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# Financing Corporate Tax Cuts with Shareholder Taxes\*

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## Abstract

We study the aggregate and distributional consequences of replacing corporate profit taxes with shareholder taxes, namely, taxes on dividends and capital gains, in a setting with incomplete markets and heterogeneity at both the household and the firm level. The reform yields distributional gains with a large majority of households benefiting. Moreover, if dividend and capital gains are taxed at the same rate, the reform is also efficiency-enhancing and the implied optimal corporate income tax rate is zero. In contrast, an asymmetric tax treatment of dividend and capital gains induces a trade-off between efficiency and distributional concerns that is optimally resolved at a positive optimal corporate tax rate, implying double taxation.

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# 1 Introduction

Corporate income tax cuts remain one of the most polarizing topics in fiscal policy. This issue has returned to the forefront of political debate with the current administration's Tax Cuts and Jobs Act of 2017, which includes a sizable reduction in corporate profit rates. Often, proponents of the tax cuts emphasize the inefficiency of raising revenues using corporate taxes relative to other income taxes, while opponents argue that the revenue loss induced by the reforms would have to be compensated with personal income tax hikes or cutbacks in benefits programs, targeted at the least wealthy, if the reforms are to be revenue-neutral. The academic literature provides ample support to both the positive efficiency gains from lower corporate taxes and the potential negative distributional effects.<sup>1</sup>

In this paper, we study whether a corporate profit tax reform can deliver some of the efficiency gains from a corporate tax cut while, at the same time, avoiding the negative distributional consequences and gaining popular support. We address these questions in an infinite horizon framework with incomplete markets that features idiosyncratic uncertainty at both the household and the firm level. In such a setting, we show that corporate profit tax cuts can gain widespread political support whenever revenue-neutrality is induced via higher taxes that fall on the same group of people, namely, the shareholders. To be more specific, we consider dividend and capital gains taxes and investigate whether increasing one, or both, of them to compensate for a reduction in the corporate tax can lead to efficiency, distributional and overall welfare improvements. In addition, by considering a series of tax cuts of different size, we are able to determine the optimal mix of corporate and shareholder taxes. This also sheds light on the question of whether double taxation of dividends is justified from an optimal perspective. To our knowledge, our model is the first one to investigate these issues in a setting with substantial amount of both household and firm heterogeneity.

From a pure efficiency perspective, our analysis can be thought of as a comparison between the relative importance of the distortions caused by the corporate tax versus the distortions caused by shareholder taxes. First, we argue that the answer can be misleadingly simple in the context of a standard growth model with no heterogeneity. In that context, corporate income taxes reduce investment incentives by lowering the after tax returns to investment, capital gains taxes also distort investment by raising the cost of capital, but a constant dividend tax does not distort the investment decision because it does not directly affect the returns to investment (although it affects stock prices).<sup>2</sup> This would suggest that concentrating all taxes on dividends only would be the optimal choice. However, this conclusion is unwarranted when markets are incomplete.

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<sup>1</sup>See e.g, the literature based on the classic Chamley-Judd results and more recent work in incomplete markets setups such as Domeij and Heathcote (2004) and Conesa, Kitao and Kruger (2009).

<sup>2</sup>See McGrattan and Prescott (2005), Santoro and Wei (2011) and Atesagaoglu (2012) amongst many others

When households face uninsurable idiosyncratic risk, the wealth effect arising from the stock price changes is transmitted in general equilibrium to savings and investment, implying that the neutrality of dividend taxes is no longer true. In addition, when firms seek external financing to grow, a difference between the dividend tax rate and the capital gains tax rate acts as a financing friction and leads to distortions in the allocation of capital across firms.<sup>3</sup> One of the main objectives of this paper is to quantify and compare the direct distortions of the corporate profit tax with the indirect distortions of shareholder taxes in the presence of a tax wedge between the shareholder taxes.

The preceding discussion suggests that the distortions due to the tax wedge could potentially be avoided simply by increasing the capital gains tax in tandem with the dividend tax, which avoids introducing the wedge. However, this would introduce a direct distortion of the capital gains tax on the cost of capital and it is an open question whether this distortion compares favorably to the direct one caused by corporate taxes. In a simple growth model, we argue that these distortions are identical and the corporate tax is equivalent to an equal tax on dividends and capital gains. Moreover, we provide conditions under which this result can be extended to an economy with incomplete markets and external financing, a result that constitutes a theoretical contribution in itself. However, the equivalence between corporate and shareholder taxes relies on a definition of taxable corporate income which is at odds with the actual tax code. In our quantitative analysis, which uses a more standard definition of taxable income, the equivalence is no longer true. Clarifying and quantifying the direct distortions of corporate and shareholder taxes is another important objective of the present paper.

Apart from efficiency considerations, our focus is on the distributional aspects of the reforms, which are very relevant since our setting includes both firm and household heterogeneity. In particular, our model features a continuum of households that are subject to uninsurable idiosyncratic labor income risk and a continuum of firms that are subject to idiosyncratic productivity shocks. Firms use a decreasing returns to scale technology that combines labor and capital to produce output. They own capital directly and decide on investment, payout and financing policy. The latter consists in choosing between using internal funds or issuing new equity. All of the firms' stocks are bundled together in one asset which can be interpreted as a mutual fund. This simplifying assumption, which we borrow from Favilukis, Ludvigson and van Nieuwerburgh (2013), is crucial in making the model tractable.<sup>4</sup> Households can trade in shares of this single asset and earn asset income, in the form of dividends and capital gains from their share holdings, as well as labor income. The government has a

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<sup>3</sup>These two points are made in Anagnostopoulos et al (2012), in the context of a model with only household heterogeneity, and by Gourio and Miao (2010), in the context of a model with only firm heterogeneity. The two papers study the effects of a reduction in shareholder taxes, but they do not study corporate tax reform.

<sup>4</sup>Favilukis et al (2013) focus on the housing market, specifically the variability of the price-rent ratio. In their model, there are only two firm-sectors, a consumption good producing sector and a housing sector. Households buy stocks in a mutual fund that combines these two productive sectors.

fixed spending which it can finance through flat taxes on firms' profits and on households' labor and asset income.

Starting at the benchmark calibrated economy we consider permanent changes in the corporate tax rate and concurrent increases in shareholder taxes that maintain long run government revenue fixed. In the first experiment, we increase both dividend and capital gains taxes maintaining the equality between the two. In the second experiment, only dividend taxes are increased and this introduces a tax wedge between dividend and capital gains taxes. In both experiments, wages increase and capital returns decrease in the long run. This ensures that households at the bottom of the wealth distribution that rely mainly on labor income benefit from the reforms. Thus both types of reform have positive distributional consequences, in the sense that high marginal utility households benefit, and are supported by a large majority of households. Interestingly, this stands in contrast to corporate tax cuts financed through labor taxes which tend to imply negative redistribution and limited support. At the same time, the two reforms are markedly different regarding their effects on efficiency.

When only dividend taxes are increased, we show that the resulting misallocation of capital due to the wedge in shareholder taxes dominates the distortions caused by the corporate tax. Although aggregate capital and output increase significantly due to the corporate tax reduction, the misallocation of capital combined with large transitional costs due to the short run increase in savings and drop in consumption lead to welfare losses from an aggregate perspective. Using a utilitarian social welfare function, these aggregate losses are traded-off against the positive distributional effects. For large reductions in the corporate tax rate social welfare decreases because the aggregate component dominates, while smaller reductions have a quantitatively small, positive effect on social welfare. The implication is that social welfare is maximized at a positive corporate tax rate, implying that double taxation can be an optimal response to the efficiency versus distribution trade-off in this case.

In contrast, increasing both dividend and capital gains taxes together yields both efficiency and distributional benefits. These become larger, the larger the decrease in corporate taxes which means that the optimal choice would be to eliminate corporate taxes in this case. The efficiency benefits arise due to an improvement in capital allocation. In the long run, aggregate capital is lower but more efficiently distributed, leading to a higher output. In contrast to the standard effects of capital tax cuts which induce additional savings to increase long run output, the transition here features a reduction in savings and an increase in consumption, which generates positive efficiency effects.

Overall, our results suggest that a reform which maintains equality of dividend and capital gains taxes might be preferable in the sense that it delivers efficiency gains on top of the distributional gains. Two important observations are worth noting. First, although the elimination of corporate taxes while maintaining the equality of shareholder taxes yields the highest social welfare gains, complete elimination is likely to face substantial opposition in practice. In fact, a less dramatic corporate tax reduction was included in the previous US administration's tax reform proposal and is included in the current administration's

Tax Cuts and Jobs Act of 2017, both of which complemented with arguments in favor of simplification of the tax code.<sup>5</sup> A simple way to capture this in our framework would be to consider a reform which equalizes the tax rates for all types of personal income as well as for corporate income. We include results from such an experiment, where the common tax rate required is approximately 28%, and we find that such a reform would lead to overall welfare gains and command wide political support in the sense of welfare gains for 84% of households. Similarly, reducing corporate profit taxes to 20%, as in the current administration’s Tax Cuts and Jobs Act of 2017, would still have the support of about 83% of the households for the status quo labor income taxes but higher shareholder taxes than the ones stipulated for the vast majority of households in the American Taxpayer Relief Act of 2012.

Second, the reform which maintains equality of dividend and capital gains taxes is also more robust to relaxing the assumption that tax changes are unexpected. We show this by also computing transitions and welfare under the assumption that the reform is anticipated one or two years in advance. In that case, a reform that increases only dividend taxes can have very different implications regarding the short run responses of macroeconomic aggregates because firms engage in tax arbitrage in an attempt to take advantage of the temporarily low dividend tax. This tax arbitrage has the effect of introducing additional fluctuation in wages during the transition and this mostly affects low-wealth individuals. As a result, the distributional benefits of the reform are reduced.

Given the computational complexity involved,<sup>6</sup> the model necessarily abstracts from several other potentially important mechanisms through which corporate taxes can affect macroeconomic outcomes. Recent studies have identified some of those mechanisms, such as the importance of the choice of the legal form of organization (Chen, Qi and Schlagenhauf (2014)), the presence of lumpy investment (Miao and Wang (2014)) or the role of capital mobility in an open economy setting (Fehr, Jokisch, Kambhampati, Kotlikoff (2013)). None of these studies consider shareholder taxation as part of the suggested reform and this is where our paper’s contribution lies relative to them.

Motivated by the Jobs and Growth Tax Relief Reconciliation Act of 2003, Gourio and Miao (2010) and Anagnostopoulos et al. (2012) investigate the effects of reducing shareholder taxes, but are silent about corporate profit tax reform. Relative to the former, our model incorporates household heterogeneity and incomplete markets which are crucial in order to capture the effects of shareholder taxes on precautionary savings as well as to evaluate the distributional welfare effects of tax reforms. At the firm level, we also extend the model to incorporate depreciation allowances, which reflect an important deduction in

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<sup>5</sup>See, for example, Luigi Zingales’ piece titled *A Better Way to Tax Corporations* at <http://www.nydailynews.com/opinion/better-tax-corporations-article-1.1093804>. The current (Trump) administration’s proposal can be found at <https://www.treasury.gov/press-center/press-releases/Documents/Tax-Framework.pdf> and the previous (Obama) administration’s proposal in *The President’s Framework for Business Tax Reform (2012)*.

<sup>6</sup>The double - sided heterogeneity is further complicated by the presence of occasionally binding constraints for both firms and households as well as the need to go further than steady states and compute transition paths in order to evaluate the welfare consequences of reforms.

the actual tax code. Relative to the latter, our model incorporates firm heterogeneity and external financing, which are crucial in order to evaluate the distortionary effects of an increase in dividend taxes. Integrating both mechanisms within the same framework is important since they can have opposite implications regarding the effects of shareholder taxes<sup>7</sup>.

Conesa and Dominguez (2013) is also related to our work, since it investigates corporate taxes in conjunction with dividend taxes. They show that the optimal scheme in the long run features zero corporate taxes and positive dividend and labor income taxes that are equalized to each other. While they go one step further by computing optimal Ramsey taxes rather than once-and-for-all tax rate changes, they abstract from capital gains taxes and heterogeneity, implying that their model does not capture the distortions arising from the tax wedge in shareholder taxes when markets are incomplete. As discussed above, these distortions imply that replacing corporate taxes with dividend taxes alone can have negative efficiency and welfare effects. In other words, our paper illustrates that their conclusion that one should switch from corporate taxes towards shareholder taxes does not hold in a framework with heterogeneity unless the use of dividend taxes is combined with equal capital gains taxes.

Section 2 provides the model, Section 3 discusses the main qualitative insights, Section 4 presents the calibration of the benchmark economy and Section 5 presents the quantitative results. Section 6 concludes.

## 2 The Model

We consider an infinite horizon economy with endogenous production, where time is discrete and indexed by  $t$ . Idiosyncratic firm productivity shocks generate firm heterogeneity and, at the same time, idiosyncratic labor efficiency shocks generate household heterogeneity. Both types of shocks wash out in the aggregate so that there is no aggregate uncertainty in this model. To keep the model tractable, we assume households trade only a single asset, which is interpreted as a mutual fund composed of all the firms in the economy as in Favilukis et al (2013). The sole role of the mutual fund is to intermediate between firms and households. A government maintains a balanced budget every period by taxing firm profits as well as household labor, dividend and capital gains income.

### 2.1 Households

There is a continuum (measure 1) of households indexed by  $i$  with identical utility functions given by

$$E_0 \sum_{t=0}^{\infty} \beta^t u(c_{it}), \quad (1)$$

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<sup>7</sup>In fact, results not provided here but available from the authors upon request show that the positive welfare results of shareholder tax cuts obtained by Gourio and Miao (2010) can be reversed if one introduces household heterogeneity into their framework.

where  $\beta \in (0, 1)$  is the subjective discount factor,  $c_{it}$  denotes consumption and  $E_0$  denotes the expectation conditional on information at date  $t = 0$ . The period utility function  $u(\cdot) : \mathbb{R}_+ \rightarrow \mathbb{R}$  is assumed to be strictly increasing, strictly concave and continuously differentiable, with  $\lim_{c_i \rightarrow 0} u'(c_i) = \infty$  and  $\lim_{c_i \rightarrow \infty} u'(c_i) = 0$ .

In the absence of leisure in the utility, households supply a fixed amount of labor (normalized to one) and receive labor income that is exogenous from their point of view. The economy-wide real wage rate is denoted by  $w_t$  but each household is subject to an idiosyncratic shock  $\epsilon_{it}$  to their productivity, so that labor income of household  $i$  is  $w_t \epsilon_{it}$ . The productivity shock is i.i.d. across households and follows a Markov process with transition matrix  $\Omega_\epsilon(\epsilon'|\epsilon)$  and  $N_\epsilon$  possible values.

Markets are incomplete. Households can only partially insure against uncertainty by trading shares  $\theta_{it}$  of a mutual fund, which comprises all the firms in the economy. Holding shares provides income to the household in the form of dividends as well as capital gains resulting from changes in the market value of these shares. Since there is no aggregate uncertainty, dividends and share prices are certain and the traded asset is risk free.

