Incidence of Capital Income Taxation in a Lifecycle Economy with Firm Heterogeneity

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Incidence of Capital Income Taxation in a Lifecycle Economy with Firm Heterogeneity*

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Abstract

We study the incidence of capital income taxation in a dynamic general equilibrium model with heterogeneous firms and lifecycle households. In this incomplete market setting, marginal excess burdens of three capital taxes, namely corporate income, dividend and capital gains taxes, are vastly different due to heterogeneous responses of firms and households, and heterogeneous effects of general equilibrium adjustments. It is indeed important to account for firm heterogeneity in productivity and investment financing as well as household heterogeneity in age and skill. Overall, taxing capital with a corporate income tax at the firm level results in higher excess burden than taxing capital with dividend and capital gains taxes at the household level. Given the existing U.S. tax treatment for capital income, reforms that shift tax burden from the firm to household side potentially result in efficiency gains and overall welfare improving. However, the welfare benefits of the tax reforms are quite different across households and generations over transition time, depending on skill, age-cohort and budget balancing tax instruments. In particular, majority of currently alive households, especially retirees, experience welfare gains under moderate corporate income tax cuts, but suffer from welfare losses under more radical tax cuts.

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Keywords: Excess burden; Tax incidence; Distributional effects; Overlapping generations; Dynamic general equilibrium

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1 Introduction

How welfare cost of capital income taxation is allocated among households is the central questions of the debate on capital tax reforms in many countries. It is critical to have a practical and sound measure to determine the existing burden of each capital income tax, and evaluate how a tax reform proposal would affect the welfare of each household group. The tax incidence analysis is a classical theoretical tool used widely in public economics to address these questions (e.g., see Harberger (1962) and also Fullerton and Metcalf (2002) for a survey).[1] Recently, Sachs, Tsyvinski and Werquin (2019) derive analytically closed form tax incidence formulas in a general equilibrium model with a continuum of endogenous wages. What is largely unexplored in the existing literature is a tax incidence analysis in an incomplete market model with heterogeneous agents.

The purpose of this paper is to fill this void by formulating a dynamic general equilibrium model with heterogeneous firms and lifecycle households. We use the model to assess quantitatively the incidence of three common capital taxes, namely corporate income tax, dividend tax and capital gains tax. We find that the welfare costs of these three capital taxes are vastly different when taking into account heterogeneity in firm productivity and investment financing, and lifecycle saving. Importantly, such tax burdens are allocated unevenly across households and generations, and over time.

More specifically, our baseline model consists of lifecycle households with different labor productivity types, heterogeneous firms due to idiosyncratic shocks to productivity, and a government with a redistributive tax and transfer system. The markets are incomplete, with households subject to borrowing constraints and no annuities and firms subject to financial constraints and capital adjustment costs. More specifically, households are of different skill types and enter the model at age 20 and potentially live to 100. Labor efficiency units for each skill type evolve over the life cycle. Households make decisions on consumption, labor supply and saving to maximize their lifetime utility. They are forward looking, but face borrowing constraints. Their decisions take into account flows of future after-tax incomes and the need for retirement savings. In the firm sector, there is a continuum of firms that produces output with its owned capital and labor rented from the labor market. Firms are ex-ante identical but differ ex-post in their histories of productivity and capital stock. Firms choose investment to optimise their market value taking into account expected future productivity shocks and profits, as well as the structure of corporate finance and taxes. Investment finance regimes are endogenous. Firms can rely on either retained earnings (internal financing) or equity insurance (external financing) to finance their investment plans. Firms pays returns to debt and equity holders, while facing financial constraints including no negative dividend payment and limited equity

[1] The economic burden of taxation is commonly measured by the area of the associated 'Harberger triangle' (e.g., see Harberger (1964)). In a partial equilibrium framework with a single market, the area of the triangle is the welfare value of the activity lost, known as the excess burden.

buy-backs. Finally, the government collects taxes on corporate income, dividend, interest income, capital gains, labor income and consumption to finance two government spending programs: general government consumption and transfers to households. In the model, three types of capital income taxation on business and personal incomes are explicitly modeled. Our baseline model is calibrated to match the US data including macroeconomic aggregates, lifecycle behaviors, and firm level statistics from the COMPUSTAT database and US tax policy settings.

In order to measure quantitatively the incidence of capital taxes we employ the marginal excess burden (MEB) analysis that has a long tradition in public economics and policy practice (e.g., see Auerbach and Hines (2002) for a review). We start from the baseline calibrated model and consider a tax reform to raise additional tax revenue in the initial steady state and also along the transition path to the new steady state. Having followed the convention in the tax incidence analysis, we allow only one tax rate to change at a time and assume that the additional revenue is transferred back to all households via an uniform lump-sum transfer scheme. Intuitively, the marginal excess burden (MEB) of a given tax is a marginal welfare change per additional unit of tax revenue gain at the point defined by the existing tax system.

Our results indicate that at aggregate level there is a large disparity in the MEBs of corporate income tax, dividend tax and capital gains tax. More specifically, the MEB for the dividend tax is \$1.56 per dollar of tax revenue raised, compared to 67 cents for the corporate income tax and −28 cents for the capital gains tax. The results imply that the welfare cost of the dividend tax is highest; meanwhile, there are efficiency and welfare gains when raising the capital gains tax. Replacing the corporate income tax with the dividend tax is not a better alternative to reduce the overall burden of capital income taxation. Interestingly, when both dividend and capital gains taxes are adjusted their MEB is only 50 cents, which is smaller than the MEB of the corporate income tax.

Importantly, the welfare cost of capital income taxation is shared unevenly among households and generations due to changes in behavior and adjustments in equilibrium prices. The marginal excess burdens of taxes vary significantly across households, depending on their skills and ages. In particular, the burden of a tax on corporate income falls mainly on the current working population due to lower wages. For one additional tax revenue, the current workers, one average, bear 77 cents in terms of MEB; meanwhile, the current retirees bears a small tax burden of only 7 cents in terms of MEB.

Arguably, capital income taxation is progressive because capital income is concentrated at the high end of the income distribution. Taxing capital income means taxing disproportionately higher income households. Our analysis confirms that high income households indeed bear highest welfare costs with MEBs of 1.35 dollar and 2.67 dollar for corporate income and dividend taxes, respectively. The welfare cost of capital income taxation is partly shifted on low income households in a dynamic general equilibrium model. The low income households bear, on average, a relatively small burden of corporate income tax. This occurs as the baseline scenarios assume any extra revenue collected is redistributed uniformly back to all households via a lump-sum transfer program. The loss of income due to lower wages is partly offset by higher lump-sum transfers. The low income households would be 3 cents and 55 cents worse off under a corporate income and dividend tax rise, respectively. Such unequal distribution of the tax burdens highlights the importance of accounting for household heterogeneity when conducting an incidence analysis of capital income taxes.

Next, we deviate from the baseline model and investigate quantitative importance of different modeling assumptions in determination of the burden of capital income taxation in a dynamic general equilibrium framework. We consider a number of alternative models in which we turn on and off one or all of following modeling features: firm heterogeneity, external finance, lifecycle motive, household heterogeneity and decreasing return to scale technology.

We find that firm heterogeneity is important to determine the burden of the considered capital taxes. Tax distortions on firms' incentives to invest and investment financing regimes amplify the misallocation of capital in a model with heterogeneous firms. Note that, this allocative efficiency channel is assumed away in a model with a representative firm. In our baseline model, firms are ex-post different. Marginal productivity of capital is different across firms, depending on firm-specific productivity shock and capital. The effects of capital taxes vary across firms, so that they can ameliorate or worsen issues of the allocative efficiency of capital. A capital income tax that causes a shift in capital from higher productivity firms to lower productivity firms will improve allocative capital efficiency.

Financial heterogeneity is another important channel through which capital taxes affect investment, capital accumulation and general equilibrium prices. In our baseline model, firms have two investment finance regimes: internal finance through retained earnings and external finance through equity issuance. In an external finance regime, the marginal source of investment finance is new equity, which reflects the traditional view that dividend tax reduces the return to investors purchasing equity and thereby reduces investment. In an internal finance regime, the marginal source of investment finance is retained earnings, which reflects the new view that dividend tax does not affect the investment decision. In our model, firms rely on different investment financing regimes and respond differently to a change in dividend taxes. The presence of endogenous corporate finance policy plays a key role in understanding the distortion of the dividend tax in a heterogeneous firm model. For example, increasing dividend tax reduces the investment of externally financing firms. The externally financing firms generally have a small capital stock but high productivity. Reducing investment from this firm increases the misallocation of capital and lower total factor productivity (TFP). The reduction in TFP lower output and welfare. While increasing corporate tax results in a larger decrease in aggregate capital it does not have a similar impact on the allocation on capital and therefore drives a smaller welfare loss. Conversely, raising capital gains tax provides an incentive for externally financing firm to invest more and thereby improve allocative efficiency. While raising capital gains tax reduces the overall capital stock the improvement in TFP raises aggregate welfare.

Lifecycle structure is essential to measure the burden of capital income taxes. While capital taxes have generally been found to distort savings and capital accumulation there are various arguments in favour of positive capital tax rates when lifecycle behavior, market incompleteness and redistributive concern are considered (e.g., see Imrohoroglu (1998), Erosa and Gervais (2002) and Conesa, Kitao and Krueger (2009))). Further, in a lifecycle model capital taxes can act as second best taxes when aged based taxes are not an option. While different forms of capital income taxation may have similar aggregate impacts they can have opposing welfare impacts on households over the life cycle. Our finding confirms the quantitative importance of including lifecycle consumption-saving motives.

Finally, we study the effects of several tax reform proposals that shift the tax burden from corporate income towards personal income including capital and labor income. We show how the tax reforms yield various welfare effects across income groups and generations, depending which tax is used to balance the government budget. The corporate income tax cuts financed by the dividend tax result welfare losses for all households and generations. These negative welfare outcomes are largely explained by the misallocation effect and the total factor productivity decrease caused by the increase in dividend tax rate. On other hand, the tax cuts financed by a combination of dividend and capital gain taxes results in overall welfare improvement at the welfare cost of current retirees. However, only 38 percent of alive households would support a radical reform that shift the entire tax burden from the corporate income tax to the dividend and capital gains taxes. Interestingly, the tax cuts financed by the labor income tax increase result in welfare gains for all currently alive households at the welfare costs of future generations.

Thus, our findings highlight the importance of the tax incidence analysis to understand how the burden of alternative corporate tax reform proposals is shared by households and generations. This positive analysis is typically the first step in policy evaluation and also an important input into later steps thinking about what policy maximizes social welfare.

The paper is structured as follows. Section 2 describes the model. Section 2.5 provides details on the calibration of our model to the US economy and its fit to the data. In Section 3 we present the quantitative analysis. Section 4 concludes. The Appendix contains additional analyses, tables and figures. The derivation of the key equations and description of the computational methods is contained in an online technical appendix.

Related literature. Our paper contributes directly to the large literature analyzing the excess burden of taxation which is a popular modeling tool in real-work policy making. Early work is dated back to Harberger (1962) and Harberger (1964). Extension of the excess burden analysis to general equilibrium framework includes Auerbach, Kotlikoff and Skinner (1983), Chamley (1981) and Ballard, Shoven and Whalley (1985). Judd (1987) further extend the excess burden analysis to a dynamic general equilibrium model with an infinitely-lived representative agent. Our contribution to this literature is an extension of the tax burden analysis to a dynamic general equilibrium model with heterogeneous households and firms. We analyze both long-run steady state outcome and transitional dynamics.

