Online Appendix for "Financing Corporate Tax Cuts with Shareholder Taxes" - **NOT FOR PUBLICATION**

Alexis Anagnostopoulos*, Orhan Erem Atesagaoglu†, Eva Cárceles-Poveda‡
Stony Brook University

February 3, 2021

Abstract

Section 1 provides the definitions of recursive competitive equilibrium, both stationary and in transition, for our benchmark economy. Section 2 provides the corresponding computational algorithms. Section 3 discusses additional experiments omitted from the main paper. Specifically, section 3.1 presents alternative calibrations of adjustment costs (including nonconvex costs), section 3.2 allows for debt financing by firms and section 3.3 discusses reform effects in the case of a representative household (complete markets).

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 (θ, ϵ) and its problem can be written recursively as follows:

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

* *Email:* alexis.anagnostopoulos@stonybrook.edu.
† *Email:* orhan.atesagaoglu@stonybrook.edu.
‡ *Email:* ecarcelespov@gmail.com.

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:

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

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 $l = g^l(k, z)$ obtained from profit maximization, given the wage w:

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

and its dynamic problem is as follows:

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

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

where r is defined by

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

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:

$$x = g^x(k, z), \; k' = g^k(k, z), \; s = g^s(k, z), \; d = g^d(k, z) \tag{6}$$

Let μ^h be the cross sectional distribution of households over the state (θ, ϵ) and μ^f the cross sectional distribution of firms over the state (k, z). These distributions follow the laws of motion

$$\mu'_h = \varphi_h(\mu_h) \tag{7}$$

$$\mu'_f = \varphi_f\left(\mu_f\right) \tag{8}$$

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

$$\begin{aligned} C &= \int g^c(\theta, \epsilon)\, d\mu_h(\theta, \epsilon) \qquad (9) \\ L^s &= \int \epsilon d\mu_h(\theta, \epsilon) \\ \Theta' &= \int g^\theta(\theta, \epsilon)\, d\mu_h(\theta, \epsilon) \end{aligned}$$

as well as aggregate labor demand L, investment X, capital stock K', output Y, operating profits Π, dividends D and equity issuance S from the firm side

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

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

- *Optimal Household Choice:* Given w, D, P and P^0, the individual policy functions $g^c(\theta,\epsilon)$ and $g^\theta(\theta,\epsilon)$ and the value function v_h solve the problem of the household in (1)
- *Optimal Firm Choice:* Given w and r, $g^l(k,z)$ solves the static problem in (3) and $g^x(k,z)$, $g^k(k,z)$, $g^s(k,z)$, $g^d(k,z)$, $v(k,z)$ 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

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

  where Π and Ψ are defined in (10).
- *Market Clearing:* Prices are such that all markets clear

  $$\begin{aligned} \Theta' &= 1 \\ L &= L^s \\ C + X + G + \Psi &= Y \end{aligned}$$

  where all the aggregates are defined in (9), (10).
- *Consistency:* φ^h and φ^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

We first define the household problem (given aggregates) in period t still in recursive form:

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

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

The solution to the household's problem consists of value functions $\{v_{ht}(\theta, \epsilon)\}_{t=0}^{\infty}$ 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

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

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

$$v_t(k, z) = \max_{\{x_t, k_{t+1}, s_t, d_t\}} \frac{1 - \tau_{dt}}{1 - \tau_{gt}} d_t(k, z) - s_t(k, z) + \frac{1}{1 + \frac{r_{t+1}}{1 - \tau_{gt}}} \sum_{z_{t+1}|z} \Omega_z(z_{t+1}|z) v_{t+1}(k_{t+1}(k, z), z_{t+1})$$

$$d_t(k, z) + x_t(k, z) + \Phi(x_t(k, z), k) = (1 - \tau_{ct}) \pi_t(k, z) + \tau_{ct} \delta k + \tau_{ct} \phi \Phi(x_t(k, z), k) + s_t(k, z)$$

$$k_{t+1}(k, z) = x_t(k, z) + (1 - \delta) k, \; d_t(k, z) \geq 0, \; s_t(k, z) \geq 0 \quad (13)$$

where r_t is defined by

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

The solution to the firm's problem consists of value functions $\{v_t(k, z)\}_{t=0}^{\infty}$ 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 μ_{ht} and μ_{ft} 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 Θ_t from the household side:

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

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

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

Definition: Given the transition matrices Ω_ϵ and Ω_z, as well as initial distributions μ_{f0} and μ_{h0}, a *recursive competitive equilibrium* relative to a government policy sequence $\{\tau_{lt}, \tau_{dt}, \tau_{gt}, \tau_{ct}\}_{t=0}^{\infty}$, consists of optimal policies for households and firms $\{c_t(\theta,\epsilon), \theta_{t+1}(\theta,\epsilon)\}_{t=0}^{\infty}$ and

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

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

- *Optimal Household Choice:* Given $\{w_t\}_{t=0}^{\infty}$ and $\left\{D_t, P_t, P_t^0\right\}_{t=0}^{\infty}$, the household policy functions $c_t(\theta,\epsilon)$ and $\theta_{t+1}(\theta,\epsilon)$ and the value function $v_{ht}(\theta,\epsilon)$ 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 $x_t(k,z)$, $k_{t+1}(k,z)$, $s_t(k,z)$, $d_t(k,z)$ and the value function $v_t(k,z)$ 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

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

  where Π_t and Ψ_t are defined in (16).