Households face proportional taxes on labor income, dividend income and capital gains income at rates of  $\tau_{lt}$ ,  $\tau_d$  and  $\tau_g$  respectively. They can use their after-tax income from all sources to purchase consumption goods or to buy shares  $\theta_{it}$  of the mutual fund at a competitive market price  $P_t$ . After-tax income includes labor income and the income from holding shares  $\theta_{it-1}$ . These shares entitle the household to a share  $\theta_{it-1}$  of the total after-tax dividend payout  $(1 - \tau_d) D_t$ . In addition, the shareholder can sell his shares at a price  $P_t^0$ , which represents the time  $t$  value of equity outstanding in period  $t - 1$ . The increase in the value of this existing equity  $(P_t^0 - P_{t-1}) \theta_{it-1}$  represents accrued capital gains, which are taxed at the rate  $\tau_g$ .<sup>8</sup> Since we allow firms to raise new equity  $S_t$ , the market value of equity at time  $t$  (after new equity is issued) is  $P_t = P_t^0 + S_t$ . The households' budget constraint can be expressed as:

$$c_{it} + P_t \theta_{it} = (1 - \tau_{lt}) w_t \epsilon_{it} + ((1 - \tau_d) D_t + P_t^0) \theta_{it-1} - \tau_g (P_t^0 - P_{t-1}) \theta_{it-1} \quad (2)$$

Short-selling of the mutual fund shares is not allowed

$$\theta_{it} \geq 0 \quad (3)$$

In each period  $t$ , households choose how much to consume and how many shares to buy given prices, dividends and tax rates  $\{P_t, P_t^0, w_t, D_t, \tau_{lt}, \tau_d, \tau_g\}_{t=0}^\infty$ . The optimal consumption/savings choice is described by a standard Euler equation which holds with equality for unconstrained households

$$1 + r_{t+1} \equiv \frac{P_{t+1}^0 + (1 - \tau_d) D_{t+1} - \tau_g (P_{t+1}^0 - P_t)}{P_t} = \frac{u'(c_{it})}{\beta E_t u'(c_{it+1})} \quad (4)$$

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<sup>8</sup> We make the simplifying assumption that capital gains taxes are paid on an accrual basis and that capital losses are subsidized at the same rate. This is the standard approach in the literature with the notable exceptions of Gavin, Kydland and Pakko (2007) and Dammon, Spatt and Zhang (2001).



where we have defined the net after tax return to be  $r_{t+1}$ . Note that, given the absence of aggregate uncertainty, that return is deterministic. Equation (4) simply states that, at an optimum, the after tax return on the asset must equal the intertemporal marginal rate of substitution of unconstrained households.

## 2.2 Firms

The production sector follows Gourio and Miao (2010) with some modifications. Firms use capital  $k$  and labor  $l$  to produce consumption goods  $y$  using a Cobb-Douglas production function with decreasing returns to scale

$$y = zf(k, l) = zk^{\alpha_k}l^{\alpha_l} \quad (5)$$

where  $0 < \alpha_k, \alpha_l < 1$  and  $\alpha_k + \alpha_l < 1$ . Production is subject to an idiosyncratic productivity shock  $z$  which is i.i.d. across firms and follows a Markov process with transition matrix  $\Omega_z(z'|z)$  and  $N_z$  possible values. We now consider the problem of a particular firm  $j$ .

Each period  $t$ , given the available capital and the current productivity realization, firm  $j$  chooses labor demand optimally. The choice of labor demand is a static problem and it defines the operating profit of the firm as follows:

$$\pi(k_{jt}, z_{jt}; w_t) \equiv \max_{l_{jt}} \{z_{jt}f(k_{jt}, l_{jt}) - w_t l_{jt}\} \quad (6)$$

where  $w_t$  is the economy-wide wage rate. The firm's labor demand is determined by the following optimality condition:

$$w_t = \alpha_l z_{jt} k_{jt}^{\alpha_k} l_{jt}^{\alpha_l - 1}$$

Given the determination of operating profits, we can now turn to the dynamic aspect of the firm's decision making problem, which includes the investment, financing and payout decisions. The firm has two sources of funds, internal and external. External funds are obtained by issuing new equity<sup>9</sup>. The value of new equity issued in period  $t$  is denoted by  $s_{jt}$ . Internal funds consist of operating profits  $\pi(k_{jt}, z_{jt}; w_t)$  net of taxes  $\tau_c T_{jt}$ , where  $T_{jt}$  denotes taxable income and  $\tau_c$  is a flat corporate income tax rate  $\tau_c$ . Funds can be allocated to dividends  $d_{jt}$  or capital expenditures, the latter consisting of new additions to the capital stock  $x_{jt}$  and capital adjustment costs  $\Phi(x_{jt}, k_{jt})$ . Thus, the firm's financing constraint is given by

$$d_{jt} + x_{jt} + \Phi(x_{jt}, k_{jt}) = \pi(k_{jt}, z_{jt}; w_t) - \tau_c T_{jt} + s_{jt} \quad (7)$$

where

$$T_{jt} = \pi(k_{jt}, z_{jt}; w_t) - \delta k_{jt} - \phi \Phi(x_{jt}, k_{jt}) \quad (8)$$

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<sup>9</sup> As shown by Gourio and Miao (2012), adding debt financing, while potentially complicating the computations considerably, does not alter the main findings.

Deductions from taxable income include a depreciation allowance  $\delta k_{jt}$  as well as a fraction  $\phi$  of adjustment costs. The firm's capital stock evolves according to:

$$k_{j,t+1} = x_{jt} + (1 - \delta) k_{jt} \quad (9)$$

where  $\delta \in [0, 1]$  is the capital depreciation rate. Finally, we assume dividend payments cannot be negative

$$d_{jt} \geq 0 \quad (10)$$

and no repurchases are allowed<sup>10</sup>

$$s_{jt} \geq 0 \quad (11)$$

We assume that firm  $j$  maximizes the expected present discounted sum of cash flows

$$E_0 \sum_{t=0}^{\infty} \left( \prod_{n=1}^t \frac{1}{1 + \frac{\tau_n}{1 - \tau_g}} \right) \left[ \frac{1 - \tau_d}{1 - \tau_g} d_{jt} - s_{jt} \right] \quad (12)$$

where the discount rate represents the shareholders' discount rate for mutual fund cash flows implied by (4).<sup>11</sup>

Let  $q_t$ ,  $\lambda_t^d$ ,  $\lambda_t^s$  be the multipliers on the constraints (9), (10) and (11) respectively.<sup>12</sup> The first order conditions of the firm's problem are:

$$\frac{1 - \tau_d}{1 - \tau_g} + \lambda_t^d + \lambda_t^s = 1 \quad (13)$$

$$q_t = \left( \frac{1 - \tau_d}{1 - \tau_g} + \lambda_t^d \right) [1 + \Phi_x(x_t, k_t) (1 - \tau_c \phi)] \quad (14)$$

$$q_t = \frac{1}{1 + \frac{\tau}{1 - \tau_g}} E_t \left( q_{t+1} (1 - \delta) + \left( \frac{1 - \tau_d}{1 - \tau_g} + \lambda_{t+1}^d \right) R_{k,t+1} \right) \quad (15)$$

$$R_{k,t+1} \equiv (1 - \tau_c) \frac{\partial \pi(k_{t+1}, z_{t+1}; w)}{\partial k_{t+1}} + \tau_c \delta - \Phi_k(x_{t+1}, k_{t+1}) (1 - \tau_c \phi) \quad (16)$$

When  $\tau_d = \tau_g$ , internal and external funds are equivalent sources of financing for the firm. In the absence of adjustment costs, marginal  $q$  would equal one for all firms and each firm would jump immediately to its long run optimal capital level. The presence of adjustment costs means firms will not in general be at their optimal level and the distribution of capital across firms could, in principle, be improved through tax changes. When  $\tau_d > \tau_g$  there is an additional friction

<sup>10</sup>This assumption is innocuous for the calibrated versions of our model where  $\tau_d = \tau_g$ . For the cases where dividend taxes are raised above capital gains taxes, we refer the reader to Gourio and Miao (2010) for a discussion of the relevance of the assumption as well as the potential effects from relaxing it.

<sup>11</sup>A discussion of alternative assumptions about the discount factor can be found in Favilukis et al (2013).

<sup>12</sup>We suppress the firm index  $j$  and focus on the stationary distribution in the following discussion.

that prevents the distribution of capital from being efficient. In that case, equity issuance is costly and firms exhaust their internal funds first before seeking external finance. Due to the tax wedge, firms will issue less equity than optimal and might even not issue equity at all and only grow internally. Firms with low current earnings but high productivity are the ones most in need of external finance and, hence, affected by this friction. As a result, the larger the tax wedge, the less efficient will be the distribution of capital.

Tax changes can affect the severity of both of these frictions and will, in general, cause a change in the distribution of capital across firms. In turn, this will have implications for total factor productivity, which can be measured in the model using:

$$TFP_t \equiv \frac{Y_t}{K_t^{\alpha_k} L_t^{\alpha_l}} \quad (17)$$

where  $Y_t$ ,  $K_t$  and  $L_t$  denote aggregate output, capital and labor input respectively. Under this definition, if capital were to increase proportionally across all firms, then  $TFP$  would remain unaffected. Thus, changes in  $TFP$  capture the effects of changes in the distribution of capital on aggregate production.

### 2.3 Government

In each period  $t$ , the government consumes an exogenous, constant amount  $G$  and taxes corporate profits, dividends, capital gains and labor income at rates  $\tau_c$ ,  $\tau_d$ ,  $\tau_g$  and  $\tau_{lt}$  respectively. We assume that the government maintains a balanced budget every period. The government budget constraint is given by

$$G = \tau_d D_t + \tau_{lt} w_t L_t + \tau_g (P_t^0 - P_{t-1}) + \tau_c \int T_{jt} dj \quad (18)$$

### 2.4 Market Clearing

At every period  $t$ , the stock market, the labor market and the goods markets clear<sup>13</sup>

$$\begin{aligned} \int \theta_{it} di &= 1 \\ \int l_{jt} dj &= \int \epsilon_{it} di \\ \int c_{it} di + \int x_{jt} dj + G + \int \Phi(x_{jt}, k_{jt}) dj &= \int y_{jt} dj \end{aligned}$$

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<sup>13</sup> A formal definition of the recursive competitive equilibrium as well as the computational algorithm used are available in an online appendix at <https://sites.google.com/a/stonybrook.edu/aanagnostopoulos/research>

### 3 Theoretical Analysis

This section discusses the main qualitative insights of the paper regarding the question of replacing corporate income taxes with shareholder taxes. Since we use the term ‘shareholder taxes’ to refer to two different tax instruments, i.e. dividend and capital gains taxes, there are several possibilities for the exact type of reform one could consider. We focus on two of them: using equal dividend and capital gains taxes to replace corporate income taxes; and using only dividend taxes to replace corporate income taxes, while keeping capital gains taxes fixed.<sup>14</sup>

We first discuss the case of a standard growth model in which the question has straightforward answers. In this benchmark, replacing corporate taxes with equal dividend and capital gains taxes has no effects. On the other hand, replacing the corporate tax with a constant dividend tax has considerable merit since a highly distortionary tax is replaced by a non-distortionary one.

The subsequent two subsections aim to clarify the reasons for why these sharp results rely on simplifying assumptions of the standard growth model and are not true in the full model. The implication is that the question of replacing corporate income taxes with shareholder taxes does not have an obvious answer and this is precisely the question addressed in this paper.

#### 3.1 Tax Effects in the Standard Growth Model

Suppose there is a representative household and a representative firm operating a constant returns to scale technology. Abstract from uncertainty, adjustment costs and equity issuance, in which case the model collapses to a standard growth model.<sup>15</sup> In the absence of taxes, the representative firm’s financing constraint is:

$$D_t + K_{t+1} - K_t = K_t^\alpha L_t^{1-\alpha} - w_t L_t - \delta K_t \quad (19)$$

The left side of the equation corresponds to dividends plus retained earnings, while the right hand side displays accounting profits, which constitute the corporate tax base. Normalizing the total number of outstanding stocks to one, let  $P_t$  denote both the market value of the firm or, equivalently, the price per stock. In this framework, the market value of the firm is equal to the aggregate capital stock,  $P_t = K_{t+1}$ . In turn, this equality between stock prices and aggregate capital implies that retained earnings  $K_{t+1} - K_t$  are equal to capital gains  $P_t - P_{t-1}$ .

Now consider introducing taxes. Several results can be easily deduced.<sup>16</sup> First, imposing a corporate tax on the corporate tax base (the right hand side

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<sup>14</sup>The third obvious case would be to raise capital gains taxes only, keeping dividend taxes fixed. However, since we start at a benchmark where  $\tau_d = \tau_g$ , this would imply  $\tau_g > \tau_d$  which would generate arbitrage possibilities and **did not happen historically**. Hence, we do not consider this option.

<sup>15</sup>The assumption of a dynamic firm that owns the capital stock, as opposed to a static firm renting capital from the household period-by-period, is innocuous. See Carceles-Poveda and Coen-Pirani (2010) for the equivalence of the two settings.

<sup>16</sup>Formal proofs are omitted, but available upon request.

of the financing constraint) is equivalent to imposing a tax at the firm level on the sum of dividends and retained earnings (i.e. an equal tax on the two terms of the left hand side of the financing constraint). This follows directly from equation (19). Second, assuming that a dynamic firm owns the capital stock and maximizes shareholder value, it can be shown that a corporate tax is also equivalent to an equal tax on dividends and capital gains at the household level. In the presence of shareholder taxes, the relationship between stock prices and aggregate capital is given by  $P_t = \frac{1-\tau_d}{1-\tau_g} K_{t+1}$ . As long as  $\tau_d = \tau_g$ , it is still the case that retained earnings are equal to capital gains and the equivalence between corporate and shareholder taxes holds. Third, since dividends are the residual of operating profits after investment has been subtracted, a constant tax on dividends does not tax investment directly and it does not distort the investment decision. In fact, McGrattan and Prescott (2005) have shown that a constant dividend tax does not affect any of the long run equilibrium aggregate variables except the market value of the firm  $P_t$ , which is affected by the change in  $\frac{1-\tau_d}{1-\tau_g}$ .

Given these results, we can conclude on the effects of the two alternative reforms mentioned above in the context of a simple growth model: replacing corporate taxes with equal dividends and capital gains taxes will have no effects, since these two taxes are equivalent, whereas replacing corporate taxes with a tax on dividends only will be an optimal policy, since the dividend tax is not distortionary.

### 3.2 Using Equal Dividend and Capital Gains Taxes in the Full Model

The simple equivalence between corporate and equal dividend and capital gains taxes that obtains in the simple growth model fails in our full model due to several features such as household heterogeneity, firm heterogeneity, uninsurable idiosyncratic risk for both firms and households, equity issuance, decreasing returns to scale technologies and adjustment costs. We explain this by providing a proposition which proves a similar equivalence result in a modified version of our model and by highlighting the modifications needed to obtain the equivalence. The crucial modification is a re-definition of accounting profits for corporate tax purposes. Since this modification does not necessarily reflect the reality of the US economy, it will serve as a guide for the intuition as to why the equivalence is broken in our more realistic full model.

Suppose that taxable income in (8) is adjusted to be:

$$\tilde{T}_{jt} = T_{jt} + (q_{jt}k_{j,t+1} - q_{jt-1}k_{jt}) - (k_{j,t+1} - k_{jt}) \quad (20)$$

where  $q_{jt}$  denotes the shadow value of capital for firm  $j$ . This definition introduces an additional component to taxable corporate income, which amounts to the difference between retained earnings and the value of those retained earnings when capital is valued at marginal  $q$ . We can now prove the following proposition.