There is a relatively new literature that connects two classical strands of the public finance literature: the study of tax incidence (e.g., Harberger (1962)) and that of optimal income taxation (Mirrlees (1971) and Stiglitz (1982)). Sachs, Tsyvinski and Werquin (2019) study the incidence of nonlinear labor income taxes in an economy with a continuum of endogenous wages, using the variational approach. They derive in closed form the effects of reforming non-linearly an arbitrary tax system and show that this problem can be formalized as an integral equation. Differently, Tran and Wende (2017) adopt the tax incidence analysis to a dynamic general equilibrium model and quantify the marginal excess burden of corporate and personal income taxes and consumption tax. Saez and Zucman (2019) propose a new way to do distributional tax incidence better connected with tax theory. We contribute to the tax incidence literature a dynamic general equilibrium analysis based on a new quantitative macroeconomic model featured with overlapping generations of lifecycle households, and heterogenous firms. We highlight that accounting for firm heterogeneity and lifecycle structure is important to better measure the distributional tax incidence analysis.

Much of the previous literature studied capital income taxation has concluded the importance for welfare issues of accounting for household heterogeneity, market completeness and lifecycle structure (e.g., see Aiyagari (1995), Imrohoroglu (1998), Domeij and Heathcote (2004), Erosa and Gervais (2002) and Conesa, Kitao and Krueger (2009)). However, these studies usually assume a representative firm and subsume all different capital taxes in a single tax in household budget. In most economies, firms are very different in size and how they finance their investment plan. Governments usually have complex income tax systems which tax business and personal capital income differently.[2] Recent studies of capital tax reforms in the US have shown how the effects of dividend and capital gains taxes are different in heterogeneous firm models (e.g., see Gourio and Miao (2010) and Gourio and Miao (2011)).[3] In this paper, we revisit the welfare effects of capital income taxation in a combined framework that combines main elements of an incomplete market, life cycle model from Conesa, Kitao and Krueger (2009) and elements of a heterogeneous firm model from Gourio and Miao (2010).

Our paper is connected to two strands of the literature: quantitative analysis of optimal capital taxation using overlapping generations models and quantitative analysis of corporate taxes using heterogeneous firms model. In a standard neoclassical model with a representative firm, Judd (1985) and Chamley (1986) show that capital tax should be zero. The recent

[2] In the US, the government taxes capital income at the firm level through corporate income taxes, and at the household level through personal income taxes, including dividend and capital gains taxes.

[3] There have been number of capital income tax reforms in the US. The Jobs and Growth Tax Relief Reconciliation Act (JGTRRA) 2003 eliminated the wedge between the tax rates on dividend and capital gains, and reduced the two rates to 15%. The US Tax Cuts and Jobs Act 2017 reduces corporate tax rate to from 35% to 21%.

taxation literature show that the government should tax capital incomes in incomplete market models with heterogeneous agents (e.g., Aiyagari (1995), Imrohoroglu (1998), Erosa and Gervais (2002) Conesa, Kitao and Krueger (2009)). How to tax capital income is a trivial issue in a complete market model. However, capital taxes are not perfect substitutes in an incomplete market economy with heterogeneous agents. Recent studies, including Aiyagari (1995), Imrohoroglu (1998) and Conesa, Kitao and Krueger (2009), abstract from modeling different types of capital income taxation. Our MEB analysis indicates that taxing capital at different income sources result in different effects on household's incentive to save and firm's incentive to invest, which subsequently imply different implications for aggregate efficiency and welfare.

Alvarez et al. (1992) and Erosa and Gervais (2002) show that in lifecycle models the optimal capital income tax in general is different from zero, at least if the tax code cannot explicitly be conditioned on the age of the household. Since Auerbach and Kotlikoff (1987) there has been a large macroeconomic and public finance literature analyzing tax policy, using overlapping generations models with households facing both borrowing constraints and earning shocks.[4] The optimal income tax structure is quantitatively characterized in Imrohoroglu (1998), Conesa and Krueger (2006), Conesa, Kitao and Krueger (2009), Fehr and Kindermann (2015) and Jung and Tran (2017). Conesa, Kitao and Krueger (2009) show that the optimal capital income tax rate is strictly positive at 36 percent in an overlapping generations economy with incomplete markets and heterogeneous agents. These studies focus on household heterogeneity, but completely neglect firm heterogeneity by assuming a representative firm. Different forms of financial assets are simplified into a single asset in household budget where there is a single capital income tax. We extend that literature to incorporate heterogeneous firms facing financial constraints and uncertainty about future productivity. We explicitly model different forms of capital taxes on different sources of capital incomes including interest payments, dividends, capital gains and corporate incomes. We find that capital taxes are not perfect substitutes in a heterogeneous firms model and capital misallocation is important channel to determine the effects of the capital tax policy.

Our paper is connected to the literature analyzing the dynamic effects of corporate taxes on investment and macroeconomic aggregates using a dynamic general equilibrium framework. In a standard growth model with a representative household and a representative firm, McGrattan and Prescott (2005), Santoro and Wei (2011) and Anagnostopoulos, Carceles-Poveda and Lin (2012) amongst many others have studies the effects of dividend taxes and find that constant dividend taxes have no effect on allocations and prices other than decreasing stock market values. Anagnostopoulos, Carceles-Poveda and Lin (2012) use an incomplete markets model and show that decrease in stock prices reduces existing precautionary wealth and can induce households to save more and, hence, increase investment. Gourio and Miao (2010) and Gourio

[4]Hubbard and Judd (1986), Aiyagari (1995) and Imrohoroglu (1998) also demonstrate that a positive capital income tax is part of the optimal tax system in a model where households subject to uninsurable idiosyncratic income risk while facing face borrowing constraints.

and Miao (2011) deviate from a representative firm paradigm and develop a heterogeneous firm model, and study whether the effects of dividend and capital gains taxes. On other hand, Domeij and Heathcote (2004) deviate from a representative household paradigm and develop an incomplete market model with heterogeneous households. They demonstrate that household heterogeneity and asset market incompleteness have important implications for analyzing the welfare effects of tax changes.

Anagnostopoulos, Atesagaoglu and Carceles-Poveda (2018) construct an incomplete market model featured with both household and firm heterogeneity. They analyze the aggregate and distributional effects of reforms that a tax on corporate income with taxes on dividends and capital gains. They find 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. Wills and Camilo (2017) include firm entry and exit and quantify whether different capital income taxes affect firm investment and capital allocation. Much of the previous literature has based on an infinitely-lived agent framework; and therefore, abstract from lifecycle structure and heterogeneity across generations. Erosa and Gervais (2002) and Conesa, Kitao and Krueger (2009) demonstrate that lifecycle structure of households is important for understanding the optimal design of capital income taxation. To our knowledge, our model is the first one of its kind that has combined elements of a heterogeneous firm model and a lifecycle model. This extension enables us to account for the mechanisms driven jointly by lifecycle structure and firm heterogeneity. In addition, it enables us to measure the inter-generational consequences of capital taxes and derive political implications. We demonstrate that the corporate income tax reform proposal as in Anagnostopoulos, Atesagaoglu and Carceles-Poveda (2018) could result in different welfare outcomes when taking into account lifecycle structure. Indeed, our paper connects the macro/finance literature on the effects of corporate taxes using heterogeneous firm models to the macro/public finance literature on the effects of capital taxes using overlapping generations models.

2 Model

The model is a discrete time dynamic general equilibrium model, which consists of overlapping generations of households, a continuum of perfectly competitive firms and a government with full commitment technology. The model assumes a balance growth path.

2.1 Household

The household sector follows Auerbach and Kotlikoff (1987) with some extensions to incorporate different skill types and assets and capital income tax payments.

Demographics The model is populated by households of different ages between 20 and 100, $j \in \mathbb{J}$ =[20, ..., 100], and three different skill types $i \in \mathbb{I}$ =[1, 2, 3]. In each period a continuum of households aged 20 enters the model and live at most 100 years. They face a stochastic probability of death every period with the age-dependent survival probability given by sp_j at age j. The unconditional probability of surviving from age 20 to age j, is given by $S_j = \prod_{s=21}^{j} sp_s$. The size of a new cohort entering the economy and the overall population both grow at the rate g^n. $M_{t,j,i}$ denotes the size of the cohort of skill type i in age j at time t, which evolves according to $M_{t+1,j+1,i} = sp_{j+1} M_{t,j,i} = M_{t,j+1,i}(1 + g^n)$.

Preferences Households maximize expected lifetime utility which is the sum of current and discounted future intra-temporal utility adjusted for the chance of death

$$U_{t,j,i} = \sum_{j'=j}^{100} S_j \hat{\beta}^{j'-j} u\left(C_{t+j'-j,j',i}, l_{t+j'-j,j',i}\right)$$

where $\hat{\beta}$ is the time discount factor and S_j is the unconditional probability of survival.

All households have identical intra-temporal preferences over consumption, $C_{t,j,i} \geq 0$, and leisure, $0 \leq l_{t,j,i} \leq 1$. The intra-temporal utility is assumed to have the form

$$u\left(C_{t,j,i}, l_{t,j,i}\right) = \frac{\left(C_{t,j,i}^{\gamma} l_{t,j,i}^{1-\gamma}\right)^{1-\sigma}}{1-\sigma},$$

where σ is a parameter governing inter-temporal elasticity of substitution and γ is the consumption share of utility.

Endowments Households differ by skill type and age in our model. New households enter the model with a specific skill type that determines their labor productivity over the life cycle. Labor efficiency unit, denoted by $e_{j,i}$, is type and age dependent, but time-invariant. In each period, households are endowed with one unit of time that can be allocated to labor market and leisure activities. As such, a typical household's before tax labor income is given by $W_t\left(1 - l_{t,j,i}\right) e_{j,i}$, where $(1 - l_{t,j,i})$ is labor supply and W_t is the market wage rate in period t.

Household problem A typical household begins with zero assets and chooses consumption, labor supply and asset holdings to maximize her utility over her lifetime. The households can buy and sell equity, $\theta_{i,j,t}(\mu_t)$, of the continuum of firms μ_t. The household's equity carried over from the previous period is valued at the price of the firm before issuance, $p_t^0(\mu_t)$, while the household buys equity for the next period at the post issuance price $p_t(\mu_t)$. The households can also buy bonds, $B_{i,j,t}$. These are the only ways the household is able to save for future consumption. The household faces a borrowing constraint and can not short sell equity or debt $\theta_{t,j,i} \geq 0, B_{t,j,i} \geq 0$.

The household receives labor income, $W_t(1-l_{t,j,i})e_{j,i}$, equity pays dividend a $d_t(\mu_t)$ and bonds generate a return r_t. In addition, the household receives accidental bequests, $BQ_{t,i}$, and government transfers, $T_{t,j,i}$. Capital gains is paid on the difference between the price paid for equity and the price it is sold at, $p_t^0(\mu_{t-1})-p_{t-1}(\mu_{t-1})$. The household pays proportional taxes on labor income, dividend income, capital gains and interest income at the rates of τ_t^l, τ_t^d, τ_t^g and τ_t^{in} respectively. Capital gains tax is a symmetric in that losses are refunded. It is charged in each period on an accrual basis.