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

$$\Theta_{t+1} = 1$$
$$L_t = L_t^s$$
$$C_t + X_t + G_t + \Psi_t = Y_t$$

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

- *Consistency:* The distributions' laws of motion φ_{ht} and φ_{ft} 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 μ_{ft+1} and μ_{ht+1} satisfy:

$$\begin{aligned} \mu_{ht+1} &= \varphi_{ht}(\mu_{ht}) \\ \mu_{ft+1} &= \varphi_{ft}(\mu_{ft}) \end{aligned}$$

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 $v(s_f)$ 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 $s = s(s_f)$ and dividends $d = d(s_f)$.

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, Π, 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 μ_h.

Step 3.3. Obtain the aggregate asset demand Θ' 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 $\left(w^0, r^0\right)$ and implied $\left(w^{new}, r^{new}\right)$ 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 $v_T(s_f) = v^*(s_f)$ to solve the firm's problem by finite backward induction and obtain the time-dependent policy functions for labor demand $l_t\left(s_f\right)$, investment $x_t\left(s_f\right)$, capital $k_{t+1}\left(s_f\right)$, equity issuance $s_t\left(s_f\right)$ and dividends $d_t\left(s_f\right)$, as well as the time-dependent value functions $v_t\left(s_f\right)$, for each period $t = 1, 2, ..., T$.

Step 2.2. Use the time-dependent policy functions and the stationary distribution of firms for the initial steady state μ_f^i to compute the implied cross-sectional distribution of firms μ_{ft} for any period $t = 1, 2, ..., T$.

Step 2.3. Obtain the firm aggregates as well as P_t, P_t^0 in each period $t = 1, 2, ..., T$ 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 $\left(\tau_c^*, \tau_d^*, \tau_g^*\right)$, 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 τ_{lt} that ensures budget balance for each $t = 1, 2, ..., T$.

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 $v_{hT}(s_h) = v_h^*(s_h)$, 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 $v_{ht}(s_h)$, for each period $t = 1, 2, ..., T$.

Step 4.2. Use the time-dependent policy functions and the stationary distribution of households for the initial steady state μ_h^i to compute the implied cross-sectional distribution of households μ_{ht} for any period $t = 1, 2, ..., T$.

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

Step 5. For each period $t = 1, 2, ..., T$, check whether the guessed prices $\left(w_t^0, r_t^0\right)$ 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). To update the prices, we use the following equations:

$$\begin{aligned} w_t^1 &= \lambda w_t^0 + (1-\lambda)\, w_t^m \\ r_t^1 &= \lambda r_t^0 + (1-\lambda)\, r_t^m \end{aligned}$$

where λ is an updating parameter and w_t^m and r_t^m are computed as follows:

$$\begin{aligned} w_t^m &= w_t^0 \left(\frac{L_t}{L_t^s}\right)^{1-\alpha_l} \\ r_t^m &= r_t^0 \left(\Theta_{t+1}\right)^{(\alpha_k - 1)} \end{aligned}$$

Note that if the demand for shares is too high, $\Theta_{t+1} > 1$, the updating rule above reduces the return on shares and vice versa. Similarly, if labor supply is too low, $L_t > L_s$, the above rule increases wages and vice versa. The rules use the demand elasticity parameters α_l and α_k to govern the strength of adjustment. We find that these updating rules with $\lambda = 0.9$ give us a convergence of the algorithm.

3 Additional Experiments and Model Extensions

This section contains more details about the sensitivity analyses that were done in the paper with respect to the nature and size of adjustment costs, the introduction of corporate debt financing and the absence of household heterogeneity.

3.1 Adjustment Costs

3.1.1 Adjustment Cost Size

This section investigates the sensitivity of the results with respect to the size of the convex adjustment cost parameter, which affects the volatility of the investment rate. In particular, we have computed our baseline tax reform experiments with the higher volatility of investment rates of 0.337 reported in Cooper and Haltiwager (2006) and have looked at the effects on the long run aggregates, as well as on welfare including the transition, of the two reforms where τ^c is reduced to zero. The results are reported below.

Table 1**:** Reforms with a higher investment rate volatility

REFORM	A: τ_c vs $\tau_d = \tau_g$	B: τ_c vs τ_d
τ_c	0	0
τ_d	0.52	0.47
τ_g	0.52	0.20
Long Run Aggregates (% Change)		
K	-5.19	37.1
TFP	1.82	-6.33
Y	0.14	3.34
C	-0.94	3.28
r	-2.42	-0.12
w	0.15	3.34
Welfare Effects (%)		
Overall	0.45	-3.16
Aggregate	0.16	-3.61
Distributional	0.29	0.46

The table reflects that the presence of lower convex adjustment costs (higher volatility of investment rates) does not change the main qualitative results of our benchmark economy. Specifically, in the case without the tax wedge, the reform still leads to a decrease in capital that is accompanied by an increase in TFP, a slight increase in output and a slight decrease in consumption. In the reform which increases the dividend tax only, we still obtain large increases in capital accompanied by a decrease in TFP and an increase in output and consumption. In both reforms, the wage still increases and the interest rate still decreases. So the main qualitative idea of positive redistribution in both cases, but efficiency improvements only when $\tau_d = \tau_g$ seems to hold regardless of the size of adjustment costs.