**Proposition 1** *Suppose  $T_{jt}$  is replaced by  $\tilde{T}_{jt}$  and, in addition,  $\phi = 1$ . Starting at a stationary distribution of this model with  $\tau_c$  and  $\tau_s (= \tau_d = \tau_g)$  being the corporate and shareholder tax rates respectively, a reform that changes these tax rates to  $\tau_c^*$  and  $\tau_s^*$  such that*

$$(1 - \tau_s^*)(1 - \tau_c^*) = (1 - \tau_s)(1 - \tau_c)$$

*has no effect on any individual or aggregate variables except the dividend payout  $d_{jt} - s_{jt}$  which is adjusted according to*

$$(d_{jt} - s_{jt})^* = (d_{jt} - s_{jt}) + (\tau_c - \tau_c^*)\tilde{T}_{jt}$$

*with the corresponding aggregate  $D_t - S_t$  adjusted accordingly.*

We provide the proof in Appendix A. The proposition shows that corporate profit taxes are equivalent to shareholder taxes that are kept equal as long as the combined tax rate on the return to capital  $(1 - \tau_s)(1 - \tau_c)$  is kept fixed. The proof follows the main idea from the standard growth model discussed above in recognizing that the corporate tax base is equivalent to the sum of dividends and retained earnings, while retained earnings are closely related to capital gains. The assumed modifications with respect to our full model ( $\tilde{T}_{jt}$ ,  $\phi = 1$ ) ensure these that these relations hold in the long run by addressing two issues.

First, a tax on dividends and retained earnings falls on a base from which the adjustment costs have already been deducted. Therefore, to obtain equivalence of corporate and shareholder taxes in the presence of adjustment costs, these costs need to be completely deductible from corporate taxes, which ensures the same tax base as with shareholder taxes. This explains the requirement that  $\phi = 1$ .

Second, in our current setting, marginal  $q$  and average  $Q$  (the stock market value of a unit of capital) are not equalized due to decreasing returns to scale, while the simple relation between the market value of the firm and the capital stock,  $p_{jt} = k_{j,t+1}$ , is no longer true in presence of adjustment costs. Instead,  $p_{jt} = Q_{jt}k_{j,t+1}$ . As a result, a tax on retained earnings  $k_{j,t+1} - k_{jt}$  and a tax on capital gains  $p_{jt} - p_{j,t-1}$  is not exactly the same thing. Under constant returns to scale, marginal  $q$  would equal average  $Q$ , in which case  $(q_{jt}k_{j,t+1} - q_{j,t-1}k_{jt})$  would capture capital gains. The additional term in  $\tilde{T}_{jt}$ , by adding the difference between capital gains and retained earnings to the corporate tax base, would ensure that the corporate tax falls on dividends and capital gains and thus that both corporate and shareholder taxes fall on the same base. In other words, this adjustment would ensure the equivalence of shareholder and corporate taxes at the margin. With decreasing returns to scale, marginal  $q$  and average  $Q$  are not equalized, and the overall revenues raised from a tax on  $\int q_{jt}k_{j,t+1}dj - \int q_{j,t-1}k_{jt}dj$  will not in general be equal to those raised from a tax on capital gains,  $P_t - P_{t-1}$ . By focusing on the long run stationary distribution, however, the proposition ensures that capital gain revenues are equal to zero and this discrepancy in revenues is not an issue.

The tax code adjustments in the proposition above that recover the equivalence between corporate and shareholder taxes in the presence of adjustment costs are inspired by Abel (1983). To see the connection more closely, one can rearrange taxable income  $\tilde{T}_{jt}$  as follows

$$\tilde{T}_{jt} = \pi(k_{jt}, z_{jt}; w_t) - \Phi(x_{jt}, k_{jt}) - (q_{jt-1} - (1 - \delta)q_{jt})k_{jt} - (1 - q_{jt})x_{jt} \quad (21)$$

As discussed in Abel (1983), this essentially replaces the deduction of physical depreciation  $\delta k_{jt}$  with a deduction of true economic depreciation, which is given by  $(q_{jt-1} - (1 - \delta)q_{jt})k_{jt}$ , and also deducts the difference between new additions to the capital stock  $x_{jt}$  and the market value of these additions after installation. Abel uses this to show that corporate taxes are neutral in the presence of debt interest deductibility. Our proposition differs in three aspects: Conceptually, we are interested in establishing an equivalence between shareholder taxes and corporate taxes whereas Abel provides conditions under which the corporate tax is non-distortionary. Second, our result is proved in a general equilibrium framework with household and firm heterogeneity whereas Abel focuses on a partial equilibrium model of one firm. Third, Abel's result relies on homogeneity assumptions on production whereas we prove our result in an environment with decreasing returns. The equivalence between shareholder and corporate taxes would hold more generally under constant returns in our adjusted model, but with decreasing returns to scale we can only show this is true at the stationary distribution.

To summarize, the proposition shows that, when replacing corporate taxes with equal shareholder taxes, as long as the combined tax rate on the return to capital  $1 - \tau = (1 - \tau_s)(1 - \tau_c)$  is kept fixed, there will be no changes in either the decisions of firms and households at the margin or the overall tax revenues of the government (i.e. the tax bills footed explicitly or implicitly by shareholders). However, this relies on full deductibility of adjustment costs and a correction of taxable income, neither of which necessarily corresponds to the actual US tax code. The main usefulness of the theoretical result is in helping to build some intuition on why the reform *does* have effects in an economy without these tax code adjustments. Since we relax these assumptions in our full model, the implication is that switching from corporate taxes to an equal dividend and capital gains tax will make a difference and we investigate this quantitatively with our calibrated model.

### 3.3 Using Only Dividend Taxes in the Full Model

Using only dividend taxes changes the tax wedge  $\frac{1-\tau_d}{1-\tau_g}$  and hence the market value of the fund  $P_t$ . In the standard growth model, this change has no other effects on equilibrium quantities. The existing literature has identified two assumptions that are crucial for this, neither of which are present in our full model: a representative household facing complete markets and a representative firm with no financing frictions.

Regarding the first, markets are incomplete in our model and households save for precautionary reasons. Anagnostopoulos et al (2012) have shown that in this environment there can be a large wealth effect which tends to increase savings and capital when this wedge goes down because dividend taxes are increased. The idea is that higher dividend taxes decrease the wedge and thus the value of equity and the overall wealth, leading to higher precautionary savings. Regarding the second, Gourio and Miao (2010) have shown that if  $\tau_d > \tau_g$ , this can create significant misallocation of capital in an environment with heterogeneous firms. The idea is that such a tax wedge makes equity financing costly and hurts disproportionately those firms that have high growth prospects and need equity financing the most. Consequently, even a constant dividend tax will have important effects on both aggregate savings and the allocation of capital across firms.

In sum, with incomplete markets, both household and firm heterogeneity break the neutrality of constant dividend taxes and it is no longer obvious that a dividend tax alone is preferable to a corporate tax. On the one hand, a corporate tax creates distortions to capital accumulation by directly affecting after tax returns to investment. On the other hand, while the dividend tax does not directly affect the after tax return to capital, it can indirectly do so through wealth effects in general equilibrium and it can also affect the allocation of capital across firms. The calibration exercise that follows incorporates these different effects and aims to quantitatively determine which of these distortions are more severe. It is worthwhile noting that, by incorporating these trade-offs between the distortions of corporate taxes and the distortions caused by dividend taxes, our model has the potential to deliver double taxation as an optimal policy. We view this as an important novel feature of our work.

## 4 Calibration

The time period is assumed to be one year and the parameters used are reported in Table 1. Preferences are of the CRRA class,  $u(c) = \frac{c^{1-\mu}-1}{1-\mu}$ , with a coefficient of relative risk aversion  $\mu = 1$ . The discount factor is set to  $\beta = 0.934$  which makes the mutual fund  $r$  equal to 4%. The implied aggregate capital to output ratio is 2.03, which is roughly in line with the average capital output ratio in the US corporate sector.

The benchmark economy features substantial heterogeneity on the household side arising from the idiosyncratic labor productivity process. This process is taken from Davila, Hong, Krusell and Ríos-Rull (2012) and is constructed so that it delivers reasonable values for the Gini coefficients of labor earnings and of wealth using a parsimonious Markov chain model with only three states.<sup>17</sup> Table 2 shows that it yields a stationary distribution with 50% of households at the low productivity, 44% with medium productivity and only 6% with high productivity.

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<sup>17</sup>For details on this see also Diaz, Pijoan-Mas, Ríos-Rull (2003) and Castaneda, Diaz-Gimenez and Ríos-Rull (2003).



The depreciation rate  $\delta$  is set to 0.054 following Atesagaoglu (2012) who computes this using National Income and Product Accounts and Fixed Asset Tables data for the post-WWII period. For the production function and firm productivity shocks, we use the calibration from Gourio and Miao (2010). They estimate the degree of decreasing returns to scale using COMPUSTAT Industrial Annual Data. The production function parameters  $\alpha_k$  and  $\alpha_l$  are obtained by choosing  $\alpha_l = 0.650$  to match the average labor income share in US data and  $\alpha_k = 0.311$  to capture the estimated degree of decreasing returns to scale. The process for firm level productivity shocks is estimated by fitting an AR(1) process to the residuals  $z_t$  of their estimated regression

$$\ln z_t = \rho \ln z_{t-1} + \varepsilon_t, \varepsilon_t \sim N(0, \sigma^2)$$

The estimated values for  $\rho$  and  $\sigma$  are 0.767 and 0.211 respectively. This process is approximated using a 10-state Markov chain, shown in Table 3, obtained by applying the method of Tauchen and Hussey (1991). Finally, the adjustment cost function is assumed to be  $\Phi(x, k) = \frac{\psi}{2} \left(\frac{x}{k} - \delta\right)^2 k$  and the parameter  $\psi = 1.210$  is chosen to match a cross-sectional volatility of the investment rate of 0.156 reported in their paper.

Regarding government variables, we set the labor income tax rate to  $\tau_l = 0.28$  following Mendoza et al (1994).<sup>18</sup> For shareholder taxes, we use  $\tau_d = \tau_g = 0.20$  which is the top statutory rate in effect since the American Taxpayer Relief Act of 2012 for a vast majority of households.<sup>19</sup> We follow Gourio and Miao (2010) in setting the corporate tax rate  $\tau_c = 0.34$  which is roughly consistent with the statutory rate at the top bracket (0.35). Given those tax rates, government budget balance implies a value of  $G = 0.186$  which means that government revenues are roughly 28% of output  $Y$  in the stationary distribution.

Auerbach (1989) argues that, even though capital costs such as installation costs are treated as capital expenditures in US tax law and are therefore not immediately deductible, they nevertheless generate deductions in the future through depreciation allowances. He shows how one can incorporate the present value of these deductions as immediate deductions and we follow that approach in Appendix B to obtain a reasonable value for the fraction  $\phi$  of adjustment costs that can be immediately deducted from corporate taxes. Using a steady state approximation, we obtain a present value of depreciation allowances using the expression  $\frac{\delta}{\frac{r}{1-\tau_g} + \delta}$ . In the benchmark version of our model, we set  $\phi = 0.52$ , which is the value implied by this expression in the pre-reform stationary distribution.<sup>20</sup> We also consider the two alternative extremes of  $\phi = 0$  and

<sup>18</sup>Using the same methodology, but more recent data, Domeij and Heathcote (2004) report a similar value.

<sup>19</sup>The values of 20% are consistent with the 2013 federal average marginal income taxes on qualified dividends and long term capital gains reported by Feenberg and Coutts (1993).

<sup>20</sup>We only use a steady state approximation because allowing for time-variation in the fraction of deductions would introduce an additional state variable significantly complicating our numerical solution. Note also that we do not take into account the changes induced by endogenous changes in  $\tau_g$  and  $r$  in our experiments, since this has a quantitatively small impact on our results.

$\phi = 1$ .

Since we assume that  $\tau_d = \tau_g$  in the benchmark economy, firms can be in one of the following two financing regimes: the dividend distribution (DD) regime or the equity issuance (EI) regime. Firms in the DD regime have sufficient internal funds to cover their desired level of investment, they do not need to issue equity and they pay the residual cash flow as dividends. These are typically firms with low marginal product, either due to low  $z_t$  or due to high capital. In contrast, firms with high marginal product will typically need to issue equity to grow and will be in the EI regime. A third financing regime discussed in Gourio and Miao (2010), liquidity constraint firms (LC), is not present in the benchmark economy. However, these firms will exist post-reform whenever the reform introduces a tax wedge  $\tau_d > \tau_g$ . In that case, equity issuance is costly and some firms with intermediate levels of marginal product will not find it optimal to pay the cost and will instead grow internally without paying dividends.

Table 4 provides some of the characteristics of the distribution of firms across the EI and DD regimes in the benchmark. The table displays the share of capital, the earnings to capital and the average Tobin's Q for each of the regimes, together with their data counterpart.<sup>21</sup> Consistent with the data, EI firms in the model are relatively small, have higher earnings to capital ratios and higher Tobin's Q. Most of the capital in the economy is held by firms in the DD regime and the share of capital held across the different regimes is consistent with the data.

## 5 Quantitative Results

We consider two alternative types of reforms in both of which the corporate profits tax rate  $\tau_c$  is permanently reduced and the government budget remains balanced. The two types of reforms differ in the tax instruments used in order to maintain the same level of long run revenue. In the first type of reform, both dividend and capital gains taxes are adjusted, whereas in the second only dividend taxes are adjusted. In both cases, we use labor taxes to balance the budget during the transition.

For each type of reform, we discuss first a specific reform that reduces the corporate tax rate to zero. We discuss both the long run effects and the transitional, distributional and welfare effects of this case. Since transitional effects can be important for welfare, we also consider alternative assumptions regarding the extent to which a reform is anticipated in advance of its implementation. At the end, we also considering a range of values for the new level of  $\tau_c$  to determine numerically the optimal level of corporate taxes.

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<sup>21</sup>We use COMPUSTAT annual data between 1988 and 2006 and we follow the standard criteria described in Gourio and Miao (2010) to clean the data and construct the variables. Whenever firms distribute dividends and issue equity at the same time, something that is not possible in our model, we classify these firms as equity issuance firms.

## 5.1 Using Equal Dividend and Capital Gains Taxes

### 5.1.1 Long Run Effects

The first column of Table 5 displays the long run effects of a reform that cuts corporate profits taxes to zero and replaces them with dividend and capital gains taxes, maintaining  $\tau_d = \tau_g$ . In the long run, the reform leads to a decrease in aggregate capital but TFP increases and this leads to an increase in aggregate output. These changes are a result of a combination of several counteracting mechanisms which can be understood with reference to the proposition of Section 3.2. It is helpful to distinguish between mechanisms that affect all firms in a similar fashion, which in turn can be used to explain changes in aggregate capital, and mechanisms that have potentially opposite effects on different firms. The latter are used to explain changes in TFP, which arise from changes in the distribution of firms.