The household's income is used to fund consumption and debt and equity purchases. The household budget constraint is given by

$$\begin{aligned}
&(1+\tau_t^c)C_{t,j,i}+\int p_t\theta_{t+1,j+1,i}(\mu_t)d\mu_t+B_{t+1,j+1,i}\\
=&(1-\tau_t^l)W_t(1-l_{t,j,i})e_{j,i}+(1+(1-\tau_t^{in})r_t)B_{t,j,i}+T_{t,j,i}+BQ_{t,i}\\
&+\int\left(p_t^0+(1-\tau_t^d)d_t(\mu_{t-1})-\tau_t^g\left(p_t^0(\mu_{t-1})-p_{t-1}(\mu_{t-1})\right)\right)\theta_{t,j,i}(\mu_{t-1})d\mu_{t-1}. \qquad (1)
\end{aligned}$$

The first order conditions from the households' problem implies that the household will only invest in equity when the expected return matches that available on debt,

$$r_{t+1}^{in}=\frac{(1-\tau_t^d)d_{t+1}+(1-\tau_t^g)(p_{t+1}^0-p_t)}{p_t},$$

where $r_t^{in}=(1-\tau^{in})r_t$ is the after tax interest rate.

We assume that all households hold the same share of each firm and a proportional level of debt. Households do not have any incentives to hold different asset portfolios as all equity have the same expected return and their tax treatment is equal. As such each households holds an equal share of each firm with $\theta_{t,j,i}(\mu_t)=\theta_{t,j,i}$. This simplifying assumption is crucial in making the household problem tractable. Let $A_{t+1,j+1,i}=\left(\int p_t d\mu_t+B_{t+1}\right)\theta_{t+1,j+1,i}$ be the value of asset portfolio. The return on the asset holdings, r_t^a, is defined by

$$r_t^a=\frac{r_t^{in}B_t+\int\left[(1-\tau_t^d)d_t+(1-\tau_t^g)(p_t-p_{t-1})\right]d\mu_{t-1}}{B_t+\int p_{t-1}d\mu_{t-1}}. \qquad (2)$$

We can re-write the household budget in terms of $A_{t,j,i}$ as

$$(1-\tau_t^c)C_{t,j,i}+A_{t+1,j+1,i}=(1-\tau_t^l)W_t(1-l_{t,j,i})e_{j,i}+(1+r_t^a)A_{t,j,i}+T_{t,j,i}+BQ_{t,i}, \qquad (3)$$

The household's utility maximization problem can be written in terms of a dynamic programming problem as

$$V_j(A_{t,j,i})=\max_{\{C_{t,j,i},l_{t,j,i},A_{t+1,j+1,i}\}}\left\{u\left(C_{t,j,i},l_{t,j,i}\right)+\hat{\beta}sp_{j+1}V_{j+1}\left(A_{t+1,j+1,i}\right)\right\} \qquad (4)$$

subject to the household's budget constraint given in equation 3, the non-borrowing constraint, $A_{t+1,j+1,i} \geq 0$, and the non-negativity of leisure and consumption $C_{t,j,i} > 0$ and $1 \geq l_{t,j,i} > 0$.

2.2 Firm

The firm sector has a similar setting as in Gourio and Miao (2010). There are a continuum of ex-ante identical firms that face idiosyncratic productivity shocks every period. Firms differ ex-post in terms of the histories of productivity shocks and capital stocks. Firms own capital and choose investment, dividends, equity and labor demand to maximize their cum dividend equity price.

Technology A typical firm produces output, y_t, by combining capital, k_t, and labor, n_t, in a decreasing returns to scale Cobb-Douglas production function that also depends on the firm specific productivity, z_t, and the economy wide productivity level, Z_t, with output given by

$$y_t\left(k_t, n_t; z_t\right) = Z_t z_t (k_t)^{\alpha_k} (n_t)^{\alpha_n}.$$

Firm specific productivity, z_t, evolves according to a Markov process given by

$$\ln z_t = \rho \ln z_{t-1} + \epsilon_t$$

where ρ is the persistence of the Markov process and the shocks, ϵ_t, are normally distributed with mean zero and standard deviation σ, $\epsilon_t \in \mathcal{N}(0, \sigma^2)$.[5]

Capital is accumulated according to the law of motion

$$k_{t+1} = (1-\delta)k_t + i_t, \tag{5}$$

where i_t is investment and δ is the depreciation rate.

Investment is subject to a quadratic capital adjustments cost with the total cost of investment given by

$$i_t + 0.5\psi \left(\frac{i_t}{k_t}\right)^2 k_t.$$

Corporate finance There are two channels through which firms finance their investment plan: internal fund from earnings after wages and taxes and external fund from issuing new equity, s_t. Equity holders/investors/households own firms in our model. Equity holders receive a return on equity in terms of dividend payments paid directly by the firm, d_t, and capital gains due to increases in the market price of equity.

[5]Economy wide productivity growth is given by $\frac{Z_{t+1}}{Z_t} = (1+g^n)^{1-\alpha_k-\alpha_n}(1+g^z)^{1-\alpha_k}$ which is consistent with labour augmenting productivity growth of g^z and steady state output growth of $g^z + g^n + g^n g^z$

While firms can distribute earnings through dividends, d_t, they can not raise funds by paying out negative dividends giving the constraint

$$d_t \geq 0. \tag{6}$$

Further, while firms can raise revenue through equity issuance they are limited in the revenue they can return to equity-holders through equity buy-backs with buy-backs constrained to be less than $\bar{s}$ giving

$$s_t \geq 0 \tag{7}$$

A positive value for $\bar{s}$ can be thought of as firms paying out a positive amount through equity buy-backs. However if we think of the model as having been normalised for population and productivity growth then $\bar{s}$ can also be thought of as capital gains arising from asset price growth without any buy-back occurring.

Firms are not allow to pay out dividends unless they are fully utilizing their ability to pay out returns through the buy-backs giving the constraint

$$d_t s_t = 0. \tag{8}$$

The value of a typical firm's equity after issuance is given by the pre-issuance value plus the value of issuance $p_t = s_t + p_t^0$. With issuance the proportion of the firm's equity purchased through the issuance as given by s_t/p_t while the equity-holders before issuance own $(p_t - s_t)/p_t$ of final value of the firm. This ensures equity bought through issuance has the same rate of return as equity owned before issuance.

Using the households' first order condition for equity we can derive the no arbitrage condition for the fair price of equity as

$$p_t = \frac{E_t\left[(1-\tau_t^d)/(1-\tau_t^g)d_{t+1} + p_{t+1} - s_{t+1}\right]}{1 + r_{t+1}^{in}/(1-\tau_t^g)}. \tag{9}$$

Corporate tax We incorporate key features of the corporate income taxation in the US. The firm pays a corporate income tax on its income which is revenue minus wages, $\tau^k(y_t - w_t n_t)$. The firm's after tax profit is given by

$$(1-\tau_t^k)\pi_t(k_t, z_t) = (1-\tau_t^k)(z_t k_t^{\alpha_k} n_t^{\alpha_n} - w_t n_t).$$

The firm can deduct from its taxable income a fraction of its investment and capital depreciation. The value of expensing deductions is given by $\chi^I i_t$, where χ^I is the deductible fraction of the investment cost. The value of depreciation deductions is equal to $\chi^\delta \delta k_t$, where χ^δ is the deductible fraction of depreciation cost.[6] The total deduction is given by $\left(\chi^I i_t + \chi^\delta \delta k_t\right)$.

[6] Immediate expensing and depreciation deductions are effectively a tax credit for gross investment. For

Firm problem Let $V_t = \frac{1-\tau_t^d}{1-\tau_t^g} d_t - s_t + p_t$ denote the firm's cum dividend value. At the beginning of each period t, given the current capital and productivity realization, the firm chooses labor demand, investment, dividend payment and equity issuance optimally to maximize its cum dividend value. The firm's dynamic programming problem can be written as

$$V_t(k_t, z_t) = \max_{d_t, s_t, i_t, n_t, k_{t+1}} \frac{1-\tau_t^d}{1-\tau_t^g} d_t - s_t + \frac{E_t\left[V_{t+1}(k_{t+1}, z_{t+1})\right]}{1 + r_{t+1}^{in}/(1-\tau_t^g)} \tag{10}$$

subject to the firm's resource constraint

$$i_t + \frac{\psi i_t^2}{2k_t} + d_t = (1-\tau_t^k)\pi(k_t, z_t) + \tau_t^k\left(\chi^I i_t + \chi^\delta \delta k_t\right) + s_t, \tag{11}$$

the law of capital accumulation (5), and the dividend and equity issuance constraints (6), (7) and (8).

The choice of labor demand is a static problem, so that the firm demands labor up to the point where the marginal product of labor equals the economy-wide wage rate $w_t = \alpha_n Z_t z_t k_t^{\alpha_k} n_t^{\alpha_n - 1}$. The optimal decision rules for investment, next period capital, equity issuance and dividend payments can be expressed as

$$i_t^* = i(k_t, z_t),\ k_{t+1}^* = g(k_t, z_t),\ s_t^* = s(k_t, z_t),\ \text{and } d_t^* = d(k_t, z_t). \tag{12}$$

2.3 Government

The government collects revenue from taxing household consumption and incomes, and firm income to finance government purchases and transfers.

Taxes The government raises revenues from consumption tax, labor income tax and capital taxes including corporate tax, dividend tax, interest income tax and capital gains tax.

The firm pays the corporate tax on its gross income with deductions. The full range of deductions is described in the firm section (2.2). Total revenue from the corporate tax is given by

$$TAX_t^k = \int \tau_t^k \left(\pi_t(k,z) - \chi^I i_t(k,z) - \chi^\delta \delta k_t\right) \mu_t(dk, dz).$$

Households labor, dividend, capital gains and interest incomes are taxed at different rates. The revenues from the labor income tax, the dividend tax, the capital gains tax, the interest

example, in Judd (1987) firms receive an investment tax credit $\theta^{\text{Judd}}(i + \delta k)$. When $\chi^I = \chi^\delta = \theta^{\text{Judd}}/\tau^k$ we have an investment tax credit in our model equal to that in Judd (1987).

income tax and the consumption tax are given by

$$\begin{aligned}
TAX_t^N &= \tau_t^l W_t \sum_{i\in\mathbb{I},j\in\mathbb{J}} \epsilon_{i,j,t} M_{i,j,t}(1-l_{i,j,t}),\\
TAX_t^d &= \int \tau_t^d d_t(k,z)\mu_t(dk,dz),\\
TAX_t^g &= \tau_t^g \int p_t^0(k,z)\mu_t(dk,dz) - \tau_t^g \int p_{t-1}(k,z)\mu_{t-1}(dk,dz),
\end{aligned}$$

$$\begin{aligned}
TAX_t^i &= \tau_t^i r_t \sum_{i\in\mathbb{I},j\in\mathbb{J}} B_{t+1,j+1,i} M_{i,j,t},\\
TAX_t^c &= \tau_t^c \sum_{i\in\mathbb{I},j\in\mathbb{J}} C_{i,j,t} M_{i,j,t},
\end{aligned}$$

where $M_{t,j,i}$ is the measure of age j and type i households at time t. Hence, the total tax revenue is a sum of all sources of tax revenues:

$$TAX_t = TAX_t^n + TAX_t^d + TAX_t^k + TAX_t^g + TAX_t^i + TAX_t^c. \tag{13}$$

Expenditures The government has two spending programs: the purchase of goods for government consumption, G_t, and government transfers, T_t. Government transfers encompass pension payments and other social security transfers. The total amount of government transfers, T_t, is the sum of transfers to all households

$$T_t = \sum_{j\in\mathbb{J}} \sum_{i\in\mathbb{I}} M_{t,j,i} T_{t,j,i}, \tag{14}$$

where $M_{t,j,i}$ is the measure of age j and type i households at time t and $T_{t,j,i}$ is the amount of transfers received by individual households which grow in line with labor augmenting productivity.