Quantitatively, there are only very small changes for the reform with $\tau_d = \tau_g$ when we change the size of adjustment costs. Some quantitative differences arise for the τ_d-only case. In particular, lower adjustment costs imply the misallocation effects are larger (TFP falls by more) and, as a result, long run output and consumption do not increase as much as in our benchmark. Overall, the welfare effects are stronger but they still exhibit the qualitative properties discussed in the paper, namely increased welfare from both an aggregate and a distributional perspective when $\tau_d = \tau_g$ and increased distributional but decreased aggregate component when $\tau_d > \tau_g$.

3.1.2 Nature of Adjustment Costs: Fixed versus Convex

As discussed in the calibration section of the main text, many of the features of lumpy investment discussed in the literature are already present in our model without any non-convex costs due to the presence of volatile idiosyncratic productivity shocks. In this section, we investigate the effects of adding non convex costs to the benchmark version of the model following Khan and Thomas (2008), except for the fact that the fixed costs are constant rather than stochastic. To be precise, we add a fixed adjustment cost to the firms' problem as follows: if firm j undertakes an unconstrained investment choosing $k_{jt+1} \in \mathbb{R}_+$, it has to pay a fixed cost ξ denominated in units of labor $w_t\xi$. Alternatively, the firm does not have to pay the cost if it undertakes a constrained investment in the interval $x_{jt} \in [a_1 k_{jt}, a_2 k_{jt}]$, where $a_1 \leq 0 \leq a_2$. In this case $k_{jt+1} \in \Omega(k_{jt}) \subseteq \mathbb{R}_+$, with $\Omega(k_{jt}) = [(a_1 + 1 - \delta) k_{jt}, (a_2 + 1 - \delta) k_{jt}]$.

In this extended version of our model, the firm's financing constraint is:

$$
\begin{aligned}
d_{jt} &= \pi(k_{jt}, z_{jt}; w_t) - w_t\xi I_{jt} + s_{jt} - k_{jt+1} + (1-\delta) k_{jt} - \Phi(x_{jt}, k_{jt}) - \tau_c T_{jt} \\
T_{jt} &= \pi(k_{jt}, z_{jt}; w_t) - w_t\xi I_{jt} - \delta k_{jt} - \phi\Phi(x_{jt}, k_{jt})
\end{aligned}
$$

where I_{jt} denotes an indicator function

$$
\begin{aligned}
I_{jt} &= 0 \text{ if } k_{jt+1} \in \Omega(k_{jt}) \\
&= 1 \text{ otherwise}
\end{aligned}
$$

Note the fixed adjustment cost is treated as a labor cost, hence deducted from corporate taxes. The rest of the model remains as before except for the labor market clearing condition which now includes these fixed costs as part of labor demand

$$
\int (l_{jt} + \xi I_{jt})\, dj = \int \epsilon_{it} di
$$

To write the problem of the firm recursively, let $v^c(z,k)$ be the value of the firm if it undertakes a constrained investment level, $k' \in \Omega(k)$, and $v^u(z,k)$ the value if the investment level is unconstrained. The problem of the firm can be written recursively as follows:

$$
\begin{aligned}
v^c(z,k) &= \max_{x,k',s,d} \frac{1-\tau_d}{1-\tau_g} d - s + \frac{1}{1+\frac{r}{1-\tau_g}} \sum_{z'|z} \Omega_z(z'|z)\, v(z',k') \\
d &= \pi(k,z;w)(1-\tau_c) + \tau_c \delta k + s - k' + (1-\delta) k - \Phi(x,k)(1-\tau_c\phi) \\
k' &= x + (1-\delta) k,\ s \geq 0,\ d \geq 0,\ \ k' \in \Omega(k)
\end{aligned}
$$

$$
\begin{aligned}
v^u(z,k) &= \max_{x,k',s,d} \frac{1-\tau_d}{1-\tau_g} d - s + \frac{1}{1+\frac{r}{1-\tau_g}} \sum_{z'|z} \Omega_z(z'|z)\, v(z',k') \\
d &= [\pi(k,z;w) - w\xi](1-\tau_c) + \tau_c \delta k + s - k' + (1-\delta) k - \Phi(x,k)(1-\tau_c\phi) \\
k' &\in \mathbb{R}_+,\ s \geq 0,\ \ d \geq 0, k' = x + (1-\delta) k
\end{aligned}
$$

$$v(z,k) = \max\{v^c(z,k), v^u(z,k)\}$$

The solution to this problem are value functions $v^c(z,k)$, $v^u(z,k)$ and $v(z,k)$ and policies $k' = g^k(k,z)$, $s = g^s(k,z)$, $x = g^x(k,z)$ and $d = g^d(k,z)$.In addition, $l = g^l(k,z)$ is defined using the static profit maximization of the firm as usual.

