decisions.

The problem of a firm be written recursively as,

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

$$+ \tilde{\beta}\mathbb{E}_{z'}\Big[\max\big\{(1 - \tau_d)\big((1 - (1 - \tau_c)\delta)k' - (1 + (1 - \tau_c)r)b'\big), P(\omega', z')\big\}\,|z\Big] \tag{11b}$$

$$\text{s.t: } \omega' = \pi(k', z') - \tau_c\big(\pi(k', z') - \delta k' - rb'\big) + (1 - \delta)k' - (1 + r)b' \tag{11c}$$

$$\text{s.t: } \theta(1 - \delta)k' \geqslant b' \tag{11d}$$

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 $P()$ 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,

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

$$= P\big((1 - \tau_c)\pi(k', z^*) + (1 - (1 - \tau_c)\delta)k' - (1 + (1 - \tau_c)r)b', z^*\big) \tag{12}$$

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.

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 higher exit rates. However when liquidations are taxed, $\tilde{\tau}_d$

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[6]) is,

$$
\begin{aligned}
(1-\tilde{\tau}_d)\tilde{\beta}^{-1} =\ & (1-\tilde{\tau}_d)(1-(1-\tau_c)\delta)\Pr\big(z' < z^*(k',b')\big) \\
& + \int_{z^*(k',b')}^{\bar{z}} P_\omega\big(\omega',z'\big)\Big(\big((1-\tau_c)\pi_k(k,z)-\delta\big)+1\Big)pr(z'|z)dz' \\
& + \theta(1-\delta)\mu
\end{aligned}
\tag{13}
$$

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 âĂŞwith probability $\Pr\big(z' < z^*(k',b')\big)$âĂŞ it keeps 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: $P_\omega\big(\omega',z'\big)$. This value satisfies,

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[6]The value function has kinks at the point where dividends are zero, and at the exit threshold.

$$
\begin{aligned}
P_\omega(\omega', z') &= 1 - \tilde{\tau}_d && \text{if } d(w', z') > 0 \\
&= 1 + \lambda_1 && \text{if } d(w', z') < 0 \\
&\in [1 - \tilde{\tau}_d, 1 + \lambda_1] && \text{if } d(w', z') = 0
\end{aligned}
\tag{14}
$$

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.

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Besides exit and investment, firms choose the value of debt to be issued. The first order condition with respect to $b'$ is given by,

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

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 $(1-\tau_i) \geqslant (1-\tau_c)(1-\tau_g)$. The last inequality implies $\tilde{\beta}(1+(1-\tau_c)r) \leqslant 1$.

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 serial correlation of shocks is 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

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

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

where, $x(z', \omega, z) = 1$ if $z' > z^*\big(k'(\omega, z), b'(\omega, z)\big)$ and $\Gamma$ denotes the distribution of productivity shock. That is, a firm with state $\omega, z$ goes into $\Omega \times \mathcal{Z}$ if its realized next

worth, given its optimal choices of investment and borrowing is in $\Omega$ with probability $\int_{\mathcal{Z}} d\Gamma(dz'|z)$, 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,

$$\Phi'(\Omega, \mathcal{Z}) = \int Q(\omega, z, \Omega, \mathcal{Z}) d\Phi(\omega, z) \qquad \text{if } 0 \notin \Omega$$

$$\Phi'(\Omega, \mathcal{Z}) = \int Q(\omega, z, \Omega, \mathcal{Z}) d\Phi(\omega, z) + M \int d\Gamma^e(z) \qquad \text{otherwise} \qquad (16b)$$

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,

$$Y_t = \int \left( z_t k_t^{\alpha_k} l_t^{\alpha_l} - f \right) d\tilde{\Phi}_t(k_t, b_t, z_t)$$

$$\Pi_t = \int \pi(z_t, k_t) d\tilde{\Phi}_t(k_t, b_t, z_t)$$

$$I_t = \int \left( k_t + 1 - (1 - \delta)k_t \right) d\tilde{\Phi}_t(k_t, b_t, z_t)$$

$$\Lambda_t = \int (\lambda_0 + \lambda_1 d_t) j_t d\Phi_t(\omega_t, z_t)$$

### 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

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

5. Markets clear in every period:

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

$$
Y_t = C_t + I_t + \Lambda_t + G_t \tag{19}
$$

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 $F(z, k, l) = z k_k^\alpha l_l^\alpha - f$. 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 calibrated 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 taxed at 15% for all incomes falling on or above the third tax bracket.[7] 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.