Budget balancing rule How the government balances its budget depends on the scenario. In the baseline the government's budget is balanced in every year and the government starts with zero debt. When the government borrows or lends the evolution of government bonds, B_t, is given by

$$B_{t+1} = TAX_t - G_t - T_t - (1 + r_t)\, B_t. \tag{15}$$

The rate of return on government bonds, r, is the risk free rate of return. In this case the government's budget is balanced by ensuring the net present value of revenue equals that of spending.

$$\sum_{t=0}^{\infty} \frac{TAX_t}{\prod_{s=0}^{t}(1+r_s)} = \sum_{t=0}^{\infty} \frac{G_t + T_t}{\prod_{s=0}^{t}(1+r_s)}. \tag{16}$$

2.4 Competitive equilibrium

The solution to the model is given by prices and quantities that are consistent with the solutions to the household's and firms' problems and the government's budget constraint.

For a given model calibration an equilibrium is defined by a set of household decisions for consumption, labor supply and equity and bonds holdings $\{C_{t,j,i},\ l_{t,j,i}, A_{t,j,i}\}_{t\in\mathbb{T},j\in\mathbb{J},i\in\mathbb{I}}$; a set of firm decisions including labor demand, capital stock, investment, dividends payments and equity issuance and debt $\{n_t(k,z), k_t(k,z), i_t(k,z), d_t(k,z), s_t(k,z)\}_{t\in\mathbb{T},k\in\mathbb{K},z\in\mathbb{Z}}$; a set of relative prices for wages, interest rates and assets prices $\{w_t, r_t, p_t(k,z)\}_{t\in\mathbb{T}}$; accidental bequests $\{BQ_{t,i}\}_{t\in\mathbb{T},k\in\mathbb{K},z\in\mathbb{Z}}$; government policy settings $\{\tau_t^n, \tau_t^k,\ \tau_t^d, \tau_t^g, \tau_t^{in}, \tau_t^c, \chi^\delta,\ \chi^I, T_{t,j,i}, G_t\}_{t\in\mathbb{T},j\in\mathbb{J},i\in\mathbb{I}}$ such that the following hold:

1. the choice of leisure, asset accumulation and consumption are consistent with solutions to the household's problem given in equation (4),

2. the choice of investment, capital stock, dividends and equity issuance are consistent with the solution firm's problem given in equation (10),

3. the price of each firm, the dividends it pays out and its equity issuance is consistent no arbitrage condition in equation (9),

4. the government's budget balances as given by equation (16),

5. the sum of individual consumption, labor supply, share holdings, debts holdings and asset holdings equals aggregate consumption, labor demand, share issuance, debt and value of firms and debt are

$$\begin{aligned} C_t &= \sum_{i\in\mathbb{I},j\in\mathbb{J}} C_{i,j,t} M_{i,j,t}, \\ N_t^s &= \sum_{i\in\mathbb{I},j\in\mathbb{J}} \epsilon_{i,j,t} M_{i,j,t}(1-l_{i,j,t}), \\ &\sum_{i\in\mathbb{I},j\in\mathbb{J}} \theta_{i,j+1,t+1} M_{i,j,t} = 1, \\ B_{t+1} &= \sum_{i\in\mathbb{I},j\in\mathbb{J}} B_{t+1,j+1,i} M_{i,j,t}, \end{aligned} \tag{17}$$

and

$$A_t = \sum_{i\in\mathbb{I},j\in\mathbb{J}} A_{i,j+1,t+1} M_{i,j,t} = \int p_t d\mu_t + B_{t+1},$$

6. the aggregate output, labor demand, investment and adjustment costs from the continuum of firms equals aggregate output, labor demand, investment and adjustment costs are given by

$$Y_t = \int y_t(k,z)\mu_t(dk,dz),$$

$$N_t^d = \int n_t(k,z)\mu_t(dk,dz),$$

$$I_t = \int i_t(k,z)\mu_t(dk,dz),$$

and

$$\Psi_t = \int \frac{\psi i_t(k,z)^2}{2k}\mu_t(dk,dz),$$

7. the aggregate resource constraint holds, with aggregate output equalling aggregate household and government consumption, aggregate investment and aggregate adjustment costs,

$$Y_t = C_t + G_t + I_t + \Psi_t, \tag{18}$$

8. bequests are equal to the deceased's assets, including returns, evenly distributed amongst the remaining agents of that type as given by

$$BQ_{t,j,i} = \frac{\sum_{j\in\mathbb{J}} \left(M_{t-1,j,i} - M_{t,j+1,i}\right)\left(p_t^a + r_t^a\right)A_{t,j+1,i}}{\sum_{j\in\mathbb{J}} M_{t,j,i}}. \tag{19}$$

9. the law of motion for the distribution of firms given by equation (20) is satisfied. The idiosyncratic productivity shocks imply that firms vary in terms of both their capital k_t and productivity z_t. The distribution of firms over capital and productivity is denoted by $\mu_t(k,z)$ and where the law of motion for the distribution is given by

$$\mu_{t+1}(A\times B) = \int \mathbf{1}_{g(k,z)\in A} Q(z,B)\mu_t(dk,dz). \tag{20}$$

Here $Q(z_t, z_{t+1})$ is the transition function for the Markov process, $\mathbf{1}$ is an indicator function and $g(k,z)$ is the firms optimal choice for next period capital as given in equation 12.

2.5 Calibration

This section describes how model parameters are calibrated. The model is calibrated to match both US macroeconomic aggregates and firm level data from the COMPUSTAT database. Other parameters are calibrated in line with the literature. The frequency of the model is annual and the unit of the model is an individual. As a basis of the calibration, we first compute a benchmark steady state economy that approximates the economy of 2013.

Demographics The population dynamics are calibrated to match The United States Census Bureau's 2014 National Population Projections Datasets. The population dynamics are set to match the average of the projection from 2014 to 2060 from table 1. Defining $Pop_{20,2014}$ be the population of persons aged 20 at 1 July 2014 the conditional survival probability is calculated as $sp^*_{21} = 1/46 \sum_{t=2014}^{2059} Pop_{21,t+1}/Pop_{20,t}$. Due to positive net migration the projected size of some age cohorts increases but we set the conditional survival probability to a maximum value 1.

Endowments There are three skill types in the model covering the first quintile, the middle 3 quintiles and highest quintile for earnings, respectively. As such they encompass 20 per cent, 60 per cent and 20 per cent of the population.

The labor efficiency parameters, $e_{j,i}$, are estimated from Bureau of Labor Statistics Median usual weekly earnings of full-time wage and salary workers by age, race, Hispanic or Latino ethnicity, and sex. First we calculate the age efficiency factors from the medium weekly earnings for the 5 year age cohorts in Table 3. The age based labor efficiency parameters are scaled by earnings of the first decile, the median earner, the ninth decile for the three skill types in Table 5. For the earnings data we use averages from quarter 1 2000 to quarter 4 2016.

The labor efficiency parameters are further scaled so that aggregate labor supply, as given by equation (17), equals 0.3 in the baseline to match labor supply in Gourio and Miao (2010).

Preferences The consumption share of utility, γ, is set to 0.25 while the inter-temporal elasticity $1/\sigma$ is set to 0.4. The household discount rate is set at $\beta = .983$, so that the steady state interest rate is 4 per cent baseline.

Technologies The firm calibration largely follows Gourio and Miao (2010). The exponent on labor is set so the labor produces 65 per cent of output as is broadly observed in US data, $\alpha_l = 0.65$. The exponent of capital, the investment adjustment cost parameter, the technology shock persistence and standard deviation are based on firm level data from the COMPUSTAT database. The depreciation rate is set so the investment to capital ratio matches that observed US macroeconomic data.

The limit on equity buy-backs, $\bar{s}$, is set to 0.085 so that capitals gains tax collections in the baseline match revenue from capital gains as a share of GDP from US treasury department data.[7]

Fiscal policy Tax rates are set to match both current US rates and to balance the government's budget in the baseline. The corporate tax rate τ^k, the dividend tax rate τ^d and the capital gains tax rate τ^g, are set to 34, 20 and 20 per cent respectively. The interest income

[7] Capital gains revenue is particularly volatile. As such we target taxes paid on long-term capital gains as a share of GDP from 2009 to 2014 which was 0.5 per cent according to U.S. Department of the Treasury.

tax rate is set to 25.0 per cent so that the after tax risk free rate is 3 per cent as in Gourio and Miao (2011). The consumption tax rate, τ^c, is set to 5 per cent to match the sales tax revenue to GDP of 3.1 per cent. The labor income tax rate, τ^n, is set 24.0 per cent to balance the government's budget in the baseline. In the baseline depreciation is fully deductible, $\chi^\delta = 1$, while investment is not deductible $\chi^I = 0$.

Government purchases of goods are set to 19.2 per cent of GDP based on the average from 2000 using the Bureau of Economic Analysis's Table 1.1.5. Gross Domestic Product.

Government transfers represent Old-Age and Survivors Insurance (OASI) payments and are calibrated so that aggregate transfers in the baseline match the average transfers to GDP ratio. We match the 2000 to 2016 average ratio based on data of total OASI expenditures from Social Security Administrators Table 4. The payments are adjusted for the three skill types to taking into account the formula for calculating retirement benefits as given by the retirement estimator.

3 Quantitative analysis

In this section we use the calibrated model to conduct a number of experiments. Our main goal is to quantify the distortions of different capital income taxes and how the burden of capital income taxes is allocated across households. We next study the quantitative importance of accounting for firm heterogeneity, lifecycle motive and corporate finance when evaluating the incidence of different capital taxes. Finally, we consider the tax reform proposals that aims to shift the capital tax burden from corporate to household income.

3.1 The welfare cost and incidence

In order to assess the relative importance of the distortions caused by different capital taxes, we adopt the marginal excess burden (MEB) analysis. The MEB approach enable us to estimate marginal welfare loss of raising taxes at the point defined by the benchmark tax policy settings.[8] Specifically, we consider a hypothetical policy experiment in which the government raise an additional dollar of revenue through one of available capital tax instruments. The tax instrument is permanently adjusted to meet the targeted net present value (NPV) revenue increase. The revenue increase is the net additional revenue change taking into account other tax bases. The MEB of each household is computed by their welfare change in terms of equivalent variation. The aggregate MEB given by the net present value of the MEBs of all households normalised by dividing by the net present value of the change in net revenue.

We compute marginal excess burdens for the corporate income tax (CIT), capital gains tax (CGT) and dividend tax (DT) separately. We also examine a combination of dividend

[8]For further details on the MEB calculation and justification of this approach we refer readers to Appendix C or Tran and Wende (2017).

and capital gains tax (DT&CGT) in which dividend and capital gains taxes are treated as one single policy instrument. For comparison, we report the labor income tax (LIT) case. Table 1 presents the marginal excess burdens (MEB) for different taxes.[9]

	CIT	DT	CGT	DT&CGT	LIT
Aggregate	\$0.67	\$1.56	-\$0.28	\$0.50	\$0.22
Retired	\$0.07	\$0.03	\$0.06	\$0.04	-\$0.81
Working	\$0.77	\$1.55	-\$0.07	\$0.61	\$0.14
Future	\$0.70	\$1.96	-\$0.59	\$0.50	\$0.58
Low skill	\$0.03	\$0.55	-\$0.53	-\$0.07	-\$0.26
Medium skill	\$0.52	\$1.30	-\$0.32	\$0.37	\$0.08
High skill	\$1.35	\$2.67	-\$0.06	\$1.10	\$0.77

Table 1: Aggregate marginal excess burdens (MEB) of different capital taxes. Note that, CIT is corporate income tax, DT is dividend tax, CGT is capital gains tax and LIT is labor income tax

Our main results indicate that the dividend tax is more distorting than the capital gains tax or the corporate tax. As shown in the first row of Table 1, the aggregate MEB for the dividend tax is \$1.56 per dollar of tax revenue raised, compared to 67 cents and $-\$0.28$ for the corporate tax and the capital gains tax, respectively. In particular, the MEB of \$1.56 indicates that raising a net dollar through the dividend tax is equivalent to taking 1.56 dollar off households, on average, through a lump sum tax and burning it. That is, households are worse off in terms of welfare due to the distortions the tax that creates marginal excess burden. According to this MEB metric, the DT is the least preferred tax while the CGT the most preferred taxes at aggregate level.