Consider first the intuition for the decrease in aggregate capital. In the modified economy of the proposition in Section 3.2, the combined marginal tax rate on the return to capital,  $1 - \tau = (1 - \tau_g)(1 - \tau_c)$ , is maintained fixed after the reform. This ensures that the optimal choices of firms and households at the margin remain the same, generating the same overall tax revenues for the government. In contrast, in our benchmark economy, maintaining the same combined marginal tax rate would not ensure the same choices and tax revenues for the government. This is because part of the adjustment costs are not deductible from corporate taxes ( $\phi < 1$  as opposed to  $\phi = 1$ ), but all adjustment costs are implicitly deducted from shareholder taxes, since dividends and capital gains realize after payment of adjustment costs. As a result, switching from corporate taxes to shareholder taxes reduces the tax base and shareholder taxes have to rise to a point in which the combined tax rate  $\tau$  is higher than before (it increases from 47.2% before the reform to 50.6% after the reform). In turn, a higher marginal tax rate on the return to capital pushes investment and capital of all firms downwards. In addition to the effect through tax revenues, there is another effect that tends to reduce the incentives of firms to invest even if  $\tau$  were to remain fixed. As reflected in the last term of equation (16), one of the benefits of increasing capital is that it lowers future adjustment costs. This benefit is taxed only partly by the corporate tax, but it is fully taxed under shareholder taxes. In other words, switching to shareholder taxes increases the marginal tax rate on this benefit and it also lowers the incentives to invest.

Before moving on to the intuition regarding TFP changes, we briefly discuss the dependence of these results on the value of  $\phi$ . It is clear from the preceding discussion that a lower value of  $\phi$  will lead to stronger effects on aggregate capital. In other words, the lower the value of  $\phi$ , the larger the increase in the combined tax rate after the reform, and the larger the decrease in the aggregate capital stock. This is what we see on Table 5, with the  $\phi = 0$  case exhibiting the largest decrease in aggregate capital and the  $\phi = 1$  case the smallest one.

Consider now the intuition for changes in the distribution of capital across firms and, hence, TFP. There are two opposing forces. First, the proposition of

Section 3.2 ensures that the reform is distributionally neutral by adding the term  $\chi_{jt} \equiv (q_{jt}k_{j,t+1} - q_{jt-1}k_{jt}) - (k_{j,t+1} - k_{jt})$  to taxable corporate income  $T_{jt}$ . Since shareholder taxes implicitly tax the adjusted income  $\tilde{T}_{jt} = T_{jt} + \chi_{jt}$ , this makes the tax base of corporate and shareholder taxes equivalent. Firms with relatively high productivity have relatively low values of  $\chi_{jt}$  due to the fact that their investment rates are currently higher than the long run and their marginal  $q$  is falling, while the opposite is true for firms with relatively low marginal productivity. Thus, in the absence of this adjustment, a switch to shareholder taxes imposes relatively higher burden to unproductive firms with high  $\chi_{jt}$  and a lower burden to those that are more productive and have a low  $\chi_{jt}$ , leading to positive capital reallocation.

Second, a reduction in the corporate tax rate essentially increases the effects of adjustment costs by virtue of shifting some of the burden of these costs away from the government and back to the firm. This increases the dispersion in marginal  $q$  and therefore the misallocation of capital due to adjustment costs. This second effect becomes stronger as the deductibility  $\phi$  of adjustment costs increases. As is evident in Table 5, the first effect dominates and TFP increases for reasonable levels of deductibility. For the extreme case with  $\phi = 1$ , where adjustment costs are fully deductible, the second effect dominates and TFP decreases. These reallocation effects can also be seen in Table 6, which reports the average capital conditional on the value of  $z$  before and after the reform that eliminates corporate taxes. For  $\phi = 0.52$  and  $\phi = 0$ , the effect of the reform is to reduce average capital for low- $z$  firms and increase it for high- $z$  firms whereas the opposite is true for  $\phi = 1$ .

### 5.1.2 Transition, Distribution and Welfare

We use a standard utilitarian social welfare function to measure welfare and determine optimality. To better understand the welfare results, we use the method of Domeij and Heathcote (2004) to provide a decomposition of overall welfare into an aggregate and a distributional component. The aggregate component captures the effects of changes in aggregate consumption, both in the long run and along the transition, by assuming these are proportionally distributed across individuals. The distributional component is computed as the residual and thus captures any departures from a proportional allocation of consumption effects. We also discuss how welfare effects differ by individual.

The bottom panel of Table 5 reports the welfare effects of the reform. The overall welfare gain is 0.39% in consumption equivalent terms. The decomposition into aggregate and distributional components indicates that there are both efficiency and distributional gains from the reform. The fundamental reason why the reform yields efficiency benefits is that it delivers higher production both in the short run and in the long run despite lower aggregate investment. This is due to the positive TFP effects, as is evident in the transition paths of macroeconomic aggregates displayed in Figure 1. The effects of these changes on aggregate consumption show a temporary but long-lived (15 years) increase

and a long run decrease.<sup>22</sup> Quantitatively, the transitional benefit dominates the long run cost and leads to a positive aggregate component of welfare of 0.13%.

The reform also delivers distributional gains of 0.25% because high marginal utility households benefit and only a small fraction of low marginal utility households lose from the reform. This is illustrated in Figure 2, which plots the welfare gains and losses for each household  $(\theta, \epsilon)$  separately. Gains are decreasing in wealth and households with few or no stocks are the main beneficiaries, while only households with substantial wealth or very high labor productivity experience losses. The underlying reason has to do with the effects of the reforms on the after tax wage and after tax return. The after tax wage rises because of the increase in TFP, whereas the after tax return falls. As a result, households which earn primarily labor income tend to benefit whereas households that earn primarily capital income (i.e. high wealth, low marginal utility households) lose.

Note that these distributional implications stand in sharp contrast to the findings in the literature regarding corporate tax cuts (e.g. Domeij and Heathcote (2004)) where such reforms are typically found to have negative distributional effects. The fundamental reason for this difference is the use of a capital tax (shareholder taxes in this case) to replace the corporate tax as opposed to using a labor tax. In existing literature, corporate tax revenues are made up using labor taxes and this implies that after tax wages drop as a result of the reform despite the positive general equilibrium effect on before tax wages.<sup>23</sup>

The bottom panel of Table 5 also reports welfare effects for the cases  $\phi = 0$  and  $\phi = 1$ . Welfare gains are decreasing in the degree of deductibility of adjustment costs. In the extreme case of full deductibility welfare gains are small, which is not surprising given the small effects on long run aggregates in this case. However, the main message of this exercise, namely that eliminating corporate taxes in favor of shareholder taxes is welfare improving, remains true regardless of the value of  $\phi$ . To the extent that adjustment costs reflect installation costs not fully deductible from the tax base, these gains can be significant.

An important robustness check is to investigate whether the welfare effects are sensitive to the assumption that tax reforms are unanticipated. For this reason, we have also computed transitions and welfare under the assumption of anticipation, with the period of anticipation being one or two years. The welfare effects for these experiments are reported in Table 7. Anticipation does not make a significant quantitative difference for this type of reform. If any-

<sup>22</sup>The long run decrease is an artifact of the simplifying assumption that adjustment costs are lost resources. This could be avoided by rebating costs back to the households at the cost of increasing computational time and introducing unintended distributional effects. Since the model yields a positive aggregate component of welfare despite this limitation, we have opted for not rebating the costs. We expect welfare gains to be larger if this is addressed.

<sup>23</sup>Our model differs from Domeij and Heathcote (2004) mainly in its production sector, where we have heterogeneous firms operating decreasing returns to scale technologies whereas they have a representative firm with constant returns to scale. In experiments not reported here, we have confirmed that the same arguments that work in the Domeij and Heathcote (2004) setting go through in our setting too when labor taxes are used to replace corporate taxes.

thing, welfare gains rise with the length of anticipation period due to slightly better distributional effects. This is because the labor tax adjustment over the transition is smoother and implies a smaller, and more short-lived, temporary drop in after tax wages.

The overall conclusion is that this reform can deliver both efficiency and distributional gains and these positive aspects are robust to different anticipation periods.

### 5.1.3 Optimal corporate tax

Although the elimination of corporate taxes in favor of shareholder taxes delivers welfare gains,  $\tau_c = 0$  might not be the optimal choice. We investigate this by repeating the benchmark experiment for a range of different values of  $\tau_c$  and determining numerically the choice of  $\tau_c$  that maximizes welfare. Figure 3 shows the overall welfare gains, as well as the decomposition to aggregate and distributional components, for several values of  $\tau_c$  from 0 up to the pre-reform value of 0.34. All cases considered yield positive overall welfare gains and these gains are increasing the larger the reduction in  $\tau_c$ . This is true for both the aggregate and the distributional component. Overall welfare gains are highest at  $\tau_c = 0$  meaning that the complete elimination of corporate taxes discussed earlier is indeed the optimal choice.

Using the welfare effects by individual and the corresponding measure of individuals at each point  $(\theta, \epsilon)$  in the stationary distribution, we can obtain the total measure of households that experience gains and the total measure experiencing losses. Table 8 reports this measure of political support and shows that such a reform would have high support. The levels reported are high for all cases, ranging from 81.2% to 84.8%, and tend to be slightly higher for reforms that do not decrease  $\tau_c$  all the way to zero.

Although the complete elimination of corporate taxes is the case associated with the highest social welfare gains, it calls for a large increase in shareholder taxes (from 20% to 50.6%) and this can make it harder to implement in practice. Given this, we also consider a couple of milder reforms. In the first, we equalize the tax rates on all types of personal income as well as corporate income,  $\tau_c = \tau_d = \tau_g = \tau_l$ . In our model, the tax rate required for this is 27.8% which is also very similar to our benchmark labor income tax rate of 28%. This is a reform often suggested in the past by political commentators on the grounds of ‘fairness’ and it is also in the spirit of calls for simplification of the tax code. Compared to the complete elimination of corporate taxes, this reform yields a smaller TFP increase of 0.48% and a smaller overall welfare gain of 0.18%, of which two-thirds are due to distributional gains and one-third due to aggregate efficiency gains. However, the gains are even more widely spread, with 84% of households in the economy experiencing welfare gains. In the second, we reduce corporate taxes to around 20%, which is the reduction stipulated in the Tax Cuts and Jobs Act of 2017, based on the tax reform advocated by the current administration. In this case, 83% of households would still experience welfare gains.

In sum, the model suggests that eliminating corporate taxes would yield the highest benefits and should command wide support but even milder, more practically feasible reforms of this type can still yield economic benefits and potentially have even wider support.

## 5.2 Using Dividend Taxes Only

### 5.2.1 Long Run Effects

Consider now a reform which uses only dividend taxes to replace the corporate profits tax, but leaves the capital gains tax rate untouched. This reform stands in sharp contrast to the one of the previous section, where the direct effect of the decrease in corporate taxes on after tax returns to investment was to a large extent counteracted by an increase in capital gains taxes. Here, with the capital gains taxes remaining unchanged as the corporate tax falls, there is now a large direct effect on the after tax return on investment which provides a strong incentive for increasing capital across all firms. In addition, because of incomplete markets, there is an indirect, general equilibrium effect that pushes (before tax) returns downwards and capital upwards. This is the wealth effect explained in Anagnostopoulos et al (2012), who study the effect of reducing shareholder taxes in a model with household heterogeneity. The idea is that higher dividend taxes reduce the market value of the mutual fund for a given capital stock through their effect on  $\frac{1-\tau_d}{1-\tau_g}$ . To ensure equilibrium in capital markets, stock returns have to fall so as to provide the signal to households to hold less wealth and the signal to firms to increase their capital stock, and hence the value of the fund, to the point where supply and demand for wealth is equalized. Both of those effects contribute to the substantial increase of 40.6% in the aggregate capital stock reported in the last column of Table 5.

Table 5 also indicates a positive effect on long run output from the reform, but the quantitative response of output is muted compared to the large increase in capital. The reason is that TFP now falls as a result of the reform. This counteracting effect, which is not present when we increase both shareholder taxes, arises from the misallocation of capital implied by the introduction of a wedge between  $\tau_d$  and  $\tau$ . This is explained in Gourio and Miao (2010), who study the effect of reducing shareholder taxes in a model with firm heterogeneity. The idea is that when  $\tau_d > \tau_g$ , a unit of equity raised by the firm reduces the (after-tax) capital gains of existing shareholders by  $1 - \tau_g$ . When that unit is paid to shareholders in the form of dividends it only yields  $1 - \tau_d < 1 - \tau_g$ . In this sense, equity financing is now more costly than internal funds. Growing firms, which need to issue equity in order to grow, are hurt by the creation of the wedge and their investment suffers as a result. In turn, this implies that these firms take longer to reach their optimal capital level and spend more time at an inefficiently low level of capital. The end result is a reallocation of capital from relatively productive firms to relatively unproductive firms. Table 6 illustrates this point by showing that changes in capital stock are not proportional across firms. Even though capital increases across all firms, average capital for low- $z$

firms increases by more than average capital for high- $z$  firms. As a result, the overall increase in output does not fully reflect the increase in aggregate capital, i.e. TFP has decreased by 1.4%.<sup>24</sup>

### 5.2.2 Transition, Distribution and Welfare

Consider now the welfare implications of the reform. In the long run, aggregate consumption rises as a result of the reform and this has a positive effect on welfare. However, even from a pure efficiency perspective, this is not enough to conclude that the aggregate component of welfare is positive because there are potentially large transitional costs. Indeed, aggregate consumption does fall during the transition while households substantially increase their savings. This short run reduction in aggregate consumption is illustrated in Figure 4. Consumption remains below the pre reform steady state after 10 years, and the magnitude of the drop is large at approximately 15% at the trough. These transitional costs dominate from an efficiency perspective and this results in a negative aggregate component of welfare of about 0.84%. On the other hand, this reform maintains the positive distributional aspects that were also found in the previous section. This is because after tax wages increase and after tax returns decrease. Figure 5 illustrates the fact that the reform benefits low wealth, low income (productivity) households and only hurts wealthy or high productivity households with low marginal utility.

Quantitatively, the unexpected elimination of corporate taxes yields an overall negative welfare effect of 0.21% in consumption equivalent terms because the aggregate component dominates the distributional component (see Table 5). As in the previous reform, anticipation effects do not reverse the qualitative welfare conclusions, but in this case overall welfare loss increases substantially with the periods of anticipation. To understand this point, it is instructive to look at the transitional paths for aggregate capital, output and consumption shown in Figure 4.

In the case of anticipated dividend tax changes, the standard argument that constant dividend taxes do not directly affect returns to investment does not apply any longer because the dividend tax path expected by the private sector is no longer constant. Instead, current dividend taxes are lower than expected future dividend taxes and that directly reduces the investment return in the short run. As a result, firms engage in tax arbitrage. They reduce current investment and increase current dividends, to take advantage of relatively lower dividend taxes that are in place temporarily<sup>25</sup>. Thus, in contrast to the unanticipated case where capital and output increase monotonically to the new steady

<sup>24</sup>In contrast to the experiment of the previous subsection, the value of  $\phi$  does not significantly affect the conclusions of the benchmark model, qualitatively or quantitatively, and we therefore do not include the results for other values of  $\phi$ . The reason is that the direct effect of  $\tau_c$  and the misallocation and wealth effects of  $\tau_d$  are much stronger mechanisms and they dominate the responses.