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[7]For instance in 2013, the 15% rate applied for incomes above \$36,250 for single taxpayers and above \$72,500 for those filing jointly.

([1994](#)). We set $\tau_l = \tau_i = 0.28$.

## 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 parameters 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 $H$.[8]

### 3.2.1 Selection of moments

We choose moments 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 $\int i(\omega, z)/k d\tilde{\Phi}(\omega, z)$. 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, $\int d(\omega, z) j(\omega, z) d\Phi(\omega, z)/\int k d\tilde{\Phi}(k, b, z)$. In order to identify $\rho_z$ and $\sigma_z$ we include the serial autocorrelation and the standard deviation of the profits to capital ratio $\pi/k$.[9] The turnover rate defined as the mass of

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[8]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.

[9]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

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entrants over the mass of incumbents, $M/\int d\Phi$ , should be informative about the cost of entry $c_e$. Average leverage $\int b/k \, d\tilde{\Phi}(k, b, z)$ 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 +

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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)[10]; 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 and model moments matched for the calibration.

|  | Data | Model |
|---|---|---|
| Average investment rate | 0.05 | 0.05 |
| Standard deviation of profits | 0.11 | 0.09 |
| Average leverage | 0.17 | 0.21 |
| Average equity issuances | 0.09 | 0.11 |
| Frequency of equity issuances | 0.19 | 0.23 |
| Autocovariance of profits | 0.39 | 0.61 |
| Turnover | 0.06 | 0.05 |
| Time at work | 0.33 | 0.33 |
| Average dividends to profits | 0.48 | 0.43 |

[10]We use the filter proprosed 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 that 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,

| Parameter | Interpretation | Value |
|:---------:|:--------------:|:-----:|
| Calibrated Parameters | | |
| $\theta$ | collateral constraint | 0.23 |
| $\lambda_0$ | fixed cost of equity issuance | 0.025 |
| $\lambda_1$ | linear cost of equity issuance | 0.24 |
| $\rho_z$ | autocorrelation of productivity shocks | 0.75 |
| $\sigma_z$ | std. deviation of productivity shocks | 0.1 |
| $\delta$ | depreciation rate | 0.08 |
| H | disutility of labor | 3.4 |
| f | fixed cost of operation | 1.44 |
| $c_e$ | cost of entry | 0.04 |
| Fixed Parameters | | |
| $\beta$ | discount rate | 0.972 |
| $\gamma$ | labor supply elasticity | 0.5 |
| $\sigma$ | intertemporal elasticity of substitution | 1 |
| $\alpha_k$ | capital share | 0.21 |
| $\alpha_l$ | capital share | 0.64 |
| Taxes | | |
| $\tau_c$ | corporate income tax | 0.35 |
| $\tau_d$ | dividend tax | 0.15 |
| $\tau_g$ | tax on capital gains | 0.15 |
| $\tau_i$ | interest income tax | 0.28 |
| $\tau_l$ | labor income tax | 0.28 |

# 4  Thought Experiment

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

Our first exercise consists on 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 disincentivizing the 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 their borrowing constraint in order 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,