We next discuss the underlying mechanisms through which each capital tax distorts economic activities and welfare.

Corporate income tax (CIT). The CIT increase distorts the firm's incentive to invest lowering the capital stock and asset prices. Raising the CIT rate lowers cash flow available for dividends or equity buy-backs which subsequently lowers the value of and the return on equity as seen in Panel 3 and 1 of Figures 3 and 8, respectively. In response firms invest less and as the capital stock decreases the marginal product of capital increases raising the rate of return. The rate of return does not return to pre-policy change values as in this model with life cycle household saving as capital supply is not perfectly elastic to the rate of return.

The capital stock decrease combined with lower labor hours and aggregate TFP results in decreased output. Aggregate TFP falls as the output of high productivity firms falls by more than for low productivity firms. High productivity firms undertake proportionally more investment and the CT increase causes the capital stock of high productivity firms to fall

[9]The results presented are normalised for population and productivity growth with the population measure normalised to one. In this setting one dollar per household equals one dollar in total. Changes in aggregate variables, such as GDP and the capital stock, can be thought of as the change per dollar of net revenue. At the same time changes in households variables, such as welfare, can be thought of as the change per dollar of revenue per household.

proportionally more as shown in Panel 2 of Figure 8. Therefore, after the policy change lower productivity firms produce proportionally more output and TFP falls. However the TFP decrease accounts for only around one sixth of the output fall unlike the DT increase where the TFP decrease accounts for around two thirds of the output change. Overall the output decrease is larger per dollar of net revenue for the CIT increase than for the DT increase.

Dividend tax (DT). Raising the dividend tax rate above the capital gains rate reduces the incentive to invest for firms in the equity financing regime that are generally firms that have recently received a positive productivity shocks. These firms are growing their capital stock and do not pay dividends. As such, higher the DT rate reduces investment by firms who have had positive productivity shocks and therefore of higher productivity firms in general. This changes the allocation of capital over firms. While the aggregate capital stock declines, as shown in panel 3 of Figure 2, this decline is led by high productivity firms. Panel 2 of Figure 1 shows that high productivity firms have the largest capital stock decrease and the capital stock of low productivity firms, those likely to be in the dividend issuance regime, increases. Firms in the dividend issuance regime are not negatively affected by the divided tax rate but benefit from lower wages and lower interest rates. In fact the lower initial interest causes the aggregate capital stock to increase before falling. Overall the distribution of capital shifts from high productivity firms to low productivity firms.

The change in the distribution of capital affects aggregate total factor productivity (TFP), output and wages.[10] The reduction in capital of high productivity firms reduces output and labor demand from these firms. While output and labor demand by lower productivity firms increases, these firms are by definition lower productivity and therefore do not offset declines by higher productivity firms. The shift in output from high productivity firms to lower productivity firm lowers TFP. This reduction in TFP accounts for around two thirds of the fall in output as seen in Panel 4 of Figure 2. This suggests the distributional impacts on capital account for around two thirds of impacts on wages and similar variables and are therefore also explain a large part of the welfare impacts.

Capital gains tax (CGT). A rise in the CGT rate affects firms' investment incentives, so that it shifts the allocation of capital to higher productivity firms and increases aggregate TFP. A higher CGT rate reduces the value of capital gains for households and increases the value of capital losses. This incentivizes firms in the equity financing regime to either reduce equity buy-backs or increase issuance and to increase investment. Firms in the equity financing regime are predominantly firms that have recently received a positive productivity shocks and are therefore generally higher productivity. Higher investment leads to a higher capital stock and therefore over time the output and labor demand of higher productivity firms. As the share of output produced by higher productivity firms increases so does aggregate TFP.

[10]We define aggregate TFP in period t as $\text{TFP}_t = Y_t/(K_t^{\alpha} N_t^{1-\alpha})$.

As shown in Panel 3 of Figure 4, the overall capital stock declines and equity prices fall; however, more capital is allocated to higher productivity firms. Increasing the CGT rate increases the effective discount households put on future returns. As such, in aggregate firms invest less and pay out a greater share of cash flow as returns and the capital stock decreases. The value of total equity falls but the price of equity per unit of capital increases as aggregate TFP increases.

Total output increases as the fall in the capital stock and small fall in labor hours is more than offset by the increase in TFP. Labor hours decrease marginally as substitution towards labor from the increase in wages is more than offset by the positive income effect of the extra transfers, as shown in Panel 3 Figure 9.

Aggregate welfare increases due to higher wages and transfers despite welfare falling for wealthy households due to the equity price fall, as seen in Panel 1 of figure 4. The increase in transfers benefits all households while the increase in wages benefits households with more time remaining in the labor force.

Raising the CGT rate causes CGT revenue to fall and the revenue from other sources to increase, as seen in Panel 2 of Figure 4. As discussed above, raising the CGT rate causes firm to reduce equity buy-backs and increase issuance reducing capital gains. However revenue overall increases as dividends and output increase. Static analysis would project to policy change to raise 70 cents implying a tax scoring estimate of $1.42.

Dividend tax and capital gains tax (DT&CGT). The DT&CGT are charged on dividends plus capital gains. Dividends plus capital gains equals the firms cash flow plus equity price changes. Taxing equity price changes creates an incentive for firms to decrease their value by decreasing their capital stock. Conversely, the CT is charged revenue minus wages and depreciation which equals cash flow plus net investment. As such the DT&CGT act like cash flow tax plus a tax on equity price changes and the CIT acts like a cash flow tax plus a tax on net investment. As with the CIT, an increase in the DT&CGT reduces the capital stock can be seen in panel 3 of Figure 5. As the CIT operates through the investment channel high productivity firms undertake proportionally more investment. The capital stock of higher productivity firms declines proportionally than for low productivity firms. Conversely, an increase in the DT&CGT reduces the capital stock of low productivity firms by proportionally more than for high productivity firms as can be seen in panel 2 of Figure 10. In the model, low productivity firms hold capital to maintain their value in expectation of future positive productivity shocks. Higher taxes on capital price changes reduce the incentive for these low productivity firms to hold onto capital. As such the capital stock of low productivity firms falls proportionally more.

The changes in the distribution of capital between the DT&CGT and CIT increases largely explain the differences in the impacts. The DT&CGT shifts the distribution of capital to higher productivity firms giving a slight increase in TFP. Conversely, the CT shifts the distribution of capital to lower productivity firms giving a slight decrease in TFP.

The capital stock decline is larger for the DT&CGT increase than for the CIT increase however the output decrease is smaller as shown in panel 4 of Figure 5. Under the DT&CGT increase the decline in the capital stock is partly offset by the small rise in TFP. The TFP increase also means that wages do not fall by as much. Therefore, labor hours decline by slight less under the as shown in panel 3 of Figure 10

Incidence of capital taxes. The MEBs of taxes are disaggregated by household group as presented in rows from 2 to 6 in Table 1. It is clear that the burdens of capital income taxes are distributed uniformly across age-cohorts and income types. There is significant variation in the MEB across income types and generations. In particular, the retired households bear the least marginal excess burdens of the company income and dividend taxes. Conversely, the working households are, on average, the biggest losers of the company income tax and dividend tax increases. The future households bear the highest welfare cost of the dividend tax increase. The overall ranking in columns 2 and 5 of Table 1 indicates that the current working households bear the highest incidence of capital income taxation and then the future households.

We now turn to how the burden of capital income taxation is allocated between low and high income households. As seen in the bottom half of Table 1, low income households are largely unaffected by the company income tax increase. They would be only 3 cents worse off under the company income tax increase. This occurs as the model assumes any extra revenue generated is re-distributed evenly via the transfer system to balance the budget, the loss of income from lower wages is offset by higher transfers. However, the low income households would still have to bear significant welfare cost, 55 cents, when there is a capital gains tax increase. On the other end, we find that the high-income households suffer significantly and bear most of the burdens of capital tax taxation. These households would be 1.35 dollars and 2.67 dollars worse off due to the increases in company income and dividend taxes, respectively.

Overall, the aggregate welfare loss per dollar of revenue is smaller for the DT&CGT increase than for the CIT increase. According to this MEB analysis, the efficiency of capital income taxation improved by relying more on DT&CGT with low MEB and less on CIT with high MEB. Moreover, the distributional tax incidence analysis implies welfare costs are lower for all household groups under DT&CGT, compared to CIT.

3.2 Model features and tax burden

In section we analyze the quantitative importance of different modelling features, including firm heterogeneity, lifecycle motive, corporate finance and market incompleteness, when assessing the welfare effects and incidence of capital taxes. To do so, we start from the baseline model and gradually relax the key assumptions and examine how each of them affects the main results. We specifically consider several alternative models in which we turn on and off following features:

heterogeneous firms, heterogeneous households with life cycle structure, internal and external finance regimes, and decreasing return to scale (DRS) technology. Here are the list of models in consideration:

(0) Model 0: the baseline model with all features including lifecycle households, heterogeneous firms, internal and external finance, and decreasing return to scale (DRS) production technology;

(1) Model 1: A model with all core features of Model 0, except for internal finance only;

(2) Model 2: A model with lifecycle households and a representative firm;

(3) Model 3: A model with a representative household and heterogeneous firms;

(4) Model 4: A model with a representative household and a representative firm;

(5) Model 5: A model with a representative household and a representative firm that has constant return to scale (CRS) production technology.

We again consider a hypothetical tax reform in which the government raise an additional dollar of revenue through one of available capital tax instruments. We presents the results of marginal excess burden (MEB) analysis in Table 2.

	CIT	DT	CGT	DT &CGT	LIT
Benchmark model	\$0.67	\$1.56	-\$0.28	\$0.50	\$0.22
Model 1: Bench. Model w/ IF only	\$0.54	\$0.13	\$1.43	\$0.52	\$0.24
Model 2: Rep. Firm	\$0.54	\$0.66	\$0.22	\$0.52	\$0.24
Model 3: Rep HH and het. firms	\$0.71	\$1.95	-\$0.36	\$0.52	\$0.22
Model 4: Rep HH, Rep Firm, EF	\$0.58	\$0.75	\$0.12	\$0.56	\$0.23
Model 5: Rep HH, Rep Firm, EF, CRS	\$0.79	\$0.80	\$0.77	\$0.79	\$0.26

Table 2: Modeling features and marginal excess burden (MEB) for taxes in . Note that, CIT is corporate tax, DT is dividend tax, CGT is capital gains tax and LIT is labor income tax

Corporate finance and financial constraints. The previous studies (e.g., see Conesa, Kitao and Krueger (2009)) usually abstract from modeling corporate finance policy. In a model where there are no financial constraints, firms can return profits to equity-holders through either dividends or equity buy-backs. Similarly, they can raise funds for investment through either issuing equity or negative dividends. In a case where capital gains and dividend taxes are equal the financial policy irrelevance theorem of Miller and Modigliani (1961) holds. However, when the tax rates differ firms will prefer a particular corporate finance policy. Financial constraints may bind for certain firms. Some firms may be able to internally finance investment, while others may need to externally finance. Capital gains or dividend tax may affect investment for some firms and not others. 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.