Let μ_f the cross sectional distribution of firms over the state (k,z), with law of motion $\mu_f' = \varphi_f(\mu_f)$. We can use the stationary distribution to calculate aggregates for the firm side: labor demand L, investment X, capital stock K', output Y, dividends D, equity issuance S and convex adjustment costs Ψ.

$$\begin{aligned}
L &= \int g^l(k,z)\, d\mu_f(k,z),\ X = \int g^x(k,z)\, d\mu_f(k,z) \\
K' &= \int g^k(k,z)\, d\mu_f(k,z),\ Y = \int zf\left(k, g^l(k,z)\right) d\mu_f(k,z) \\
D &= \int g^d(k,z)\, d\mu_f(k,z),\ S = \int g^s(k,z)\, d\mu_f(k,z) \\
\Psi &\equiv \int \Phi\left(g^x(k,z), k\right) d\mu_f(k,z)
\end{aligned}$$

In the presence of fixed costs, the household sector is the same as before. Moreover, the government budget and the market clearing conditions are:[1]

$$G = \tau_c\left(Y - wL - w\xi I_\xi - \phi\Psi - \delta K\right) + \tau_l w L^h + \tau_d D + \tau_g\left(P^0 - P\right)$$

$$\begin{aligned}
\Theta' &= 1 \\
L + I_\xi \xi &= L^h \\
C + X + G + \Psi &= Y
\end{aligned}$$

To solve the model, we choose $a_2 = -a_1 = 0.01$ and calibrate the parameter ξ capturing the size of the fixed costs to match the fraction of inactive firms in data. The convex cost parameter is adjusted to maintain the same investment rate volatility of 0.156 as in the benchmark. As can be seen in the third column of the table below (FC), the presence of fixed costs can help match the 8% inaction rate. Because our inactivity rate is quite close to the data anyway, only a very small fixed cost is enough to move inactivity up to 8%. Introducing this small fixed cost has no significant other effects, neither on the benchmark distribution nor, more importantly, on the reform effects (which are essentially identical to the case of no fixed cost and are not reported).

Table 2: Moments of the Investment Rate Distribution

[1] I_ξ denotes the measure of firms that pay the fixed cost, i.e. that have $g^k(k,z) \notin \Omega(k)$.

	Data	No FC	FC
Inactive ($\left\|\frac{x}{k}\right\| < 0.01$)	0.081	0.061	0.080
Pos ($\frac{x}{k} > 0.01$)	0.815	0.577	0.563
Neg ($\frac{x}{k} < -0.01$)	0.104	0.362	0.357
Pos spikes ($\frac{x}{k} > 0.2$)	0.186	0.162	0.162
Neg spikes ($\frac{x}{k} < -0.2$)	0.018	0.001	0.001

3.2 Debt Financing

We consider an extension of our model where firms can issue debt that can be bought by households. Interest payments on debt are deductible from corporate income taxes but households pay taxes on the interest income. Following the suggestion of a referee, we do not follow Gourio and Miao (2010) in assuming a collateral constraint that would exogenously fix the debt to capital ratio. Instead we assume quadratic costs of holding debt as a trade-off to the tax advantage. Optimally one would allow for firm default instead (see e.g. Cooley and Quadrini (2001), Hennessy and Whited (2005) or Covas and DenHaan (2011)) but given the computational complexity of the model as it is, we have opted for this reduced form approach to capture the main idea. Below, we describe the model with debt focusing only on the parts of the model that change. Subsequently, we discuss the main trade-off that informs the intuition for our computational experiments with this setting. In the last part, we discuss our quantitative findings.

3.2.1 Firms

Firm j can use internal funds $\pi(k_{jt}, z_{jt}; w_t) - \tau_c T_{jt}$ and external funds as before. The difference is that there are now two options for external funds: in addition to equity issuance s_{jt} firms can also issue new debt $b_{jt+1} - b_{jt}$, where b_{jt} denotes debt outstanding at t from the previous period. The firm has to pay an interest rate $\tilde{r}_t$ on its outstanding debt as well as a quadratic cost $\xi\tilde{r}_t\frac{b_{jt}^2}{k_{jt}}$. One way to think about the cost is as if the interest rate were increasing in the debt to capital ratio, i.e. as if the interest rate were actually $\tilde{r}_t\left(1+\xi\frac{b_{jt}}{k_{jt}}\right)$. The firm can use these sources of funds to finance dividends, investment (including adjustment costs) and debt interest payments (including costs), so the firm's financing constraint becomes:

$$d_{jt} + x_{jt} + \Phi(x_{jt}, k_{jt}) + \tilde{r}_t b_{jt} + \xi\tilde{r}_t\frac{b_{jt}^2}{k_{jt}} = \pi(k_{jt}, z_{jt}; w_t) - \tau_c T_{jt} + s_{jt} + b_{jt+1} - b_{jt}$$

where taxable corporate income now also excludes debt interest payments plus cost

$$T_{jt} = \pi(k_{jt}, z_{jt}; w_t) - \delta k_{jt} - \phi\Phi(x_{jt}, k_{jt}) - \tilde{r}_t b_{jt}\left(1+\xi\frac{b_{jt}}{k_{jt}}\right)$$

The introduction of debt implies that a firm's state variables now include the debt level, i.e. the state is (z_{jt}, k_{jt}, b_{jt}) and thus in solving the model recursively we redefine all policy functions as well as the firm distribution μ^f as functions of these three variables.