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

Figure 1 depicts the effect of the described change in government policy on several
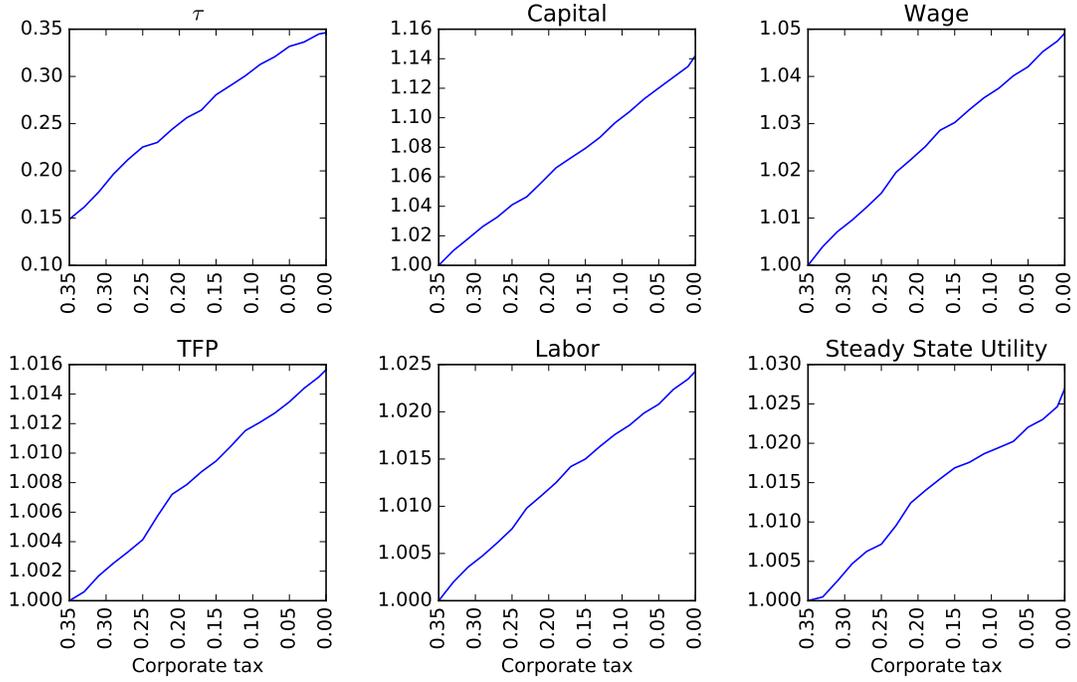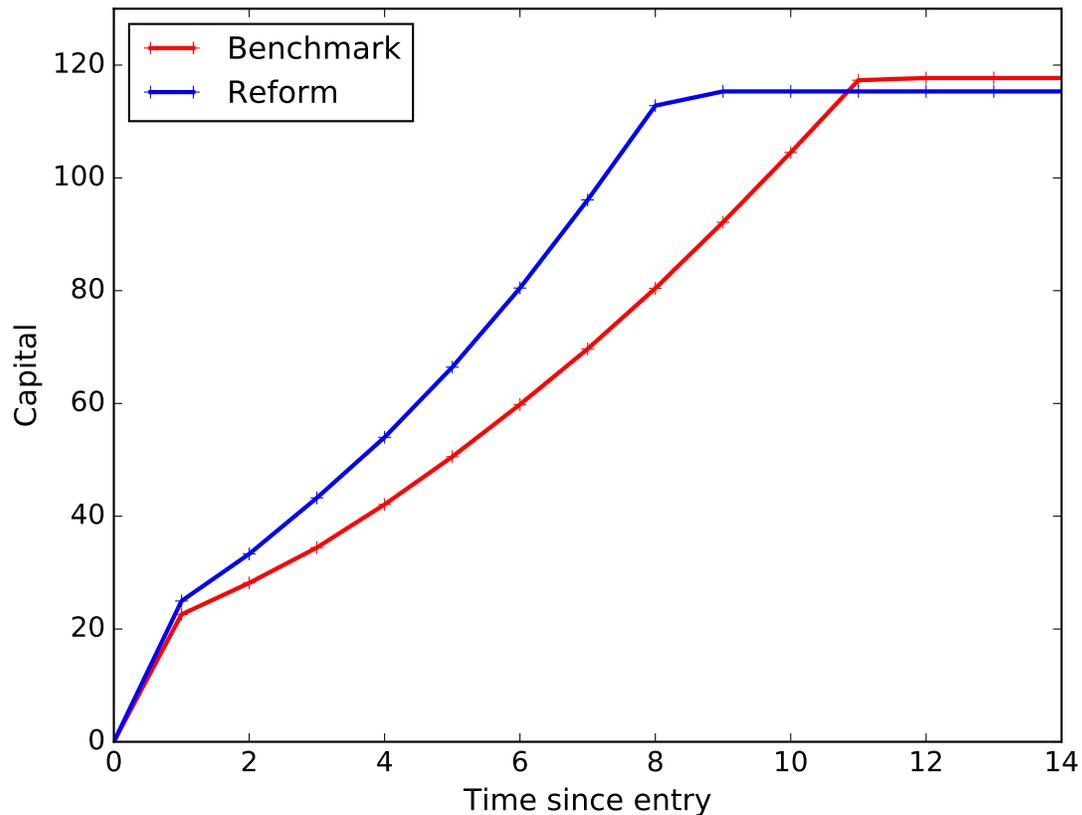
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Figure 1: Effects of Tax Reform

Figure 2: Capital Accumulation Before and After Reform



variables of interest. As shown by the first panel, the corporate income tax can be replaced by a common tax on shareholders of 34.6%. The rate is comparatively low and suggests substantial efficiency gains. In fact, the second panel shows that TFP increases of 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 2. 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 way.