In order to examine the role of external finance we consider a model in which firms face financial constraints and have to rely on internal finance only (Model 1). As reported in row

2 of Table 2, the MEB of CIT are relatively smaller, while the MEB of DT&CGP is relatively larger in Model 1 where external finance is removed.

Firm heterogeneity. Recent studies of capital tax reforms in the US have shown how the effects of dividend and capital gains taxes are different in heterogeneous firm models (e.g., see Gourio and Miao (2010) and Gourio and Miao (2011)). We examine that the quantitative role of firm heterogeneity in determining the burden of capital income taxation by considering an alternative economy in which firms face no idiosyncratic productivity shocks. In this setting, there are lifecycle households as in the baseline model, but there is only one representative firm (Model 2).

The MEB of the dividend tax is much higher in the models with heterogeneous firms as these models capture how taxation affects the capital allocation. As discussed in the analysis of dividend tax, an increase in the DT shifts the allocation of capital to lower productivity firms and lowers TFP. The models without firm heterogeneity abstract from this misallocation mechanism, which results in relatively small tax distortions. However, the size of the distortion from the DT still depends on investment financing regime and lifecycle structure. When the representative firm is assumed to be internally financing and there is a representative household the DT causes no distortion. Maintaining the internal finance assumption but introducing overlapping generations means the DT causes a distortion. In this setting, the DT has distributional impacts through the equity price change and thereby results in an aggregate welfare loss. Under the external finance assumption the DT lowers investment and creates a larger distortion.

Excluding firm heterogeneity slightly lowers the MEB of the CIT increase. In the full model raising the CIT rate lowers TFP by shifting the capital allocation to lower productivity firms. Excluding overlapping generations raises the aggregate MEB of the CIT as capital supply is perfectly elastic in the long run with a representative household.

In the models with firm heterogeneity, raising the CGT improves the efficiency of capital allocation and results in a welfare gain. The models without firm heterogeneity do not capture this mechanism. The financing assumptions also affect the magnitude of the impact of the CGT on firm investment and therefore the aggregate MEB.

A combination of the DT&CGT increase has similar impacts to the CIT increase. However, the DT&CGT change results in a slight increase in TFP while the CIT change results in a slight decline. As such including firm heterogeneity raises the MEB of the CIT increase and lowers the MEB of the DT&CGT increase.

Lifecycle structure. Erosa and Gervais (2002) and Conesa, Kitao and Krueger (2009) demonstrate that lifecycle structure of households is important for understanding the optimal design of capital income taxation. We modify the baseline model to assume away finite lifetime horizon and lifecycle motive. That is, the household sector in this model consists of a representative household who lives infinitely while the firm sector still consists of many firms facing idiosyncratic shocks to productivity every period (Model 3). We find the MEBs of the CIT and

DT are relatively larger, compared to the MEBs from the models with lifecycle households. This implies that the adverse effects of capital income taxation on savings are stronger in a lifecycle model.

Constant return to scale. So far we assume firms have a decreasing return to scale technology. For comparison with a standard neoclassical growth model we consider two representative agent models with two different production technologies: one with decreasing return to scale production technology (Model 4) and one with constant return to scale production technology (Model 5).

Lastly, in Models 1 to 4 we keep the assumption the production technology is decreasing return to scale (DRS). In model 5, we relax this assumption and use the constant returns to scale (CRS) production technology. That is, Model 5 is very similar to the standard neoclassical growth model in the previous literature (e.g. see Judd (1985)).

Our MEB estimates from the baseline model and Models 4 and 5 show how our results relate to the previous studies. Judd (1985) using a model similar to Model 5 and finds a MEB of 98 cents for a tax on the returns for capital and 12 cents for labor income tax. Our MEB estimates are 65 cents and 18 cents for of the capital taxes and labor tax in Model F. The differences are mainly due to differences in calibration values. Ballard, Shoven and Whalley (1985) finds MEB estimates in the range of 18 to 46 cents for industry level capital taxes and a range of 12 to 23 cents for industry level labor taxes. The lack of forward looking behaviour in that analysis is likely to be responsible for these estimates being significantly lower than the MEB of the corporate tax in any of the models we use.

Further the aggregate MEB is larger under a constant returns to scale production function as capital demand is more elastic.

3.3 Incidence of capital tax reforms

Our previous results indicate that the efficiency of capital income taxation can be improved by relying more on capital gains and dividend taxes which have relatively lower MEB and less on corporate income tax which has relatively higher MEB. In this section, we study the aggregate and welfare effects of capital tax reforms that shifts the tax burden from corporate income to personal capital income.

We consider the revenue-neutral tax cuts which the government raises either dividend and capital gains taxes or labor income tax to finance the committed government spending programs which are kept at the level in the baseline calibrated model. We report the results for two sets of experiments: (*i*) the dividend and capital gain taxes both adjust at the same rate, and (*ii*) the labor income tax adjusts.

Dividend and capital gains taxes (DT&CGT) Table 3 presents the results of an experiment in which the government cuts the corporate tax and use the dividend and capital gains tax rates to balance the government budget. Small cuts in the corporate tax rate are universally supported by living households. The welfare increase of moving from corporate tax to dividend and capital gains tax comes as corporate tax does not allow new investment to be fully expensed while dividend and capital gains only tax profits after investment, as explained in section 3. This decreases the user cost of capital and increases investment and the capital stock. However, for larger increases in DT and CGT the decrease in the capital prices does not offset the capital stock increase and as such the value of equity falls.

Corporate income tax rate (%)	0	8	16	24	32
Output change (%)	1	0.8	0.7	0.4	0.1
Welfare change (%)	0.23	0.29	0.29	0.22	0.06
Retired welfare Δ (%)	-0.35	-0.19	-0.07	0	0.01
Working welfare Δ (%)	0.12	0.2	0.22	0.18	0.05
Future welfare Δ (%)	0.33	0.39	0.37	0.27	0.07
Low skill Δ (%)	0.21	0.27	0.28	0.21	0.06
Medium skill Δ (%)	0.21	0.27	0.28	0.21	0.06
High Skill Δ (%)	0.26	0.31	0.3	0.22	0.06
Population support (%)	25	34	45	83	100
τ^d, τ^g (%)	53.4	47.8	41.1	33	22.9

Table 3: The welfare effects of the corporate tax cuts financed by dividend and capital gains taxes.

The reform that replaces the corporate tax with the mix of dividend and capital gains taxes results in an overall welfare gain. However, older households are worse off. This implies that the total welfare gains of the current working households dominate that of the current retirees. Interestingly, we only find 38 percent of current households support the reform. This finding opposes the result in Anagnostopoulos, Atesagaoglu and Carceles-Poveda (2018) where a majority of infinitely-lived households with different income and assets experience welfare gains. Note that, they abstract from overlapping generations of households, which is important to understand political feasibility for overhaul corporate income tax reforms.

Labor income tax (LIT) Table 4 presents the results of an experiment in which the government cuts the corporate tax and balance the government budget by increasing the labor income tax rate. Overall, welfare is increased but this mainly driven by current high asset households. Future households are worse off as although asset prices, the capital stock and before tax wages are all higher after tax wages are lower. That said, households alive at the time of the policy change largely support the change. The households that do not support the policy change are predominantly low income as these households rely more on labor income.

This results highlights important non-linearities when combining policy changes. The MEB of corporate tax is higher than for labor income tax for all cohorts, as shown in Table 1. Nonetheless, future households do not benefit from a corporate tax cut funded by a labour income tax increase. The non-linearity comes through a combination of the interest rate and total factor productivity. Raising LIT reduces household income, saving and the interest rate. With the higher interest rate the benefit of lower corporate tax is diminished.

Corporate tax rate (%)	0	8	16	24	32
Output change (%)	2.4	2.1	1.6	1	0.2
Welfare change (%)	1.58	1.38	1.08	0.68	0.16
Retired welfare Δ (%)	9.9	7.64	5.34	3	0.6
Working welfare Δ (%)	2.72	2.28	1.73	1.05	0.23
Future welfare Δ (%)	-1.67	-0.92	-0.36	-0.03	0.03
Low skill Δ (%)	1.85	1.58	1.22	0.76	0.17
Medium skill Δ (%)	1.84	1.58	1.22	0.76	0.17
High Skill Δ (%)	1.24	1.12	0.91	0.59	0.14
Population support (%)	82	82	84	85	87
τ^n (%)	26.4	24.6	22.7	20.8	19

Table 4: The welfare effects of the corporate tax cuts financed by labor income tax.

Implications for the Tax Cuts and Jobs Act (TCJA) After the Tax Cuts and Jobs Act of 2017 the effects of corporate income tax cuts have returned to the forefront of policy debate. Proponents of the tax cuts emphasize the inefficiency of raising revenues through corporate income taxes relative to other personal income taxes. However, proponents of corporate income tax cuts usually argue that the revenue loss induced by the reforms would result in negative distributional effects as the government has to raise personal income taxes or cutback benefits programs. The most important component of the TCAJ is a reduction in the statutory tax rate for corporations from 35% to 21%. Our incidence analysis sheds lights on the consequences of the TCJA, even though not all features of the TCJA are not included in our model.[11]

First, the economy is likely to experience a GDP growth in long run as the tax reform will reduce tax distortions and improve aggregate efficiency. Interestingly, the tax reform leads to welfare gains for majority of current and future households. More than 80 percent of the current alive households will experience welfare improving and support the tax reform.

Second, if revenue neutrality is required under the TCJA, which budget-balancing tax instrument the government use would have different implications for macro aggregates and welfare. In our model, it appears that there are larger aggregate efficiency and welfare gains if the labor income tax is used. Interestingly, the future generations who are born after the tax reform will be losers as higher labor income tax reduces their labor income and welfare.

4 Conclusion

We study the incidence of capital income taxation using in a dynamic general equilibrium, overlapping generations model with heterogeneous firms calibrated to the US. We find that

[11] There are other different features of the tax reform that are not considered in this paper.

the burdens of corporate income tax, dividend and capital gains taxes are vastly different in our model with endogenous investment, financing regimes and capital allocation. Accounting for the impacts of capital income taxes on capital allocation results in new insights in the tax incidence analysis. In particular, the burden of the dividend tax is larger than that of the corporate income tax, even though it causes a relatively smaller distortion on capital accumulation. A tax on capital gains improves welfare because it mitigates misallocation of capital and improves aggregate TFP, which outweights the adverse effects of the capital gains tax on investment incentives and capital accumulation. More importantly, we are able to map out the incidence of each tax on capital income. We find that the tax burdens are allocated unevenly among households and generations. Taxing capital income either at the firm or household side lowers the welfare of wealthy households as higher capital tax rates decreases asset prices. Dividend and corporate taxes in particular lower future wages and therefore lower the welfare of most younger and future households. Conversely, capital gains tax raises future wages and therefore raises welfare of young and future household.

We demonstrate how the burden of capital income taxes is affected when we relax modeling assumptions. Accounting for allocative efficiency and lifecycle structure are important when assessing the marginal excess burden of capital income taxation. Without firm heterogeneity we would not be able to capture the allocative efficiency impacts of a capital income tax. Without household heterogeneity we would not be able to examine how the tax burdens are allocated among households and distributional implications of a tax reform. Moreover, the magnitudes of the tax burdens also hinge on corporate finance structure and financial heterogeneity. The assumptions on internal or external finance are important to the allocative efficiency impacts, including debt financing would lower the burden of corporate income tax while allowing for a variable debt financing share would lower the allocative efficiency impacts of dividend and capital gains taxes.