Finally, the firm's discount factor for time t payout is again based on the household problem and can be expressed as (see next section)

$$\left(\prod_{n=1}^{t} \frac{1}{1+\frac{\tilde{r}_n(1-\tau_i)}{1-\tau_g}}\right)$$

We denote the total bonds of all firms by

$$B_t = \int b_{jt} dj$$

3.2.2 Households

Households can now buy both corporate stocks and corporate bonds. However, in the absence of aggregate uncertainty, corporate stocks and corporate bonds are both risk free assets and, hence, are essentially the same asset. In equilibrium, their after-tax returns are equalized and the household problem is essentially unaffected, although it includes some additional notation. The household budget is now:

$$\begin{aligned} & c_{it} + P_t\theta_{it} + b^h_{it+1} \\ = \; & (1-\tau_l)w_t\epsilon_{it} + \left((1-\tau_d)D_t + P^0_t\right)\theta_{it-1} - \tau_g\left(P^0_t - P_{t-1}\right)\theta_{it-1} + \left(1+\tilde{r}_t\left(1-\tau_i\right)\right)b^h_{it} \end{aligned}$$

where τ_i denotes the tax rate on interest income. First order conditions for shares θ_{it} and bonds b^h_{it+1} are given by

$$\begin{aligned} \frac{P^0_{t+1} + (1-\tau_d)\,D_{t+1} - \tau_g\left(P^0_{t+1} - P_t\right)}{P_t} &= \frac{u'\left(c_{it}\right)}{\beta E_t u'\left(c_{it+1}\right)} \\ 1 + \left(1-\tau_i\right)\tilde{r}_{t+1} &= \frac{u'\left(c_{it}\right)}{\beta E_t u'\left(c_{it+1}\right)} \end{aligned}$$

for unconstrained households. These imply equalization of (risk free) returns

$$1 + \left(1-\tau_i\right)\tilde{r}_{t+1} = \frac{P^0_{t+1} + (1-\tau_d)\,D_{t+1} - \tau_g\left(P^0_{t+1} - P_t\right)}{P_t}$$

and this also implies that households choose overall savings $P_t\theta_{it}+b^h_{it+1}$ (subject to a no-borrowing constraint $P_t\theta_{it}+b^h_{it+1} \geq 0$ as usual) but the portfolio between stocks and bonds is indeterminate from a household point of view. Finally, this implies that the (ex-dividend) market value of equity is given by

$$P_t = \frac{1}{1+\frac{1-\tau_i}{1-\tau_g}\tilde{r}_{t+1}}\left[\frac{(1-\tau_d)}{(1-\tau_g)}D_{t+1} - S_{t+1} + P_{t+1}\right]$$

where we have substituted $P^0_{t+1} = P_{t+1} - S_{t+1}$ as usual. Note this provides the discount factor $\frac{1}{1+\frac{1-\tau_i}{1-\tau_g}\tilde{r}_{t+1}}$ used for the firm.

The household's state variables are the shock ϵ_{it} and household wealth $a_{it} \equiv P_{t-1}\theta_{it-1} + b^h_{it}$. To keep notation as in the main paper, and without loss of generality, we re-write the choice of households as being the share θ^a_{it} of the total wealth value $A_{t+1} \equiv P_t + B_{t+1}$ and the household budget as

$$c_{it} + A_{t+1}\theta^a_{it} = (1-\tau_l)w_t\epsilon_{it} + (1+\tilde{r}_t(1-\tau_i))A_t\theta^a_{it-1}$$

As a result, the state variables for the household are $\left(\theta^a_{it-1}, \epsilon_{it}\right)$.

3.2.3 Government Budget and Market Clearing

The adjusted government budget constraint and goods market clearing are given by

$$G = \tau_d D_t + \tau_{lt}w_t L_t + \tau_g(P^0_t - P_{t-1}) + \tau_c\int T_{jt}dj + \tau_i B_t\tilde{r}_t$$

and

$$\int c_{it}di + \int x_{jt}dj + G + \int \Phi\left(x_{jt}, k_{jt}\right)dj + \int \xi\tilde{r}_t\frac{b^2_{jt}}{k_{jt}}dj = \int y_{jt}dj$$

Shares and labor market clearing conditions are unaffected

$$\int \theta^a_{it}di = 1$$

$$\int l_{jt}dj = \int \epsilon_{it}di$$

3.2.4 Stationary Recursive Formulation

The problem of the firm can be written recursively as follows

$$\begin{aligned} v(z,k,b) &= \max_{b',k',s,x} \frac{1-\tau_d}{1-\tau_g}d - s + \frac{1}{1+\frac{\tilde{r}(1-\tau_i)}{1-\tau_g}}\sum_{z'|z}\Omega_z(z'|z)\,v(z',k',b') \\ d + x + \Phi(x,k) + \tilde{r}b\left(1+\xi\frac{b}{k}\right) &= \pi(k,z;w) - \tau_c T + s + b' - b \\ T &= \pi(k,z;w) - \delta k - \phi\Phi(x,k) - \tilde{r}b\left(1+\xi\frac{b}{k}\right) \\ s &\geq 0,\ d \geq 0, k' = x + (1-\delta)k \end{aligned}$$

and the solution are value functions $v(z,k,b)$ and policies $b' = g^b(k,b,z)$, $k' = g^k(k,b,z)$, $s = g^s(k,b,z)$, $x = g^x(k,b,z)$ and $d = g^d(k,b,z)$. In addition, $l = g^l(k,z)$ is defined by static profit maximization as usual.