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 reserch.

# References

Arellano, M. and Bond, S. (1991). Some tests of specification for panel data: Monte carlo evidence and an application to employment equations. *The review of economic studies*, 58(2):277–297. 23

Auerbach, A. J. (1979). Share valuation and corporate equity policy. *Journal of Public Economics*, 11(3):291–305. 3, 15

Auerbach, A. J. (2002). Taxation and corporate financial policy. *Handbook of public economics*, 3:1251–1292. 3

Bradford, D. F. (1981). The incidence and allocation effects of a tax on corporate distributions. *Journal of Public Economics*, 15(1):1–22. 3, 15

Chetty, R., Guren, A., Manoli, D., and Weber, A. (2011). Are micro and macro labor supply elasticities consistent? a review of evidence on the intensive and extensive margins. *The American Economic Review*, 101(3):471–475. 21

Cooley, T. F. and Quadrini, V. (2001). Financial markets and firm dynamics. *American Economic Review*, pages 1286–1310. 4

Gomes, J. F. (2001). Financing investment. *American Economic Review*, pages 1263–1285. 4, 20, 25

Gourio, F. and Miao, J. (2010). Firm heterogeneity and the long-run effects of dividend tax reform. *American Economic Journal: Macroeconomics*, pages 131–168. 5, 8

Gourio, F. and Miao, J. (2011). Transitional dynamics of dividend and capital gains tax cuts. *Review of Economic Dynamics*, 14(2):368–383. 5, 8

Greenwood, J., Hercowitz, Z., and Huffman, G. W. (1988). Investment, capacity utilization, and the real business cycle. *The American Economic Review*, pages 402–417. 20

Hassett, K. A. and Hubbard, R. G. (2002). Tax policy and business investment. *Handbook of public economics*, 3:1293–1343. 4

Hennessy, C. A. and Whited, T. M. (2005). Debt dynamics. *The Journal of Finance*, 60(3):1129–1165. 4, 8, 25

Hennessy, C. A. and Whited, T. M. (2007). How costly is external financing? evidence from a structural estimation. *The Journal of Finance*, 62(4):1705–1745. 4, 8

Hopenhayn, H. A. (1992). Entry, exit, and firm dynamics in long run equilibrium. *Econometrica: Journal of the Econometric Society*, pages 1127–1150. 6, 7

King, M. A. (1974). Taxation and the cost of capital. *The Review of Economic Studies*, pages 21–35. 3, 15

Kiyotaki, N. and Moore, J. (1995). Credit cycles. Technical report, National Bureau of Economic Research. 8

Krueger, D. and Ludwig, A. (2016). On the optimal provision of social insurance: Progressive taxation versus education subsidies in general equilibrium. *Journal of Monetary Economics*, 77:72–98. 9, 21

Lee, Y. (2007). The importance of reallocations in cyclical productivity and returns to scale: evidence from plant-level data. *US Census Bureau Center for Economic Studies Paper No. CES-WP-07-05*, pages 05–09. 20

Lee, Y. and Mukoyama, T. (2015). Productivity and employment dynamics of us manufacturing plants. *Economics Letters*, 136:190–193. 23

Li, S., Whited, T. M., and Wu, Y. (2016). Collateral, taxes, and leverage. *Review of Financial Studies*, page hhw008. 25

McKeon, S. B. (2015). Employee option exercise and equity issuance motives. *Available at SSRN 1920985*. 24

Mendoza, E. G., Razin, A., and Tesar, L. L. (1994). Effective tax rates in macroeconomics: Cross-country estimates of tax rates on factor incomes and consumption. *Journal of Monetary Economics*, 34(3):297–323. 21

Prescott, E. C. (1986). Theory ahead of business-cycle measurement. In *Carnegie-Rochester conference series on public policy*, volume 25, pages 11–44. Elsevier. 20

Yagan, D. (2015). Capital tax reform and the real economy: The effects of the 2003 dividend tax cut. *The American Economic Review*, 105(12):3531–3563. 4

Zwick, E., Mahon, J., et al. (2014). Do financial frictions amplify fiscal policy? evidence from business investment stimulus. *Harvard University*. 4