The set-up of household sector is simplified. While allowing for household heterogeneity by age and skill we abstract from exogenous income shocks. There is no precautionary savings motive. We also abstract from progressive income taxes and transfers. Our model can be extended to improve the accuracy of marginal analysis. We leave these issues for future research.

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5 Appendix

5.1 Appendix A: Capital tax wedge and investment financing

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 does not hold. As pointed out in Gourio and Miao (2010), 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. To revisit this point in our model we consider three tax scenarios: (i) dividend tax (DT) and capital gains tax (CGT) are equal; (ii) dividend tax (DT) is greater than the capital gain tax (CGT); and (iii) DT is less than the CGT.

When dividend and capital gains taxes are equal, $\tau^d = \tau^g$, firms are indifferent between financial policies as in Miller and Modigliani (1961). That is, the firm is indifferent paying out returns through equity buy-backs or dividends. Without the constraints on dividends and equity buy-backs financial policy would be indeterminate however the constraints in equations 6, 7 and 8 determine the firms' financial policies. Firms behaviour is determined by their cash surplus which given by revenue after wages, taxes and investment cost. When their cash surplus is less than or equal to $\bar{s}$ they issue or buy back equity equal to this value. When cash surplus is greater than $\bar{s}$ the firms buy back equity of value $\bar{s}$ and pay out the remainder as dividends. In either case the dividend tax does not affect the firm's investment decision. The marginal unit of investment faces the same tax whether it is invested and results in future dividends or if it is not invested and paid out now. As such the dividend tax does not distort the firm investment decision. However, the CGT does reduce the firms incentive to invest. If the firm is investing the CGT reduces the returns on any price increase the investment causes. If the firm is not investing the CGT provides an incentive to decrease its capital stock as the households as able to deduct any resulting capital losses. The CGT acts in such a way that it is equivalent to households increasing the discount they apply to future returns.

When $\tau^d > \tau^g$ households prefer returns paid through equity buys back rather than dividends. The constraint on equity buys backs, equation 7, causes firms to fall into 3 financing regimes. When the cash surplus is greater than $\bar{s}$ the firm pays out returns through both buy-backs and dividends and we call this the dividend paying regime. In this case DT does not affect the firms investment decision. The marginal unit of investment faces dividend tax whether it is not invested and paid out as a dividend now or if it is invested and results in higher future dividends. As such the dividend tax does not distort the firms investment decision. When cash flow is less than $\bar{s}$ the firm is either buying back equity or issuing equity equal to the value of the cash flow. The marginal unit of investment is financed by equity which is taxed at the CGT rate. The CGT rate is less than the DT rate levied on possible future dividends resulting from the investment. The wedge between the DT rate and CGT rate lowers investment for these firms. Lastly, there is a group of firms who are cash flow constrained in that they choose investment such that their cash flow exactly equals $\bar{s}$. For these firms an additional unit of investment would be financed by equity which pays the CGT rate while an additional unit not invested would result in strictly positive dividend which is taxed at the higher rate. As such they choose to remain in the cash flow constrained position.

When $\tau^g > \tau^d$ households prefer returns paid out through dividends rather than equity buy-backs. The issuance constraint given by equation 8 binds for all firms in that all firms would like to issue equity to pay dividends independent of their cash flow. The issuance constraint further implies the firms must first buy back equity before paying dividends.[12] Nonetheless, the constraint means that firms in the dividend issuing regime invests comparatively less. As in the other tax cases the dividend tax rate does not affect the firms investment decision if they are in the dividend paying regime. However when firms are in the equity financed regime the CGT provides an incentive to increase investment. Increasing investment either reduces equity buy-backs or increases losses from equity issuance both of which are taxed at a higher rate than the dividends.

5.2 Appendix B: Calibration

We provide detailed information on our calibration and properties of the calibrated model.

	Parameter	Value
Exponent on capital	α_k	0.311
Exponent on labor	α_l	0.650
Shock persistence	ρ	0.767
Shock standard deviation	σ	0.211
Depreciation rate	δ	0.095
Adjustment cost	ψ	0.890
Equity buy-back constraint	$\bar{s}$	0.085
Discount factor	β	0.983
Consumption share	γ	0.25
Inter-temporal elasticity	$1/\sigma$	0.4
Corporate income tax	τ^k	0.340
Dividend tax	τ^d	0.200
Capital gains tax	τ^g	0.200
Interest income tax	τ^r	0.250
labor income tax	τ^n	0.240
Consumption tax	τ^n	0.025
Deductibility of depreciation	χ^δ	1.00
Deductibility of investment	χ^I	0.00

Table 5: Parameter calibration

[12] When the buy back constraint is introduced in equation 7 we note how these buy-backs would equate to capital gains from trend growth if the model wasn't normalized.

$z =$	0.00	0.02	0.08	0.16	0.24	0.24	0.16	0.08	0.02	0.00
$\mu =$	0.36	0.47	0.59	0.73	0.90	1.11	1.36	1.69	2.13	2.79
$\pi =$	0.31	0.46	0.20	0.03	0.00	0.00	0.00	0.00	0.00	0.00
	0.06	0.33	0.40	0.17	0.03	0.00	0.00	0.00	0.00	0.00
	0.01	0.11	0.35	0.36	0.14	0.02	0.00	0.00	0.00	0.00
	0.00	0.02	0.17	0.37	0.32	0.11	0.01	0.00	0.00	0.00
	0.00	0.00	0.04	0.22	0.39	0.27	0.07	0.01	0.00	0.00
	0.00	0.00	0.01	0.07	0.27	0.39	0.22	0.04	0.00	0.00
	0.00	0.00	0.00	0.01	0.11	0.32	0.37	0.17	0.02	0.00
	0.00	0.00	0.00	0.00	0.02	0.14	0.36	0.35	0.11	0.01
	0.00	0.00	0.00	0.00	0.00	0.03	0.17	0.40	0.33	0.06
	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.20	0.46	0.31

Table 6: Productivity process calibration

$\mu =$	0.20	0.60	0.20

Table 7: Household parameters

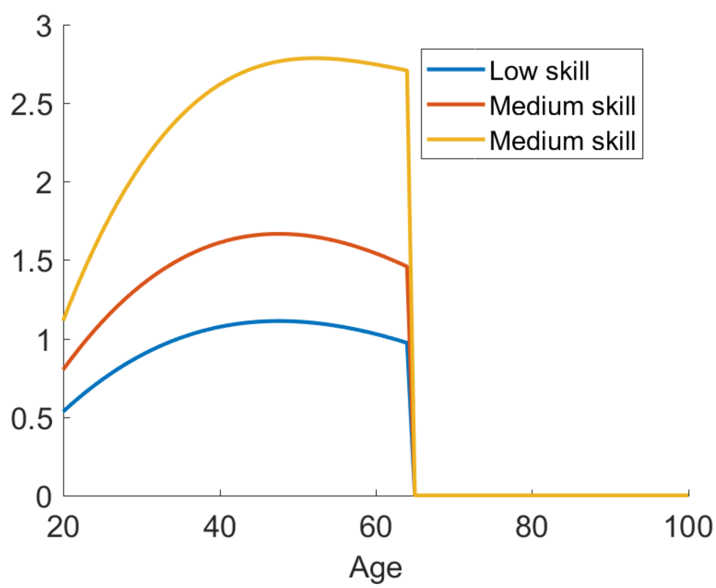

Figure 1: **Labour productivity** ϵ by age and skill type.

Target	Model baseline value	Data Value
Total government receipts to GDP	26.5%	27.9%
Corporate tax revenue to GDP	6.8%	2.4%
Personal tax revenue and OASI to GDP	18.2%	16.4%
Labour income tax revenue to GDP	16.3%	-
Dividend tax revenue to GDP	1.7%	-
CGT revenue to GDP	0.3%	0.4%
Consumption tax revenue to GDP	1.5%	3%
Government consumption to GDP	21.9%	19.2%
Social security to GDP	4.6%	4.6%

Table 8: **Model fiscal fit**

Regime	Equity financed	Cash flow constrained	Dividend paying
Share of capital	46.9 %	0%	53.1%

Table 9: **Distribution of firms**

Model	A	B	C	D	E	F	G
WN/Y %	65	65	65	65	65	65	65
C/Y %	62.4	62	62	62.3	61.9	61.9	59.6
I/Y %	15.1	17.9	17.9	15.1	17.9	17.9	20.2
Ψ/Y %	3.39	0.92	0.92	3.39	0.92	0.92	1.04
G/Y %	19.2	19.2	19.2	19.2	19.2	19.2	19.2
K/Y %	1.59	1.88	1.88	1.59	1.89	1.89	2.12
A/Y %	2.61	2.76	2.76	2.61	2.77	2.77	2.34
TAX_k/Y %	6.78	5.81	5.81	6.77	5.8	5.8	5.04
TAX_n/Y %	12	12.9	12.9	12.1	12.9	12.9	14
TAX_d/Y %	1.33	1.45	1.45	1.33	1.45	1.45	1.13
TAX_g/Y %	0.62	0.62	0.62	0.62	0.62	0.62	0.62
TAX_i/Y %	0	0	0	0	0	0	0
TAX_c/Y %	3.03	3.01	3.01	3.03	3.01	3.01	3.01
τ^k %	34	34	34	34	34	34	34
τ^n %	18.5	19.8	19.8	18.5	19.9	19.9	21.5
τ^d %	20	20	20	20	20	20	20
τ^g %	20	20	20	20	20	20	20
τ^i %	25	25	25	25	25	25	25
τ^c %	4.86	4.86	4.86	4.86	4.86	4.86	5.05
α_k	0.311	0.311	0.311	0.311	0.311	0.311	0.35
α_n	0.65	0.65	0.65	0.65	0.65	0.65	0.65
$\bar{s}$	0.15	0.017	0.017	0.15	0.016	0.016	0.015
ρ	0.767	0	0	0.767	0	0	0
σ	0.211	0	0	0.211	0	0	0

Table 10: **Parameters and initial calibration of all models.** Note that, BM is benchmark model, Model A is Rep Firm IF, Model B is Rep Firm EF, Model C is Rep HH, Model D is Rep HH Rep Firm IF, Model E is Rep HH Rep Firm EF, and Model F is Rep HH Rep Firm.

5.3 Appendix C: Computation of marginal excess burden (MEB)

We follow Judd (1987) and use Hicksian equivalent variation to measure the excess burden. That said, as we have finitely lived heterogeneous households we modify the equivalent variation calculation. More broadly our approach is consistent with many of the definitions of the excess burden measure and we provide additional discussion with how our measure fits of the broader MEB literature in the technical appendix.