Let μ_f the cross sectional distribution of firms over the state (k,b,z), with law of motion $\mu'_f = \varphi_f\left(\mu_f\right)$. We can use the stationary distribution to calculate aggregates for the firm side: labor demand L, investment X, capital stock K', output Y, dividends D, equity issuance S, new debt B', capital adjustment adjustment costs Ψ and debt costs Ξ.

$$\begin{aligned}
L &= \int g^{l}(k,z)\,d\mu_f(k,b,z)\,,\; X = \int g^{x}(k,b,z)\,d\mu_f(k,b,z) \\
K' &= \int g^{k}(k,b,z)\,d\mu_f(k,b,z)\,,\; Y = \int zf\left(k, g^{l}(k,b,z)\right)d\mu_f(k,b,z) \\
D &= \int g^{d}(k,b,z)\,d\mu_f(k,b,z)\,,\; S = \int g^{s}(k,b,z)\,d\mu_f(k,b,z) \\
B' &= \int g^{b}(k,b,z)\,d\mu_f(k,b,z)\,,\; \Psi \equiv \int \Phi\left(g^{x}(k,b,z),k\right)d\mu_f(k,b,z) \\
\Xi &\equiv \int \xi\tilde{r}\frac{b^2}{k}d\mu_f(k,b,z)
\end{aligned}$$

In a stationary environment, total wealth is $A \equiv P + B$ and the problem of the households can be written recursively as follows:

$$\begin{aligned}
v_h(\theta^a,\epsilon) &= \max_{\{\theta',c\}} u(c) + \beta\sum_{\epsilon'}\Omega_\epsilon(\epsilon',\epsilon)\,v_h\left(\theta^{a\prime},\epsilon'\right) \text{ s.t.} \\
c + A\theta^{a\prime} &= (1-\tau_l)w\epsilon + \left(1+\tilde{r}(1-\tau_i)\right)A\theta^a \\
\theta^{a\prime} &\geq 0
\end{aligned}$$

The solution are value functions $v_h(\theta^a,\epsilon)$ and policies $c = g^c(\theta^a,\epsilon)$, $\theta' = g^\theta(\theta^a,\epsilon)$. Let μ_h be the cross sectional distribution of households over the state $s_h = (\theta^a,\epsilon)$, with law of motion $\mu_h' = \varphi_h(\mu_h)$. We can use the stationary distributions to calculate aggregates from the household side:

$$\begin{aligned}
C &= \int g^c(s_h)\,d\mu_h(s_h) \\
L^s &= \int \epsilon\, d\mu_h(s_h) \\
\Theta' &= \int g^\theta(s_h)\,d\mu_h(s_h)
\end{aligned}$$

The government budget constraint and the market clearing conditions are given by:

$$G = \tau_c\left(Y - wL - \phi\Psi - \tilde{r}B - \Xi - \delta K\right) + \tau_l wL^h + \tau_d D + \tau_g\left(P^0 - P\right) + \tau_i B\tilde{r}$$

$$\begin{aligned}
\Theta' &= 1 \\
L &= L^s \\
C + X + G + \Psi + \Xi &= Y
\end{aligned}$$

3.2.5 The optimal choice of debt

The main difference from our benchmark model is the firms' choice of debt. This can be described using the firm's Euler equation for debt

$$\gamma_{jt} = E_t \frac{\left(1 + (1-\tau_c)\,\tilde{r}_{t+1}\left(1 + 2\xi \frac{b_{jt+1}}{k_{jt+1}}\right)\right)\gamma_{jt+1}}{1 + \frac{1-\tau_i}{1-\tau_g}\tilde{r}_{t+1}}$$

where γ_{jt} denotes the marginal value of resources for the firm (the multiplier on the financing constraint). The marginal value of resources can be characterized using the first order conditions for dividends and equity issuance

$$\begin{aligned} \gamma_{jt} &= \frac{1-\tau_d}{1-\tau_g} + \lambda_{jt}^d \\ \gamma_{jt} &= 1 - \lambda_{jt}^s \end{aligned}$$

where λ_{jt}^d and λ_{jt}^s are the multipliers of the dividend and equity issuance non-negativity constraints. Similarly to the case of no debt, this marginal value of resources equals $\frac{1-\tau_d}{1-\tau_g}$ for dividend-distributing firms, it equals 1 for equity-issuing firms and satisfies $\gamma_{jt} \in \left(\frac{1-\tau_d}{1-\tau_g}, 1\right)$ for liquidity-constrained firms with $d_{jt} = s_{jt} = 0$.