<sup>25</sup>This point is also made in Gourio and Miao (2011) in the context of unanticipated, temporary dividend tax changes, which induce an anticipation of tax changes in the future when the temporary reform expires.



state, with anticipation capital and output fall initially until the reform is implemented and then rise slowly from a lower level to the new steady state. In terms of aggregate consumption, with anticipation it rises initially but then falls more abruptly at implementation. From an aggregate welfare perspective, the initial rise in consumption is counteracted by the subsequent larger drop and overall more fluctuation and this increases the welfare costs with anticipation. Moreover, the benefits of tax arbitrage accrue mostly to shareholders. In contrast, low wealth individuals with limited ability to smooth consumption are hurt by the additional fluctuation in after tax wages. Thus, the distributional component of welfare also becomes worse in the case of anticipation. As a result of these changes, the overall welfare costs equivalent to 0.21% of consumption that were found in the unanticipated case, now become even higher with anticipation and can be as large as 1.03% (1.13%) of consumption for the case of 1 (2) years of anticipation.

### 5.2.3 Optimal corporate tax

We consider again a range of levels for the new value of  $\tau_c$  in order to determine the optimal choice for this type of reform, focusing on unanticipated changes. The welfare effects are displayed in Figure 6. It is interesting to note that the overall welfare effect is non-monotonic in  $\tau_c$ . Specifically, welfare gains from the reform rise as  $\tau_c$  is reduced from 34% to 29% but then fall and eventually become negative when  $\tau_c$  is reduced further down to 0. Thus, our quantitative experiment suggests an optimal tax rate for  $\tau_c$  close to 29% and a corresponding tax rate on dividends of 24.5%. That is, it suggests that taxing both corporate profits and dividends at the same time is an optimal response to the trade-off between efficiency and distribution. From a pure efficiency perspective, i.e. focusing on the aggregate component, the replacement of corporate taxes with shareholder taxes yields negative effects. This indicates that the financing distortions introduced by the dividend tax outweigh the usual distortions associated with corporate taxes. However, this is outweighed by the positive redistributive effects and the overall welfare gain in consumption equivalent terms is 0.03% at the optimum with  $\tau_c = 0.29$ . In terms of political support, this reform also delivers high support as shown on Table 8, with approximately 76.5% of households gaining from the tax change.

## 6 Conclusion

We find that reforms which replace corporate income taxes with shareholder taxes can enjoy widespread popular support. Whether such reforms are efficiency-enhancing hinges critically on the mix of dividend and capital gains taxes and the degree to which the new policy is anticipated. In particular, if dividends and capital gains are taxed at the same rate, we predict efficiency gains that are robust to different degrees of anticipation. However, when the shareholder tax used is only the dividend tax rate, this policy can have negative consequences on

efficiency because the resulting misallocation of capital creates more distortions than the ones solved by the removal of the corporate tax. Moreover, this reform can have additional negative consequences to the extent that it is anticipated.

These results are derived in a rich environment, consistent with key features of the US economy, such as wealth inequality at the household level, imperfect risk-sharing, productivity differences across firms and endogenous financing decisions for the corporate sector. All of these components are important in evaluating the effects of different types of capital income taxes. However, our model abstracts from the fact that a significant fraction of household savings are not subject to dividend or capital gains taxes because they are held in retirement accounts. It also necessarily abstracts from other potentially important channels through which a corporate profits tax cut can affect macroeconomic performance. These include the choice of legal form of organization, the extensive margin effects when investment is lumpy, the effects on employment as well as the possibility of international capital flows. It is noteworthy that studies which include these other channels seem to reach a similar conclusion to ours, namely that a reduction in corporate profits taxes can be beneficial to the economy. This paper contributes to the discussion by suggesting an alternative way of financing this tax cut that can increase popular support for such a reform.

An additional argument in favor of reducing corporate taxes and replacing them with shareholder taxation is advanced by Luigi Zingales and relates to the issue of tax avoidance.<sup>26</sup> Zingales argues that it is no longer the case that corporations are easier to locate and audit than individuals. In addition, lobbying power is much more concentrated in large corporations than it is amongst a few wealthy individuals. As a result, corporate taxes have ended up being a very ineffective way of raising revenue due to endless loopholes in the tax code. Although our model does not incorporate tax avoidance strategies, this argument would strengthen our main conclusion which is that the tax code should be focused on taxing shareholders directly rather than indirectly through corporations. As a first step, reducing the corporate income tax rate to around 28% and removing the preferential tax treatment of shareholder income relative to other personal income, seem to be measures that a large majority could agree with and benefit from.

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<sup>26</sup>See "A Better Way to Tax Corporations" at <http://www.nydailynews.com/opinion/better-tax-corporations-article-1.1093804>.

## APPENDIX A - Proof of Proposition

The goal is to show that all long run equilibrium conditions are satisfied for the new taxes  $\tau_c^*$ ,  $\tau_s^*$  and dividend payout  $(d_{jt} - s_{jt})^*$  but for otherwise identical allocations and prices to the ones before the reform. We focus only on the conditions that involve the taxes and dividend payout, since the rest are trivially satisfied. Throughout the section, we let  $\pi_{jt} \equiv \pi(k_{jt}, z_{jt}; w_t)$ .

Firms' conditions have to be adjusted according to the new tax code assumptions. Using the newly defined taxable corporate income in (20), the firms' financing constraint reads

$$d_{jt} - s_{jt} = \pi_{jt} - \Phi(x_{jt}, k_{jt}) - x_{jt} - \tau_c \tilde{T}_{jt}$$

After the reform this financing constraint is satisfied by construction of the dividend payout specified in the Proposition. Recall that with equal capital gains and dividend taxes,  $\lambda_t^d = \lambda_t^s = 0$  and note that we use  $\tau_s$  to denote both dividend and capital gains tax rates since they are equal. The first order condition for investment is now

$$q_{jt} = 1 + (1 - \tau_c \phi) \Phi_x(x_{jt}, k_{jt}) - \tau_c \phi (1 - q_{jt})$$

After some rearrangement, this gives

$$q_{jt} = 1 + \Phi_x(x_{jt}, k_{jt})$$

which is still satisfied after the reform for the same allocations since no tax term is involved. The capital first order condition is now:

$$\begin{aligned} q_{jt} &= \frac{1}{1 + \frac{r}{1 - \tau_s}} E_t \left[ (1 - \delta) q_{j,t+1} + (1 - \tau_c) \frac{\partial \pi_{j,t+1}}{\partial k_{j,t+1}} \right] \\ &\quad + \frac{1}{1 + \frac{r}{1 - \tau_s}} E_t [\tau_c (q_{jt} - (1 - \delta) q_{j,t+1}) - (1 - \tau_c \phi) \Phi_k(x_{j,t+1}, k_{j,t+1})] \end{aligned}$$

After some manipulation this can be simplified to

$$r = \frac{1}{q_{j,t}} E_t (1 - \tau_s) \left[ (1 - \tau_c) \left( (1 - \delta) q_{j,t+1} - q_{j,t} + \frac{\partial \pi_{j,t+1}}{\partial k_{j,t+1}} \right) - (1 - \tau_c \phi) \Phi_k(x_{j,t+1}, k_{j,t+1}) \right]$$

It is easy to see that if  $\phi = 1$ , the previous condition is also still satisfied for the same allocation when the overall tax wedge  $(1 - \tau_c)(1 - \tau_s)$  is kept fixed.

The household budget constraint and the first order condition for stocks are the same as in Section 2. At steady state, these are

$$c_{it} + P(\theta_{it} - \theta_{it-1}) = (1 - \tau_l) w \epsilon_{it} + (1 - \tau_s)(D - S)\theta_{it-1}$$

and

$$r \equiv \frac{(1 - \tau_s)(D - S)}{P}$$

From the households' perspective taxes may affect the overall payoff  $(1 - \tau_s)(D - S)$  on the right hand side of both of those conditions. Using the financing constraint of a firm together with the taxable income in equation (20) and aggregating over all firms  $j$ , this term can be written as:

$$\begin{aligned}
& (1 - \tau_s)(D - S) \\
= & (1 - \tau_s) \left[ \Pi - \Psi - X - \tau_c \int \tilde{T}_{jt} dj \right] \\
= & (1 - \tau_s) \left[ \Pi - \Psi - X - \tau_c \left[ \Pi - \Psi - X + \int (q_{jt} k_{j,t+1} - q_{jt-1} k_{jt}) \right] \right] \\
= & (1 - \tau_s)(1 - \tau_c)(\Pi - \Psi - X) - \tau_c(1 - \tau_s) \left[ \int (q_{jt} k_{j,t+1} - q_{jt-1} k_{jt}) \right]
\end{aligned}$$

where  $\Pi = \int \pi_{jt} dj$ ,  $\Psi = \int \Phi(x_{jt}, k_{jt}) dj$  and we have used  $\phi = 1$  again. In a stationary distribution, the last term disappears. As a result, every household's budget constraint (2) and Euler equation (4) are still satisfied after the reform. It follows that government revenues are the same after the reform and thus the government's budget is also satisfied. This completes the proof.

## APPENDIX B - Modelling Depreciation Allowances

In this section, we show how the present value of depreciation allowances can be captured through the parameter  $\phi$ . To model depreciation allowances, we closely follow Auerbach (1989). Throughout the section, we let  $\pi_{jt} \equiv \pi(k_{jt}, z_{jt}; w_t)$ .

Let  $G_{jt}$  represent the depreciation allowances at time  $t$  arising from all past capital expenditures including installation costs. The constraints of the firm can be written as:

$$\begin{aligned} d_{jt} + x_{jt} + \Phi(x_{jt}, k_{jt}) &= \pi_{jt} - \tau_c [\pi_{jt} - G_{jt}] + s_{jt} \\ k_{jt+1} &= (1 - \delta) k_{jt} + x_{jt} \\ G_{jt} &= \sum_{u=-\infty}^{t-1} \delta (1 - \delta)^{t-1-u} [x_{ju} + \Phi(x_{ju}, k_{ju})] \\ n_{jt} &\geq 0 \\ d_{jt} &\geq 0 \end{aligned}$$

Using the capital accumulation equation to express  $k_{jt}$  in terms of all past investment as

$$k_{jt} = \sum_{u=-\infty}^{t-1} (1 - \delta)^{t-1-u} x_{ju}$$

$G_{jt}$  can equivalently be written as:

$$G_{jt} = \delta k_{jt} + \sum_{u=-\infty}^{t-1} \delta (1 - \delta)^{t-1-u} \Phi(x_{ju}, k_{ju})$$

This makes explicit the fact that total allowances are composed of the standard depreciation term  $\delta k_{jt}$  plus a second component corresponding to the "depreciation" of installation costs. To simplify this second component, let the discount factor of the firm between periods  $t$  and  $s$  be denoted by

$$M_{t,s} = \left( \prod_{n=1}^{s-t} \frac{1}{1 + \frac{r_{t+n}}{1-\tau_g}} \right).$$

If we write the Lagrangian of the firm's problem and assume that the multiplier on the financing constraint is equal to  $M_{0t}\gamma_{jt}$ , the term involving  $G_{jt}$  can be written as:

$$\begin{aligned} \sum_{t=0}^{\infty} M_{0,t} \gamma_{jt} \tau_c G_{jt} &= \tau_c \sum_{t=0}^{\infty} M_{0,t} \gamma_{jt} \left[ \delta k_{jt} + \delta \sum_{u=-\infty}^{t-1} (1 - \delta)^{t-1-u} \Phi(x_{ju}, k_{ju}) \right] \\ &= \tau_c \sum_{t=0}^{\infty} M_{0,t} \gamma_{jt} [\delta k_{jt} + \Gamma_{jt} \Phi(x_{jt}, k_{jt})] \end{aligned}$$

where

$$\Gamma_{jt} = \delta \sum_{s=1}^{\infty} M_{t,t+s} \frac{\gamma_{js+t}}{\gamma_{jt}} (1 - \delta)^{s-1}$$

and we have used the fact that  $M_{0,s+t} = M_{0t}M_{t,t+s}$ . This has collected together all the future depreciation allowances arising from the time  $t$  installation costs and expressed them in present value terms. The total fraction of the current installation costs  $\Phi(x_{jt}, k_{jt})$  that is ultimately deducted is, in present value terms, represented by  $\Gamma_{jt}$ .

Using this expression, the financing constraint of the firm can be written as:

$$d_{jt} + x_{jt} + \Phi(x_{jt}, k_{jt}) = \pi_{jt} - \tau_c [\pi_{jt} - \delta k_{jt} - \Gamma_{jt} \Phi(x_{jt}, k_{jt})] + s_{jt}$$

which essentially implies that the firm is deducting a fraction  $\Gamma_{jt}$  of capital adjustment costs every period.

Because of the presence of time varying endogenous variables in the infinite sum of  $\Gamma_{jt}$ , a full numerical implementation of this problem would require an additional state variable, essentially capturing the "stock" of installation costs paid.<sup>27</sup> Given the additional computational complexity this would introduce, we instead choose to follow Auerbach's approach, which is to simply compute the value of  $\Gamma$  at the long run equilibrium. We focus on the case  $\tau_d = \tau_g$  where  $\gamma_{js+t} = \gamma_{jt}$ . Replacing the long run value of the firm's discount factor, the value of  $\Gamma$  is equal to:

$$\Gamma = \frac{\delta}{\frac{r}{1-\tau_g} + \delta}$$

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<sup>27</sup> A recursive formulation can be provided upon request.

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Table 1. Parameter Values - Baseline Calibration

	Parameter	Value
Discount Factor	$\beta$	0.934
Share of Capital in Production	$\alpha_k$	0.311
Share of Labor in Production	$\alpha_l$	0.650
Depreciation Rate	$\delta$	0.054
Adjustment Cost Parameter	$\psi$	1.210
CRRA Parameter	$\mu$	1.00
Fraction of Adjustment Cost Deducted	$\phi$	0.52
Labor Productivity Shocks	$\epsilon_{it}$	See Table 2
Firm Level Productivity Shocks	$z_{it}$	See Table 3
Tax Rate on Corporate Income	$\tau_c$	0.34
Tax Rate on Dividends	$\tau_d$	0.20
Tax Rate on Capital Gains	$\tau_g$	0.20
Tax Rate on Labor Income	$\tau_l$	0.28

Table 2. Labor Productivity Process \*

$\mathbf{c} = \begin{bmatrix} 1.00 & 5.29 & 46.55 \end{bmatrix}$
$\Omega_c^* = \begin{bmatrix} 0.498 & 0.443 & 0.059 \end{bmatrix}$
$\Omega_c(\mathbf{c}'/\mathbf{c}) = \begin{bmatrix} 0.992 & 0.008 & 0.000 \\ 0.009 & 0.980 & 0.011 \\ 0.000 & 0.083 & 0.917 \end{bmatrix}$

\* Notation:  $\mathbf{c}$  denotes the values of the labor productivity shock,  $\Omega_c^*$  is the stationary distribution of the labor productivity shock process, and  $\Omega_c(\mathbf{c}'/\mathbf{c})$  is the Markov transition matrix.