Consider first the case $\tau_d = \tau_g$. In this case $\gamma_{jt} = 1$ for all t, j and the debt to capital ratio for all firms is given by:

$$\frac{b_{jt+1}}{k_{jt+1}} = \frac{\frac{1-\tau_i}{(1-\tau_g)(1-\tau_c)} - 1}{2\xi}$$

The relative size of taxes on corporate income versus interest income determine whether debt has a tax advantage or not. Specifically, debt has a tax advantage whenever $(1-\tau_g)(1-\tau_c) < (1-\tau_i)$ or, more intuitively, whenever the combined tax rate on corporate income $\tau_c + \tau_g(1-\tau_c)$ is larger than the household tax rate on interest income τ_i. The first order condition reflects the trade-off between the tax advantage and the cost of holding debt. Whenever there is a tax advantage, as is the case in our benchmark and in all post-reform experiments, this gives an optimally positive debt to capital ratio.

When $\tau_d > \tau_g$, different firms can have different debt-to-capital ratios depending on the relative size of γ_{jt} and $E_t\gamma_{jt+1}$. Intuitively, firms with high current marginal value of resources that expect this to be lower tomorrow find it optimal to hold a higher debt-to-capital ratio. These are growing firms, for example currently issuing equity ($\gamma_{jt} = 1$) but expecting to be in the liquidity constrained or dividend distribution regime with positive probability in the following period ($E_t\gamma_{jt+1} < 1$). Vice versa, some shrinking firms will choose lower debt-to-capital ratios.

In both cases ($\tau_d = \tau_g$ and $\tau_d > \tau_g$) growing firms will typically issue new debt and shrinking firms will retire debt. Importantly, the changes in tax rates can have significant effects on the debt-to-capital ratio depending on their effect on the combined tax rate on corporate income. Previewing the quantitative results below, the combined tax rate on corporate income increases somewhat in the experiments where the equality of τ_d and τ_g is maintained and hence debt to capital ratios increase. In contrast, the combined tax rate on corporate income decreases significantly when τ_c is decreased keeping τ_g constant and thus debt to capital ratios decrease. In the extreme case discussed below where τ_c is reduced to zero and $1 - \tau_i < (1 - \tau_g)(1 - \tau_c)$, the firm has incentives to hold cash $b_{jt+1} < 0$. In that case, the interpretation of the quadratic cost on holding cash is less intuitive so we prefer to simply impose debt non-negativity and let the optimal choice of debt be at a corner (zero).

3.2.6 Quantitative Results

Hennessy and Whited (2007) report a ratio of debt to assets of 0.12 from Compustat data. We calibrate the debt cost parameter ξ in the benchmark economy to match this ratio. We consider the long run aggregate effects of eliminating corporate income taxes ($\tau_c = 0$) in the presence of debt financing for the two cases, namely reform A (where $\tau_d = \tau_g$) and reform B (where $\tau_d > \tau_g$). Consider first how the reforms affect aggregate debt and equity issuance.

Table: Reform effects on Aggregate Equity Issuance (S), Debt Issuance and Debt Level (B)

REFORM	A: τ_c vs $\tau_d = \tau_g$	B: τ_c vs τ_d
Financial Aggregates (% Change)		
S	-55.8	-98.9
Debt Issuance	56.7	-23.7
B	33.7	-83.8

In the benchmark economy, all firms maintain a constant debt to capital ratio of 0.15 so growing firms issue new debt and shrinking firms retire debt in proportion to their capital change. As a result of reform A, the combined tax rate on corporate profits increases from $\tau_c + \tau_g (1 - \tau_c) = 0.34 + 0.2(1 - 0.34) = 0.472$ to $\tau_g = 0.52$. The implication in terms of debt choices is that the tax advantage of debt is now stronger and the debt to capital ratio increases across firms. Quantitatively, the debt to capital ratio increases from 0.15 to 0.21. This also implies an increase in the total amount of debt held, despite the decrease in aggregate capital. Because debt is now more attractive, we do observe some substitution away from equity issuance and into debt issuance. However, in terms of the macro aggregates, the effects of the reform are qualitatively similar to the case of no debt. This can be seen in the Table below presenting percentage changes in the macroeconomic aggregates and including the results from the benchmark economy without debt in parentheses for comparison. As in the case of no debt, capital and interest rates decrease, TFP increases and output and wages remain largely unaffected. Quantitatively, the combined tax rate increases slightly more compared to the case of no debt and thus, interest rates and capital fall by slightly more.

Table: Reform effects on Macro Aggregates

REFORM	A: τ_c vs $\tau_d = \tau_g$	B: τ_c vs τ_d
τ_c	0	0
τ_d	0.52 (0.51)	0.42 (0.44)
τ_g	0.52 (0.51)	0.20 (0.20)
Macro Aggregates (% Change)		
K	-5.4 (-4.4)	36.3 (40.6)
TFP	1.5 (1.5)	-0.8 (-1.4)
Y	-0.3 (0.1)	9.2 (9.7)
C	-1.7 (-0.9)	8.4 (8.5)
r	-2.8 (-2.0)	-0.8 (-2.2)
w	-0.3 (0.1)	9.2 (9.7)

As a result of reform B, the combined tax rate on corporate profits decreases from $\tau_c + \tau_g (1 - \tau_c) = 0.472$ to $\tau_g = 0.20$. Note that the tax rate on interest income is $\tau_i = 0.28 (> 0.20)$ so the tax advantage on debt has disappeared. If anything, in this extreme scenario of no corporate taxes, tax incentives point towards cash hoarding. We impose a no-cash constraint and, as a result, most firms hold zero debt. Still, some severely cash-strapped, growing firms ($\gamma_{jt} >> E_t \gamma_{jt+1}$) actually issue and hold debt. Overall, the aggregate debt to capital ratio falls from 0.15 to 0.03. In terms of the long run effects of the reform, compared to the case of no debt, the dividend tax increases by slightly less. The effect of this is to reduce the strength of the wealth effect which implies a smaller drop in interest rates and hence a smaller increase in aggregate capital. The drop in TFP is also smaller than in the case with no debt since, when equity issuance becomes very costly as in this scenario, the presence of debt means there is still an option to finance externally through debt. This mitigation of the negative effects of the reform on external financing is not very strong exactly because the reform also reduces incentives to hold and use debt. To put it differently, the reform that cuts τ_c increasing only τ_d has negative effects on both equity and debt financing incentives and hence there is only a limited amount of substitution from equity to debt that takes place.

Notice that the role of debt in this model is as a means of obtaining external financing for investment just like equity and not to be used as a buffer against shocks. The firm does face idiosyncratic shocks but it does not have an incentive to smooth its payments to shareholders since such smoothing occurs automatically for shareholders at the mutual fund level (in the long run aggregate payout to shareholders is constant). This is reflected in the firm's discount factor which is not stochastic, rather it reflects the deterministic risk-free rate of return. To consider the buffering role of debt we would need to introduce some aggregate shocks, an interesting but computationally very difficult thing to do.

3.3 Long Run Effects of the Reforms with a Representative Household

This section presents the effects of the reforms on the long run aggregates in the absence of household heterogeneity, namely, in a model where the after tax return if fixed to the pre-reform level. The results are presented in Table 3 below, together with the results with household heterogeneity and incomplete markets in parenthesis for comparison.

Intuitively, uninsurable idiosyncratic risk faced by households matters for the response of aggregate capital to the reforms. The reason is that this assumption implies an upward sloping aggregate asset demand line, as opposed to a perfectly elastic demand in the long run of a growth model. When the capital taxes change as a result of the reforms, the firms' demand for capital changes. In a standard growth model, the after tax return in the long run would still have to equal the time preference rate and thus all of the demand change would translate to changes in equilibrium capital. In contrast, in our economy the interest rate also adjusts endogenously to some extent. To investigate the quantitative importance of this mechanism, we have computed the long run aggregates for a version of the model with a representative agent and complete markets.[2] The results from this experiment are presented in Table 3 below. The results with incomplete markets from Table 7 of our paper are provided in parenthesis for comparison.

Table 3: Long Run Effects of Reform in a representative household economy

REFORM	A: τ_c vs $\tau_d = \tau_g$	B: τ_c vs τ_d
τ_c	0	0
τ_d	0.51 (0.51)	0.44 (0.44)
τ_g	0.51 (0.51)	0.20 (0.20)
Long Run Aggregates (% Change)		
K	-7.1 (-4.4)	38.4 (40.6)
TFP	1.6 (1.5)	-1.3 (-1.4)
Y	-0.7 (0.1)	9.2 (9.7)
C	-1.7 (-0.9)	8.1 (8.5)
r	0 (-2.0)	0 (-2.2)
w	-0.7 (0.1)	9.5 (9.7)

For the reform with $\tau_d = \tau_g$, the combined tax rate on capital $\tau_c + \tau_g (1 - \tau_c)$ increases from 47.2% to approximately 51% and capital demand from firms is reduced. With incomplete markets aggregate capital falls by 4.4% because the interest rate adjusts downwards and mitigates this decrease. In contrast, with complete markets, the interest rate remains fixed and this implies a larger decrease in aggregate capital of about 7%. Since the effect on TFP is similar

[2] Note this is equivalent to assuming the after tax return is fixed to the pre-reform level and finding the new stationary distribution after the tax changes.

to our benchmark incomplete markets economy, but the response of aggregate capital is larger, the implication is that now output and wages fall in the long run. Notice that, with wages falling, a complete markets model with household heterogeneity in wealth could reverse our prediction of distributional gains from this reform. In this sense, even the presence of incomplete markets is crucial for some of our findings.

For the reform with $\tau_d > \tau_g$, the incomplete markets assumption has only small quantitative effects on the aggregates. The main effect of market incompleteness is that higher dividend taxes push aggregate capital to increase a bit more (40.6% versus 38.4%) due to the wealth effect described in Anagnostopoulos, Carceles and Lin (2012).[3]

[3] Note that this does not mean that household heterogeneity is not important. Heterogeneity still matters a lot for distribution and welfare results.