Table 3. Firm Level Productivity Process \*

$z = \left[ \begin{array}{ccccccccc} 0.36 & 0.47 & 0.59 & 0.73 & 0.90 & 1.11 & 1.36 & 1.69 & 2.13 & 2.79 \end{array} \right]$
$\Omega_z^* = \left[ \begin{array}{ccccccccc} 0.00 & 0.02 & 0.08 & 0.16 & 0.24 & 0.24 & 0.16 & 0.08 & 0.02 & 0.00 \end{array} \right]$
$\Omega_z(z'/z) = \left[ \begin{array}{ccccccccc} 0.308 & 0.463 & 0.195 & 0.031 & 0.003 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.062 & 0.327 & 0.404 & 0.175 & 0.030 & 0.002 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.007 & 0.114 & 0.354 & 0.360 & 0.141 & 0.022 & 0.002 & 0.000 & 0.000 & 0.000 \\ 0.001 & 0.022 & 0.166 & 0.374 & 0.316 & 0.106 & 0.014 & 0.001 & 0.000 & 0.000 \\ 0.000 & 0.003 & 0.045 & 0.218 & 0.385 & 0.269 & 0.073 & 0.007 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.007 & 0.073 & 0.269 & 0.385 & 0.218 & 0.045 & 0.003 & 0.000 \\ 0.000 & 0.000 & 0.001 & 0.014 & 0.106 & 0.316 & 0.374 & 0.166 & 0.022 & 0.001 \\ 0.000 & 0.000 & 0.000 & 0.002 & 0.022 & 0.141 & 0.360 & 0.354 & 0.114 & 0.007 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.002 & 0.030 & 0.175 & 0.404 & 0.327 & 0.062 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.003 & 0.031 & 0.195 & 0.463 & 0.308 \end{array} \right]$

\* Notation:  $z$  denotes the values of the firm level productivity shock,  $\Omega_z^*$  is the stationary distribution of the firm level productivity shock process, and  $\Omega_z(z'/z)$  is the Markov transition matrix.

Table 4. Distribution of Firms Across Finance Regimes (Data vs. Model)  
Benchmark Economy - (Pre-Reform Steady State)

	Equity Issuance Regime	Liquidity Constrained Regime	Dividend Distribution Regime
Share of Capital			
Data <sup>1</sup>	0.21	0.06	0.73
Model	0.19	0.00	0.81
Earnings/Capital Ratio			
Data <sup>1</sup>	0.56	0.29	0.33
Model	0.35	n/a	0.13
Tobin's Q			
Data <sup>1</sup>	3.63	1.81	2.50
Model	1.96	n/a	1.20

<sup>1</sup> The data reported are authors' calculations using COMPUSTAT Industrial Annual data for the years 1988-2006. Firms that simultaneously issue equity and distribute dividends are classified under the "Equity issuance Regime". Their share of capital is 17%.

Table 5. Eliminating Corporate Income Taxes

REFORM	$\tau_g = \tau_d$ <sup>1</sup>			$\tau_d$ <sup>2</sup>
	$\phi=0.52$ (Benchmark)	$\phi=0.00$	$\phi=1.00$	$\phi=0.52$ (Benchmark)
Tax Rates				
$\tau_c$	0.0	0.0	0.0	0.0
$\tau_d$	50.6	52.4	47.2	43.7
$\tau_g$	50.6	52.4	47.2	20.0
Long Run Aggregates (% change)				
Y	0.1	1.1	-0.5	9.7
K	-4.4	-6.4	-0.4	40.6
C	-0.9	-0.6	-0.3	8.5
TFP	1.5	3.2	-0.4	-1.4
w	0.1	1.1	-0.5	9.7
r	-2.0	-3.5	0.5	-2.2
Welfare (%) <sup>3</sup>				
Overall	0.39	1.08	0.01	-0.21
Aggregate	0.13	0.65	0.02	-0.84
Distributional	0.25	0.42	-0.01	0.64

<sup>1</sup> In this reform, dividend and capital gains taxes change together, equalized to each other

<sup>2</sup> In this reform, capital gains taxes are kept constant at their benchmark levels ( $\tau_g=0.20$ ).

<sup>3</sup> Social welfare gain/loss in consumption equivalent terms. It incorporates the effects of transition.

Table 6. Effects of Eliminating  $\tau_c$  on Capital Distribution Across Productivity Levels

Productivity (z)	z1	z2	z3	z4	z5	z6	z7	z8	z9	z10
Change (%) in $E(k z)$ <sup>1</sup>										
Reform - ( $\tau_c$ vs. $\tau_d=\tau_g$ )										
Case - ( $\phi=0.52$ ) (Benchmark)	-23.7	-20.5	-17.2	-13.7	-10.0	-5.9	-1.4	3.6	9.0	14.5
Case - ( $\phi=0.00$ )	-41.7	-36.4	-30.8	-24.7	-17.8	-9.8	-0.7	9.7	21.7	34.0
Case - ( $\phi=1.00$ )	2.4	1.9	1.4	0.9	0.3	-0.2	-0.9	1.5	-2.2	-2.9
Reform - ( $\tau_c$ vs. $\tau_d$ )										
Case - ( $\phi=0.52$ )	66.0	60.2	55.2	50.4	45.8	41.3	36.9	32.9	29.7	27.6

<sup>1</sup> Mean capital conditional on productivity z

**Table 7. Welfare Effects with Anticipation - Elimination of Corporate Income Taxes**  
**Benchmark Economy ( $\phi=0.52$ )**

<b>Case <math>\tau_g = \tau_d</math> : Financing with Dividend and Capital Gains Taxes</b>			
Years of Anticipation	0	1	2
<b>Welfare (%)</b> <sup>1</sup>			
Overall	0.39	0.40	0.41
Aggregate	0.13	0.13	0.12
Distributional	0.25	0.27	0.29
<b>Case <math>\tau_d</math> : Financing with Dividend Taxes</b>			
Years of Anticipation	0	1	2
<b>Welfare (%)</b> <sup>1</sup>			
Overall	-0.21	-1.03	-1.13
Aggregate	-0.84	-1.20	-1.18
Distributional	0.64	0.18	0.05

<sup>1</sup> Social welfare gain/loss in consumption equivalent terms. It incorporates the effects of transition.

Table 8. Political Support

A. Reform ( $\tau_c$  vs.  $\tau_d=\tau_g$ )

$\tau_c$	0	0.04	0.09	0.14	0.19	0.24	<b><i>0.278</i></b>	0.29	<b>0.34</b>
$\tau_d=\tau_g$	0.506	0.482	0.448	0.410	0.367	0.319	<b><i>0.278</i></b>	0.264	<b>0.200</b>
Fraction in Favor (%)	0.812	0.814	0.817	0.825	0.831	0.837	<b><i>0.840</i></b>	0.848	-

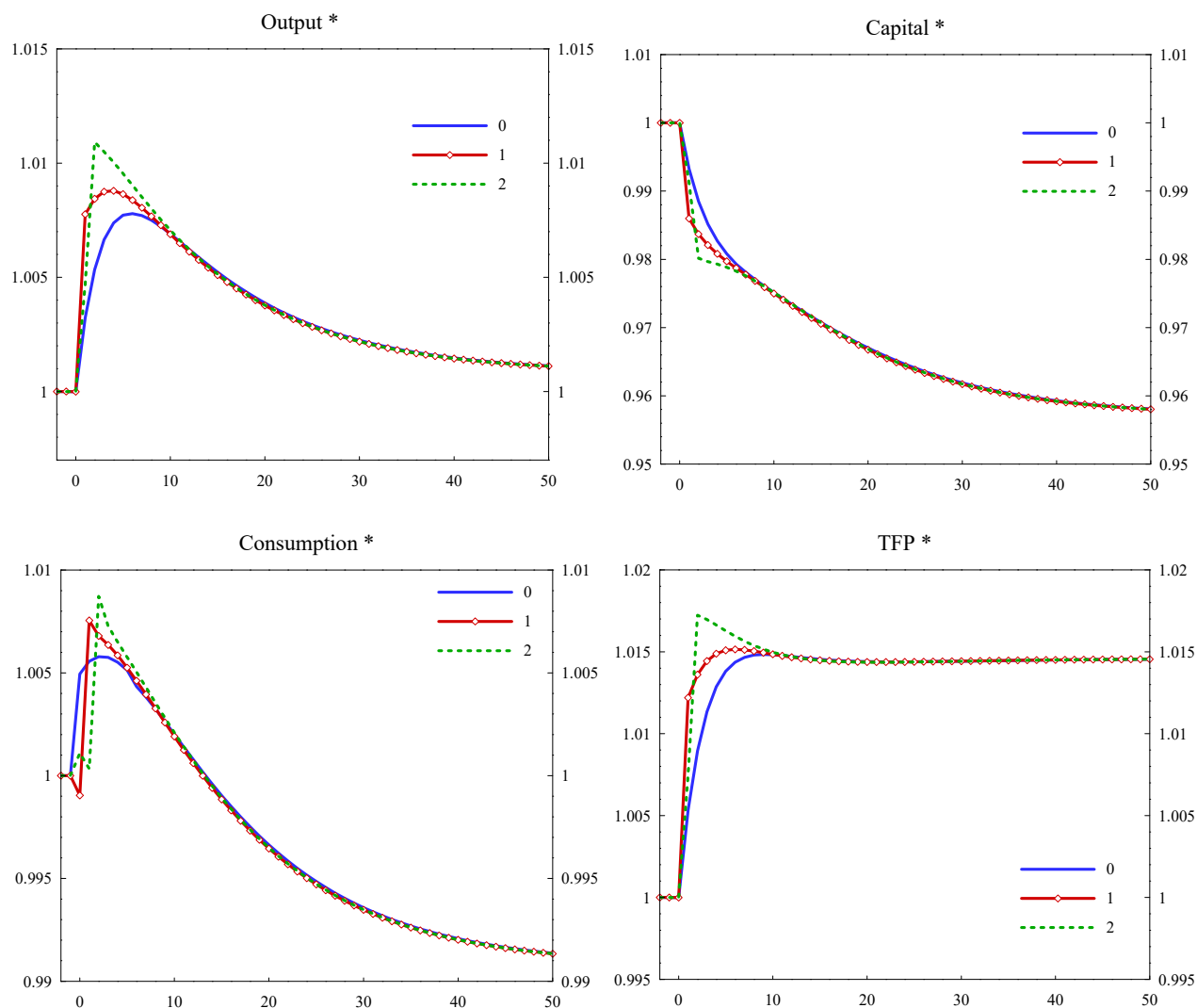
B. Reform ( $\tau_c$  vs.  $\tau_d$ )

$\tau_c$	0	0.04	0.09	0.14	0.19	0.24	0.29	<b>0.34</b>
$\tau_d$	0.437	0.417	0.390	0.360	0.326	0.288	0.245	<b>0.200</b>
Fraction in Favor (%)	0.755	0.755	0.756	0.757	0.758	0.759	0.765	-

Figure 1: Transition Paths when Corporate Income Taxes are Eliminated

Reform (  $\tau_c$  vs.  $\tau_d = \tau_g$  )

(  $\phi = 0.52$  )



\* value relative to the pre-reform level

Note:  $t=0$  is when the tax reform is announced. Actual change in taxes occurs at  $t=0, 1$  or  $2$  depending on the case.

Figure 2: Individual Welfare Gains from Eliminating Corporate Taxes

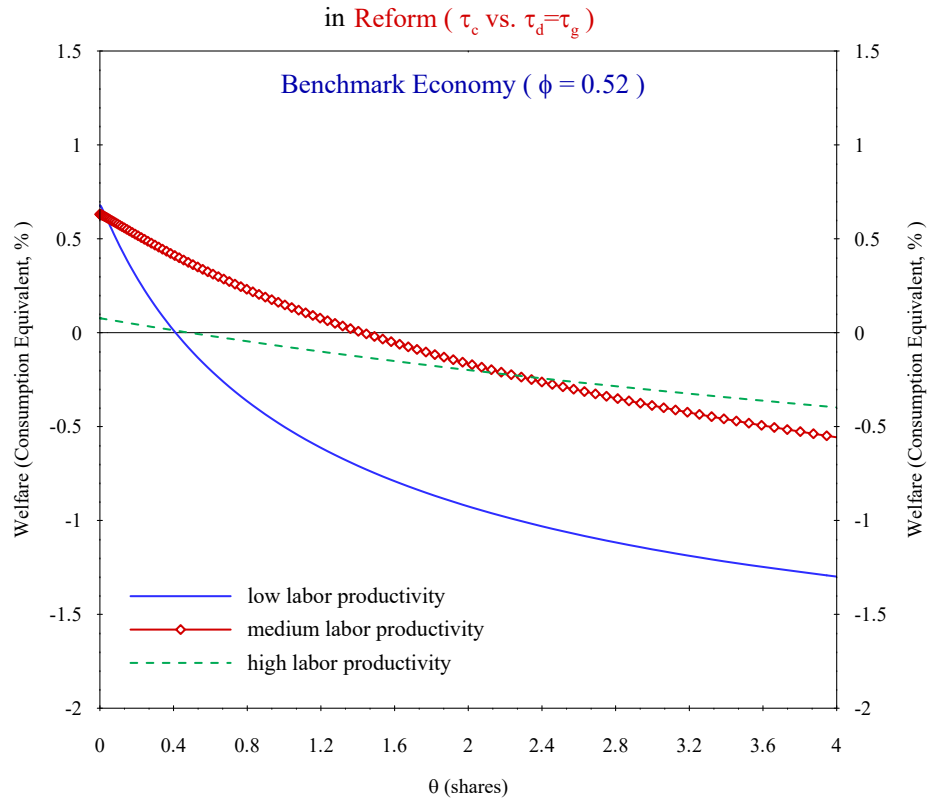


Figure 3. Welfare Effects of Reform ( $\tau_c$  vs.  $\tau_d = \tau_g$ )

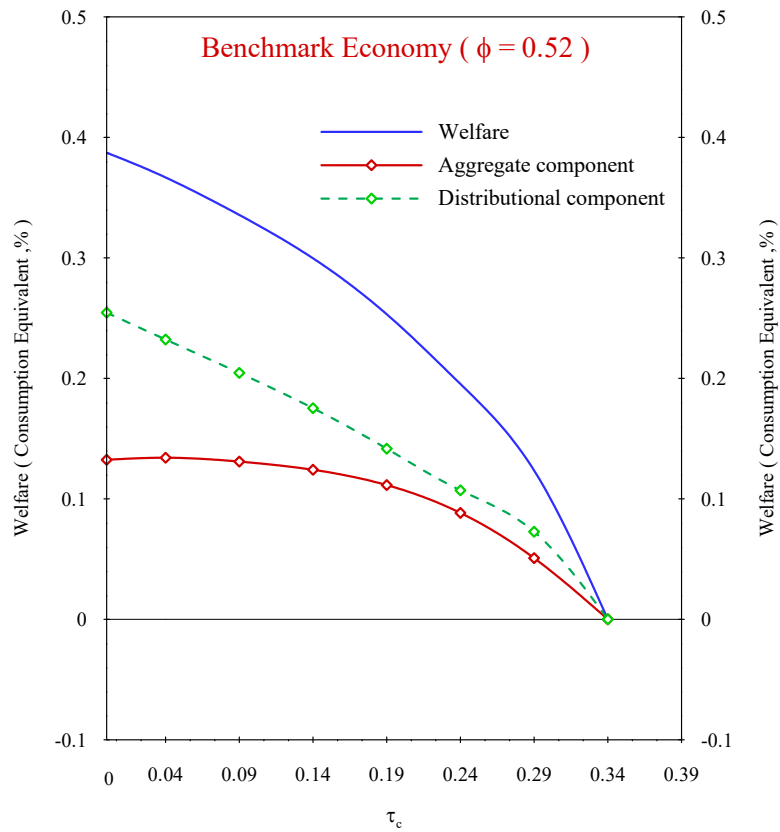
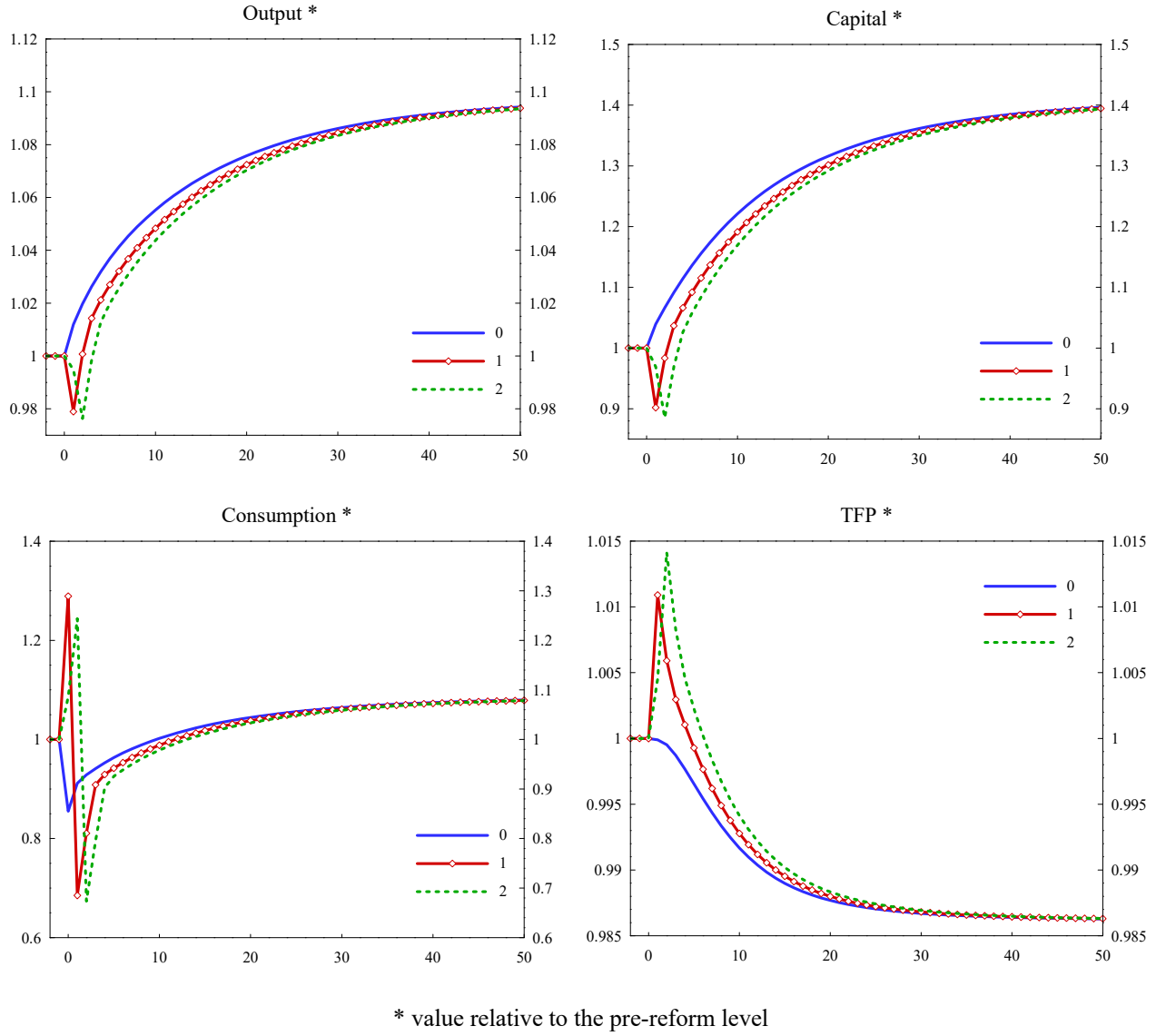




Figure 4: Transition Paths when Corporate Income Taxes are Eliminated

Reform (  $\tau_c$  vs.  $\tau_d$  )

(  $\phi = 0.52$  )



Note:  $t=0$  is when the tax reform is announced. Actual change in taxes occurs at  $t=0, 1$  or  $2$  depending on the case.

Figure 5: Individual Welfare Gains from Eliminating Corporate Taxes  
in Reform ( $\tau_c$  vs.  $\tau_d$ )

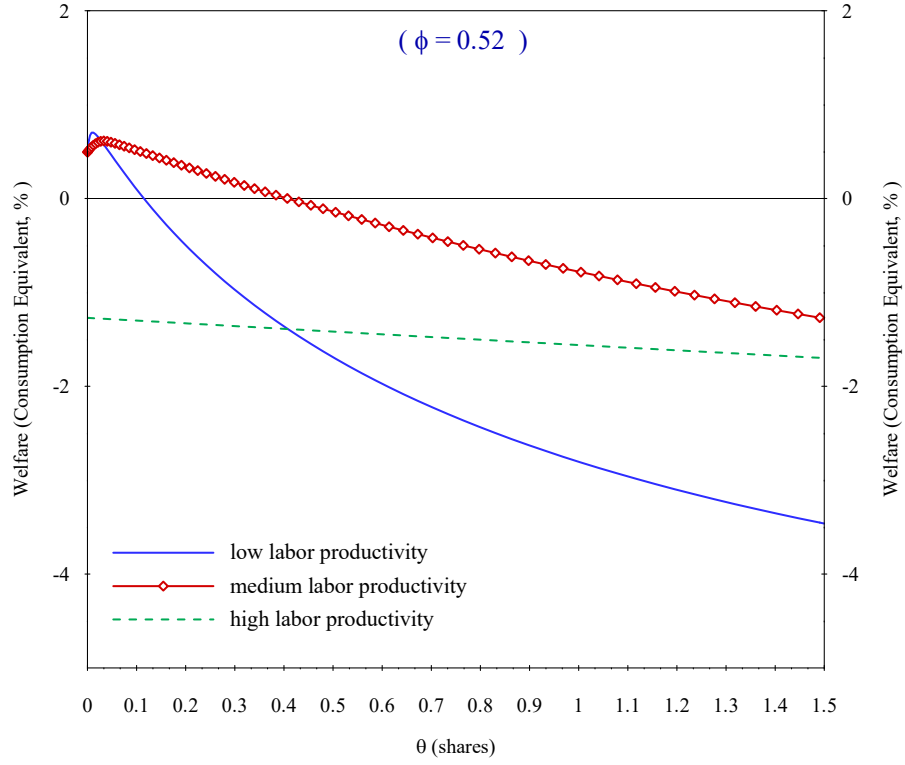
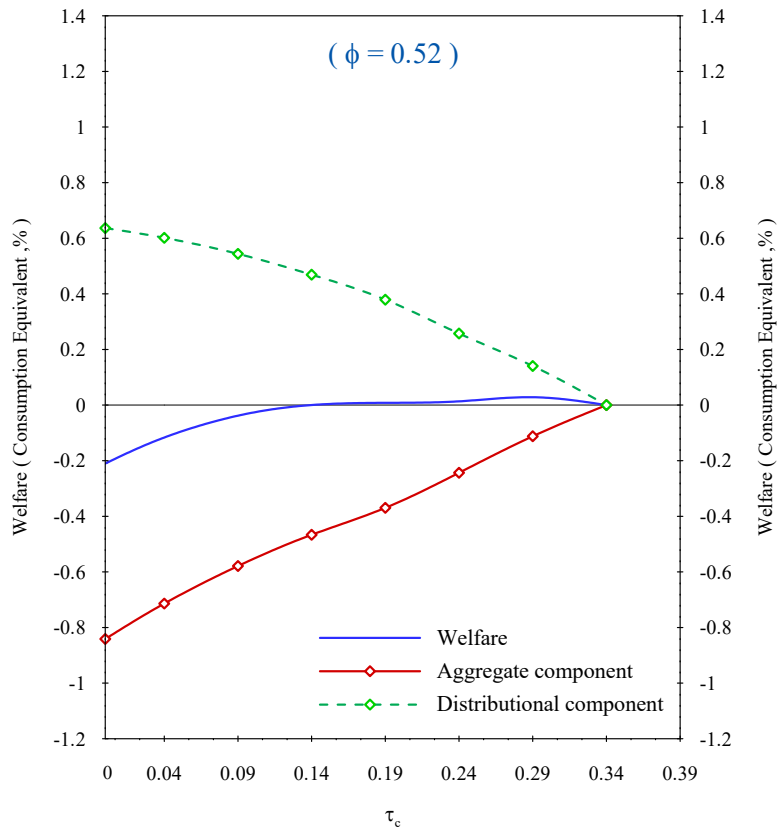


Figure 6. Welfare Effects of Reform ( $\tau_c$  vs.  $\tau_d$ )



# Online Appendix for "On the Double Taxation of Corporate Profits" - **NOT FOR PUBLICATION**

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## Abstract

This Appendix provides the definitions of recursive competitive equilibrium and the computational algorithm used for the main paper. We provide these both for the stationary equilibrium and for the transition.

## 1 Recursive Competitive Equilibrium

### 1.1 Stationary Recursive Competitive Equilibrium

In this section, we provide the recursive formulation of the household and firm problems and define a stationary recursive competitive equilibrium. Given the absence of aggregate uncertainty, in the long run all aggregates are constant and household and firm problems can be expressed in terms of individual state variables only.

The household's state vector is fully characterized by the pair  $(\theta, \epsilon)$  and its problem can be written recursively as follows:

$$\begin{aligned} v^h(\theta, \epsilon) &= \max_{\{c, \theta'\}} u(c) + \beta \sum_{\epsilon'} \Omega_{\epsilon}(\epsilon', \epsilon) v^h(\theta', \epsilon') \quad \text{s.t.} \\ c + P\theta' &= (1 - \tau_l)w\epsilon + ((1 - \tau_d)D + P^0)\theta - \tau_g(P^0 - P)\theta \\ \theta' &\geq 0 \end{aligned} \tag{1}$$

The solution to the household's problem consists of a value function  $v_h$  as well as policy rules for shares and consumption which we denote by:

$$c = c(\theta, \epsilon), \theta' = g^h(\theta, \epsilon) \tag{2}$$

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Similarly, the state vector for a given firm is given by the pair  $(k, z)$ , its static labor demand decision is described by a decision rule  $l = l(k, z)$  obtained from profit maximization, given the wage  $w$ :

$$\pi^f(k, z) = \max_l \{zf(k, l) - wl\} \quad (3)$$

and its dynamic problem is as follows:

$$v^f(k, z) = \max_{\{x, k', s, d\}} \frac{1 - \tau_d}{1 - \tau_g} d - s + \frac{1}{1 + \frac{r}{1 - \tau_g}} \sum_{z'|z} \Omega_z(z'|z) v^f(k', z') \quad (4)$$

$$\begin{aligned} d + x + \Phi(x, k)(1 - \tau_c \phi) &= (1 - \tau_c) \pi^f(k, z) + \tau_c \delta k + s, \\ k' &= x + (1 - \delta)k, \quad d \geq 0, \quad s \geq 0 \end{aligned}$$

where  $r$  is defined by

$$1 + r \equiv \frac{P^0 + (1 - \tau_d)D - \tau_g(P^0 - P)}{P} \quad (5)$$

The solution to the firm's problem consists of a value function  $v_f$  as well as policy rules for investment, capital, equity issuance and dividends:

$$x = x(k, z), \quad k' = g(k, z), \quad s = s(k, z), \quad d = d(k, z) \quad (6)$$

Let  $\mu^h$  be the cross sectional distribution of households over the state  $(\theta, \epsilon)$  and  $\mu^f$  the cross sectional distribution of firms over the state  $(k, z)$ . These distributions follow the laws of motion

$$\mu^{h'} = \varphi^h(\mu^h) \quad (7)$$

$$\mu^{f'} = \varphi^f(\mu^f) \quad (8)$$

These stationary distributions can be used to calculate aggregate consumption demand  $C$ , aggregate effective labor supply  $L^s$  and aggregate demand for share holdings  $\Theta$  from the household side

$$C = \int c(\theta, \epsilon) d\mu^h(\theta, \epsilon) \quad (9)$$

$$L^s = \int \epsilon d\mu^h(\theta, \epsilon)$$

$$\Theta' = \int g^h(\theta, \epsilon) d\mu^h(\theta, \epsilon)$$

as well as aggregate labor demand  $L$ , investment  $X$ , capital stock  $K'$ , output

$Y$ , operating profits  $\Pi$ , dividends  $D$  and equity issuance  $S$  from the firm side

$$\begin{aligned} L &= \int l(k, z) d\mu^f(k, z), \quad X = \int x(k, z) d\mu^f(k, z) \\ K' &= \int g(k, z) d\mu^f(k, z), \quad Y = \int z f(k, l(k, z)) d\mu^f(k, z) \\ \Pi &= \int \pi(k, z) d\mu^f(k, z), \quad D = \int d(k, z) d\mu^f(k, z) \\ S &= \int s(k, z) d\mu^f(k, z), \quad \Psi \equiv \int \Phi(x(k, z), k) d\mu^f(k, z) \end{aligned} \quad (10)$$

**Definition:** A *stationary recursive competitive equilibrium* relative to a government policy  $(\tau_l, \tau_d, \tau_g, \tau_c, G)$ , consists of stationary distributions  $\mu^h$  and  $\mu^f$ , laws of motion  $\varphi^h$  and  $\varphi^f$ , prices  $w$  and  $r$ , firm aggregate dividends and share values  $D, P, P^0$ , decision rules for firms and households,  $l(k, z), x(k, z), g(k, z), s(k, z), d(k, z), c(\theta, \epsilon), g^h(\theta, \epsilon)$ , as well as associated value functions  $v^h(\theta, \epsilon)$  and  $v^f(k, z)$  such that:

- *Optimal Household Choice:* Given  $w, D, P$  and  $P^0$ , the individual policy functions  $c(\theta, \epsilon)$  and  $g^h(\theta, \epsilon)$  and the value function  $v_h$  solve the problem of the household in (1)
- *Optimal Firm Choice:* Given  $w$  and  $r$ ,  $l(k, z)$  solves the static problem in (3) and  $x(k, z), g(k, z), s(k, z), d(k, z), v^f(k, z)$  solve the dynamic problem in (4)
- The firm aggregate dividends and share values  $D, P, P^0$  satisfy (10), the definition (5) and  $P^0 = P - S$ .
- *Government Budget Balance:* Government spending equals government revenue

$$G = \tau_l w L + \tau_d D + \tau_g (P^0 - P) + \tau_c (\Pi - \delta K - \phi \Psi)$$

where  $\Pi$  and  $\Psi$  are defined in (10).

- *Market Clearing:* Prices are such that all markets clear

$$\begin{aligned} \Theta' &= 1 \\ L &= L^s \end{aligned}$$

$$C + X + G + \Psi = Y$$

where all the aggregates are defined in (9), (10).

- *Consistency:*  $\varphi^h$  and  $\varphi^f$  are consistent with the households' and firms' optimal decisions respectively, in the sense that they are generated by the optimal decision rules and by the laws of motions of the shocks, and the distributions satisfy:

$$\begin{aligned} \mu^h &= \varphi^h(\mu^h) \\ \mu^f &= \varphi^f(\mu^f) \end{aligned}$$

## 1.2 Recursive Competitive Equilibrium in the Transition

This section defines the recursive competitive equilibrium in transition. We denote the initial stationary joint distribution over household shares and productivity by  $\mu_i^h$  and the initial stationary joint distribution over individual firm capital and productivity by  $\mu_i^f$ .

We first define the household problem in period  $t$  still in recursive form:

$$v_t^h(\theta, \epsilon) = \max_{\{\theta_{t+1}, c_t\}} u(c_t(\theta, \epsilon)) + \beta \sum_{\epsilon_{t+1}} \Omega_\epsilon(\epsilon_{t+1}, \epsilon) v_{t+1}^h(\theta_{t+1}(\theta, \epsilon), \epsilon_{t+1}) \quad (11)$$

$$\begin{aligned} c_t(\theta, \epsilon) + P_t \theta_{t+1}(\theta, \epsilon) &= (1 - \tau_{lt}) w_t \epsilon + ((1 - \tau_{dt}) D_t + P_t^0) \theta - \tau_{gt} (P_t^0 - P_t) \theta \\ \theta_{t+1}(\theta, \epsilon) &\geq 0 \end{aligned}$$

The solution to the household's problem consists of value functions  $\{v_t^h(\theta, \epsilon)\}_{t=0}^\infty$  as well as optimal policies for shares and consumption  $\{c_t(\theta, \epsilon), \theta_{t+1}(\theta, \epsilon)\}_{t=0}^\infty$ .

The static labor demand decision of the firm at period  $t$  is described by a decision rule  $l_t(k, z)$  obtained from period  $t$  profit maximization given wages

$$\pi_t^f(k, z) = \max_{l_t} \{z f(k, l_t) - w_t l_t\} \quad (12)$$

The problem of the firm at period  $t$  can be written recursively as follows:

$$\begin{aligned} v_t^f(k, z) &= \max_{\{x_t, k_{t+1}, s_t, d_t\}} \frac{1 - \tau_{dt}}{1 - \tau_{gt}} d_t(k, z) - s_t(k, z) + \frac{1}{1 + \frac{r_{t+1}}{1 - \tau_{gt}}} \sum_{z_{t+1}|z} \Omega_z(z_{t+1}|z) v_{t+1}^f(k_{t+1}(k, z), z_{t+1}) \\ d_t(k, z) + x_t(k, z) + \Phi(x_t(k, z), k) &= (1 - \tau_{ct}) \pi_t^f(k, z) + \tau_{ct} \delta k + \tau_{ct} \phi \Phi(x_t(k, z), k) + s_t(k, z) \\ k_{t+1}(k, z) &= x_t(k, z) + (1 - \delta) k, \quad d_t(k, z) \geq 0, \quad s_t(k, z) \geq 0 \end{aligned} \quad (13)$$

where  $r_t$  is defined by

$$1 + r_{t+1} \equiv \frac{P_{t+1}^0 + (1 - \tau_{dt+1}) D_{t+1} - \tau_{gt+1} (P_{t+1}^0 - P_{t+1})}{P_t} \quad (14)$$

The solution to the firm's problem consists of value functions  $\{v_t^f(k, z)\}_{t=0}^\infty$  as well as policy rules for investment, capital, equity issuance and dividends:

$$\{x_t(k, z), k_{t+1}(k, z), s_t(k, z), d_t(k, z)\}_{t=0}^\infty$$

The period  $t$  distributions  $\mu_t^h$  and  $\mu_t^f$  can be used to calculate the period  $t$  aggregate consumption demand  $C_t$ , aggregate effective labor supply  $L_t^s$  and aggregate demand for share holdings  $\Theta_t$  from the household side:

$$\begin{aligned} C_t &= \int c_t(\theta, \epsilon) d\mu_t^h(\theta, \epsilon) \\ L_t^s &= \int \epsilon d\mu_t^h(\theta, \epsilon) \\ \Theta_{t+1} &= \int \theta_{t+1}(\theta, \epsilon) d\mu_t^h(\theta, \epsilon) \end{aligned} \quad (15)$$

as well as the period  $t$  aggregate labor demand  $L_t$ , investment  $X_t$ , capital stock  $K_{t+1}$ , output  $Y_t$ , operating profits  $\Pi_t$ , dividends  $D_t$  and equity issuance  $S_t$  from the firm side:

$$\begin{aligned} L_t &= \int l_t(k, z) d\mu_t^f(k, z), \quad X_t = \int x_t(k, z) d\mu_t^f(k, z) \\ K_{t+1} &= \int k_{t+1}(k, z) d\mu_t^f(k, z), \quad Y_t = \int z_t f(k, l_t(k, z)) d\mu_t^f(k, z) \\ \Pi_t &= \int \pi_t^f(k, z) d\mu_t^f(k, z), \quad D_t = \int d_t(k, z) d\mu_t^f(k, z) \\ S_t &= \int s_t(k, z) d\mu_t^f(k, z), \quad \Psi_t \equiv \int \Phi(x_t(k, z), k) d\mu_t^f(k, z) \end{aligned} \quad (16)$$

**Definition:** Given the transition matrices  $\Omega_\epsilon$  and  $\Omega_z$ , as well as initial stationary distributions  $\mu_i^f$  and  $\mu_i^h$ , a *recursive competitive equilibrium* relative to a sequence of government policy  $\{\tau_{lt}, \tau_{dt}, \tau_{gt}, \tau_{ct}, G_t\}_{t=0}^\infty$ , consists of optimal policies for households and firms  $\{c_t(\theta, \epsilon), \theta_{t+1}(\theta, \epsilon)\}_{t=0}^\infty$  and

$$\{l_t(k, z), x_t(k, z), k_{t+1}(k, z), s_t(k, z), d_t(k, z), y_t(k, z)\}_{t=0}^\infty$$

as well as associated value functions  $\{v_t^h(\theta, \epsilon)\}_{t=0}^\infty$  and  $\{v_t^f(k, z)\}_{t=0}^\infty$ , wages  $\{w_t\}_{t=0}^\infty$ , returns  $\{r_t\}_{t=0}^\infty$ , firm dividends and share values  $\{D_t, P_t, P_t^0\}_{t=0}^\infty$  and distributions  $\{\mu_t^f\}_{t=0}^\infty$  and  $\{\mu_t^h\}_{t=0}^\infty$  such that:

- *Optimal Household Choice:* Given  $\{w_t\}_{t=0}^\infty$  and  $\{D_t, P_t, P_t^0\}_{t=0}^\infty$ , the household policy functions  $c_t(\theta, \epsilon)$  and  $\theta_{t+1}(\theta, \epsilon)$  and the value function  $v_t^h(\theta, \epsilon)$  solve the problem of the household in (11) for all  $t$
- *Optimal Firm Choice:* Given  $\{w_t\}_{t=0}^\infty$  and  $\{r_t\}_{t=0}^\infty$ , the firm policy function  $l_t(k, z)$  solves the static problem in (12) and the policy functions  $x_t(k, z)$ ,  $k_{t+1}(k, z)$ ,  $s_t(k, z)$ ,  $d_t(k, z)$ ,  $y_t(k, z)$  and the value function  $v_t^f(k, z)$  solve the dynamic problem in (13) for all  $t$
- The aggregates  $D_t, P_t, P_t^0$  satisfy (16), the definition (14) and  $P_t^0 = P_t - S_t$ .
- *Government Budget Balance:* Government spending equals government revenue

$$G_t = \tau_{lt} w_t L_t + \tau_{dt} D_t + \tau_{gt} (P_t^0 - P_t) + \tau_{ct} (\Pi_t - \delta K_t - \phi \Psi_t)$$

where  $\Pi_t$  and  $\Psi_t$  are defined in (16).

- *Market Clearing:* Wages and returns are such that all markets clear

$$\begin{aligned} \Theta_{t+1} &= 1 \\ L_t &= L_t^s \end{aligned}$$

$$C_t + X_t + G_t + \Psi_t = Y_t$$

where all the aggregates are defined in (15), (16).

- *Consistency*: The distributions' laws of motion  $\varphi_t^h$  and  $\varphi_t^f$  are consistent with the households' and firms' optimal decisions respectively, in the sense that they are generated by the optimal decision rules and by the laws of motions of the shocks, and the distributions  $\mu_{t+1}^f$  and  $\mu_{t+1}^h$  satisfy:

$$\begin{aligned}\mu_{t+1}^h &= \varphi_t^h(\mu_t^h) \\ \mu_{t+1}^f &= \varphi_t^f(\mu_t^f)\end{aligned}$$

## 2 Computational Algorithm

### 2.1 Computing the Stationary Competitive Equilibrium

For given prices, the problems of individual firms and households are solved using value function iteration algorithms. Policy rules are then used to obtain stationary distributions and aggregate variables and these, in turn, are used to check market clearing and update prices. Let the individual firm state vector be denoted by  $s_f = (k, z)$  and the individual household state vector be denoted by  $s_h = (\theta, \epsilon)$ .

Step 1. Guess a wage and a return  $(w^0, r^0)$ .

Step 2. (Firm Problem)

Step 2.1. Solve the firm's problem given  $(w^0, r^0)$  using value function iterations and obtain the value function  $v^f(s_f)$  and the optimal decision rules for the firm, namely labor demand  $l = l(s_f)$ , investment  $x = x(s_f)$ , capital  $k' = g(s_f)$ , equity issuance  $s = s(s_f)$ , dividends  $d = d(s_f)$  and output  $y = y(s_f)$ .

Step 2.2. Use the firm decision rules from step 2.1 to solve for the stationary distribution of firms  $\mu^f = \mu^f(k, z)$ .

Step 2.3. Obtain the firm aggregates  $L, X, K', Y, \Pi, S$  and  $D$  using equations (10),  $P$  using the steady state version of (5) and  $P^0 = P - S$ .

Step 2.4. Check that the wage rate  $w^0$  clears the labor market, namely that  $L = L^s$ , where  $L^s = \int \epsilon d\mu^h(\theta, \epsilon)$  is the exogenous (effective) labor supply from the households. If labor markets do not clear, update the wage rate.

Step 2.5: Repeat steps 2.1 - 2.4 until the labor market clears. This will deliver a new wage  $w^{new}$ .

Step 3 (Household Problem)

Step 3.1 Solve the household's problem given  $(r^0, w^{new}, P, P^0, D)$  using value function iterations and obtain the value function  $v^h(s_h)$  and the optimal decision rules for the households, namely asset holdings  $\theta' = g_h(s_h)$  and consumption choices  $c = c(s_h)$ .

Step 3.2. Use the household decision rules from step 3.1 to solve for the stationary distribution of households  $\mu^h$ .

Step 3.3. Obtain the aggregate asset demand  $\Theta'$  and consumption  $C$  using equations (9).



Step 3.4. Check whether the guessed return  $r^0$  clears the asset market, namely that  $\Theta' = 1$ . If asset markets do not clear, update the interest rate.

Step 3.5: Repeat steps 3.1 - 3.4 until the asset market clears. This will deliver a new interest rate  $r^{new}$ .

Step 4. Update the price vector using a standard bisection method between the guessed  $(w^0, r^0)$  and implied  $(w^{new}, r^{new})$  prices and repeat steps 2 and 3 until convergence.

In the pre-reform steady state all taxes are exogenously given and the solution process simply delivers the endogenous value of  $G$ . In the post-reform steady state,  $G$  is fixed and one (or two, depending on the experiment) of the tax rates needs to be solved for endogenously. The algorithm in that case involves an outer loop where the endogenous tax rates are guessed and then updated until they imply government budget balance.

## 2.2 Computing the Transitional Dynamics

Let  $(\tau_c^i, \tau_d^i, \tau_g^i, \tau_l^i)$  be the tax rates associated with the initial steady state and  $(\tau_c^*, \tau_d^*, \tau_g^*, \tau_l^*)$  denote the tax rates associated with the new steady state. Similar notation is used for the policies, value functions and prices in the two steady states which are already computed using the stationary equilibrium algorithm. For example  $r^i$  is the return in the initial steady state and  $r^*$  the one in the final steady state. Let the individual firm state vector be denoted by  $s_f = (k, z)$  and the individual household state vector be denoted by  $s_h = (\theta, \epsilon)$ . Assume that the economy converges to the new steady state in  $T$  periods.

Step 1. Guess a path for the prices  $\{w_t^0, r_t^0\}_{t=1}^T$ .

Step 2. (Firm Problem)

Step 2.1. Use the path of prices  $\{w_t^0, r_t^0\}_{t=1}^T$  together with the fact that  $v_T^f(s_f) = v^{f*}(s_f)$  to solve the firm's problem by finite backward induction and obtain the time-dependent policy functions for labor demand  $l_t(s_f)$ , investment  $x_t(s_f)$ , capital  $k_{t+1}(s_f)$ , equity issuance  $s_t(s_f)$  and dividends  $d_t(s_f)$ , as well as the time-dependent value functions  $v_t^f(s_f)$ , for each period  $t = 1, 2, \dots, T$ .

Step 2.2. Use the time-dependent policy functions and the stationary distribution of firms for the initial steady state  $\mu_i^f$  to compute the implied cross-sectional distribution of firms  $\mu_t^f$  for any period  $t = 1, 2, \dots, T$ .

Step 2.3. Obtain the firm aggregates as well as  $P_t, P_t^0$  in each period  $t = 1, 2, \dots, T$  using equations (16), the Euler condition of households and  $P_t^0 = P_t - S_t$ .

Step 3. (Government Budget)

Given government spending  $G$ , fixed tax rates  $(\tau_c^*, \tau_d^*, \tau_g^*)$ , the exogenous labor supply level  $L^s$  and the paths for wages and firm aggregates, use the government budget in period  $t$  to obtain the labor tax rate  $\tau_{lt}$  that ensures budget balance for each  $t = 1, 2, \dots, T$ .

Step 4. (Household Problem)

Step 4.1 Use the path of prices  $\{w_t^0, r_t^0\}_{t=1}^T$  and the computed paths for the financial aggregates  $\{P_t, P_t^0, D_t\}_{t=1}^T$  and labor taxes  $\{\tau_{lt}\}_{t=1}^T$ , together with the fact that  $v_T^h(s_h) = v^{h*}(s_h)$ , to solve the household's problem by finite backward induction and obtain the time-dependent policy functions for asset holdings  $\theta_{t+1}(s_h)$  and consumption choices  $c_t(s_h)$ , as well as the time-dependent value functions  $v_t^h(s_h)$ , for each period  $t = 1, 2, \dots, T$ .

Step 4.2. Use the time-dependent policy functions and the stationary distribution of households for the initial steady state  $\mu_i^h$  to compute the implied cross-sectional distribution of households  $\mu_t^h$  for any period  $t = 1, 2, \dots, T$ .

Step 4.3 Obtain the path for aggregate asset demand  $\{\Theta_{t+1}\}_{t=1}^T$  using the expression in (15) for each period  $t = 1, 2, \dots, T$ .

Step 5. For each period  $t = 1, 2, \dots, T$ , check whether the guessed prices  $(w_t^0, r_t^0)$  clear the asset market and the labor market and, if not, update the prices and repeat steps 2 - 5 until convergence (i.e. until both markets clear).