Equivalent variation. We measure the welfare change using the equivalent variation. We define the equivalent variation in terms of the per period transfer that delivers the same change in expected utility as the policy change. The equivalent variation EV is given by

$$EV(\mathcal{P}^p, \mathcal{P}^b) = \min\ T^{EV}_{t,20,i} \quad \text{such that} \quad \bar{V}_{t,20,i}\left(\bar{A}_{t,j,i}|\mathcal{P}^b, T^{EV}_{t,20,i}\right) \geq V_{t,20,i}(A_{t,j,i}, \mathcal{P}^p).$$

where the household's value function with the additional transfer T^{EV} is denoted by $\bar{V}_{t,j,i}(A_{t,j,i}, T^{EV}_{t,j,i})$. We use the overscore to denote baseline values, as such the value function $\bar{V_{t,j,i}}$ encompasses the budget constraint given by

$$\begin{aligned} &\bar{p}^a_t A_{t+1,j+1,i} + (1+\bar{\tau}^c)C_{t,j,i} = \\ &(1-\bar{\tau}^p)\left(\bar{W}_t(1-L_{t,j,i})\epsilon_{j,i} + (\bar{r}^a_t + \bar{r}^{FC}_t)A_{t,j,i}\right) + \bar{TR}_{t,j,i} + T^{EV}_{t,j,i} + \bar{p}^a_t A_{t,j,i} + \bar{BQ}_{t,i}, \end{aligned} \tag{21}$$

The households value function with the transfers is given by

$$\begin{aligned} &\bar{V}_{t,j,i}(A_{t,j,i}, T^{EV}_{t,j,i}) = \\ &\max_{\{C_{t,j,i}, L_{t,j,i}, A_{t+1,j+1,i}\}} \left\{U\left(C_{t,j,i}, L_{t,j,i}\right) + \hat{\beta} sp_{j+1}\bar{V}_{t+1,j+1,i}\left(A_{t+1,j+1,i}, T^{EV}_{t+1,j+1,i}\right)\right\} \end{aligned} \tag{22}$$

where the equivalent variation transfers for a given household are defined to grow in-line with productivity, $T^{EV}_{t,j,i}(1+g^{\Lambda}) = T^{EV}_{t+1,j+1,i}$.

For households in the model at the time of the policy change, $t = 0$, the transfers are calculated at this time. For these households the equivalent variation is given by

$$\min T^{EV}_{t,20,i} \quad \text{such that} \quad \bar{V}_{0,j,i}\left(A_{0,j,i}, T^{EV}_{t,20,i})\right) \geq V_{0,j,i}(A_{0,j,i}) \tag{23}$$

Marginal excess burden. In the core scenarios the additional revenue is returned to households allowing us to assess the distortion caused by a tax. When additional revenue is uniformly returned to households, a uniform lump tax causes no changes in the model and therefore no distortions. Conversely, a uniform lump sum tax that is used to fund increased government consumption would result in a negative income effect for households, a labor supply response and broader macroeconomic changes. When the revenue is returned to households uniformly, any changes from a tax increase are due to the adverse effects of the tax relative to a uniform lump sum tax. As such, the excess burden in these scenarios is the welfare change as measured by the equivalent variation.

For an overall measure of the distortion of the tax we aggregate over the welfare loss faced by the households. Our aggregation weights all households equally and discounts future welfare change by the interest rate faced by government. We normalize the aggregation by dividing by the net present value of the change in revenue. We define this measure as the aggregate marginal excess burden (AMEB) which is given by

$$\text{AMEB} = \frac{\sum_{t=0}^{\infty}\sum_{i=1}^{3}\sum_{j=20}^{100} M_{t,j,i} T_{t,j,i}^{EV}\left(\frac{1}{1+r}\right)^{t}}{\sum_{t=0}^{\infty}\frac{TAX_t^N - T\bar{A}X_t^N}{\prod_{i=0}^{t}(1+r_i)}}.$$

As discussed above, the equivalent variation is calculated the year the household enters the labor market or the year of the policy change occurs, which ever comes first.

The AMEB is a summary metric for the distortion from each tax that aggregates household's excess burdens. The welfare impacts of different households vary significantly across generations and types which makes comparing taxes difficult. The summary metric provides a point of reference in comparing the taxes. The summary metric is an aggregation of the households welfare changes. The choice of weights when aggregating the excess burdens is in itself a normative choice but we feel the measure constructed here is intuitive. The metric can be used as a proxy for the efficiency of a tax as the metric closely matches the welfare changes under a Lump Sum Redistributive Authority scenarios. The summary metric is not only useful in comparing different taxes it is also useful in examining the impact parameter choices and model formulations. We do not suggest that this summary metric should be the only measure a policy maker should consider. However, it serves as a useful starting point.

We also construct sub-aggregations to compare MEB for different age-cohorts and types. MEB for each household group is constructed in the same way as the total aggregation. We present the MEB for the old, young and future generations. These are simple averages where old is defined as those 65 and over at the time of the policy change, young are those alive and below 65 at the policy change and the future generation shows the MEB in the long run steady state.

5.4 Appendix D: Transition dynamics

We report results on how each tax distorts economic activities and who bear the burden of taxes in transition.

Dividend tax (DT) Figure 2 displays the dynamic effects of the dividend tax (DT) increase on four key variables: excess burden, tax revenue, value of assets and labor income.[13] Figure 1 in Appendix 5.4 presents the impacts on other variables including expected after tax return

[13]The value of assets is given by end of period assets $\int p_t^a du + d_{t+1}$

on assets, capital stock by firm productivity, labor income and labor supply by age at policy change (APC).

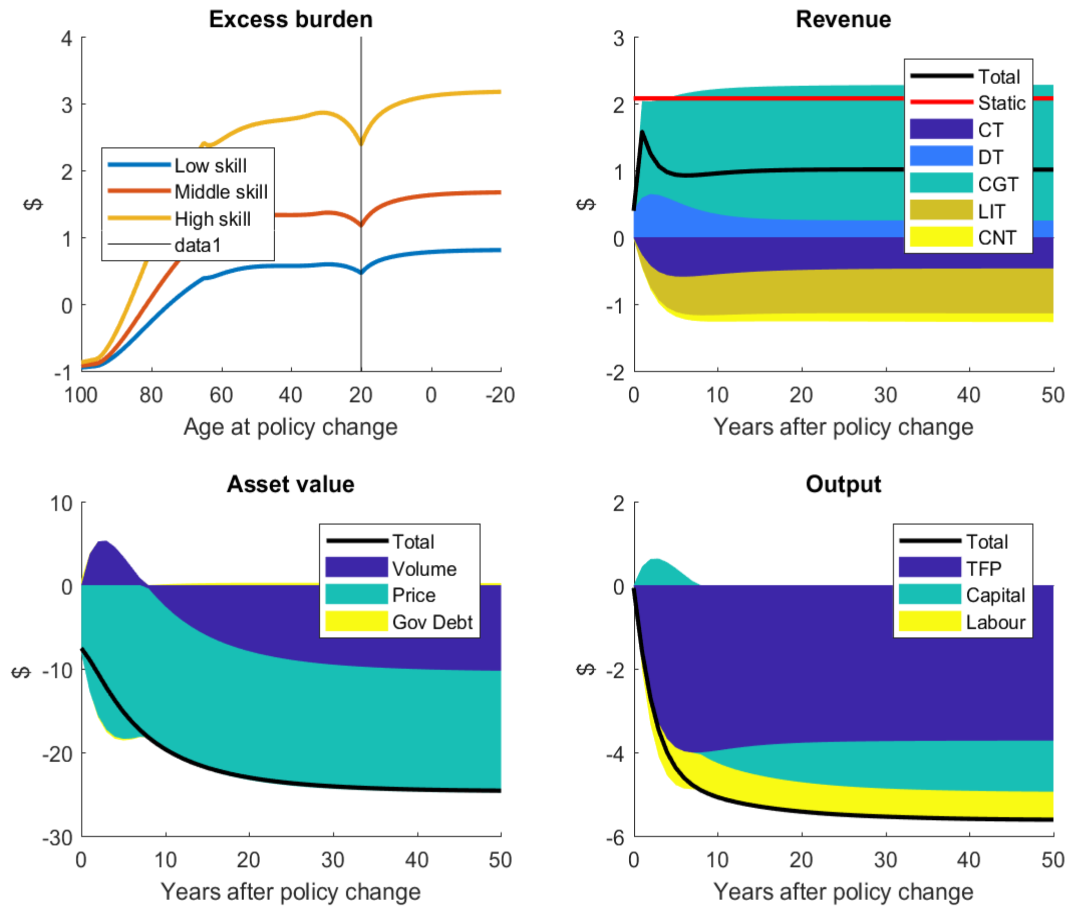

Figure 2: **The impacts of dividend tax (DT) increase.** Note that, the DT rate is permanently adjusted to raise net present value (NPV) revenue increase by the equivalent of $1 per period.

Raising the dividend tax rate above the capital gains rate reduces the incentive to invest for firms in the equity financing regime, as detailed in the discussion on the firm's financial problem in Section 2.2. Firms in the equity financing regime are generally firms that have recently received a positive productivity shocks. These firms are growing their capital stock a rate that does not afford dividend payment. As such, raising the DT rate reduces investment by firms who have had positive productivity shocks and therefore of higher productivity firms in general. This changes the distribution of capital over firms. While the aggregate capital stock declines, as shown in panel 3 of Figure 2, this decline is led by high productivity firms. Panel 2 of Figure 1 shows that high productivity firms have the largest capital stock decrease and the capital stock of low productivity firms, those likely to be in the dividend issuance regime, increases. Firms in the dividend issuance regime are not negatively affected by the divided tax rate but benefit from lower wages and lower interest rates. In fact the lower initial interest causes the aggregate capital stock to increase before falling. Overall the distribution of capital shifts from high productivity firms to low productivity firms.

The change in the distribution of capital affects aggregate total factor productivity (TFP), output and wages.[14] The reduction in capital of high productivity firms reduces output and labor demand from these firms. While output and labor demand by lower productivity firms increases, these firms are by definition lower productivity and therefore do not offset declines by higher productivity firms. The shift in output from high productivity firms to lower productivity firm lowers TFP. This reduction in TFP accounts for around two thirds of the fall in output as seen in Panel 4 of Figure 2. This suggests the distributional impacts on capital account for around two thirds of impacts on wages and similar variables and are therefore also explain a large part of the welfare impacts.

In response to the change in capital stock, output and wages labor hours are flat initially before falling as wages continue to decline. There are offsetting factors causing labor supply to remain unchanged initially. Households anticipate that wages will decline further as the capital transition proceeds which provides an incentive to raise labor supply immediately after the policy change. However, households also have an incentive to delay labor supply as the decline in the rate of return reduces the motivation to save and work. These offsetting factors, along with the positive income effect of higher transfers decreasing labor supply, means labor supply is broadly flat directly after the policy change. In the long run labor hours to decline in aggregate as the substitution effect of lower wages combined with the income effect of higher transfers dominates the negative income effect of lower wages. Similarly, saving and capital supply decline due to the substitution effect of lower rates of return combined with reduced ability to save from lower wages.

The changes in welfare vary significantly by skill type and cohort as shown in Panel 1 of Figure 2. The welfare changes are driven by lower assets prices, interest rates and wages and higher transfers. The increase in the DT rate reduces the value of firms as dividends are worth less. The fall in assets price particularly affects households who are near the retirement age and are of the highest skill type as these households have the highest asset holdings. These households are also particularly affected by lower rates of return seen in Panel 1 of Figure 1. Lower wages mainly affect young and future households as the wage decreases take time to come into effect. Lower skill households are less affected as their labor income loss is offset by increases in transfers to a relatively greater extent.

To raise one dollar of net revenue on average dividend tax raises only around 50 cents in the longer as the DT increase drives an increase in capital gains tax. The CGT increases as raising the DT rate provides an incentive for firm to pay out more returns through capital gains. The increases in DT and CGT are offset by the CIT and LIT decreases as output and wages fall as shown in Panel 2 of Figure 1.[15] If changes in quantities, the distribution of capital and factor prices were not taken into account the tax increase would be projected to raise $2.08. We refer to this projection, that does not take into account changes in quantities and prices, as the

[14]We define aggregate TFP in period t as $\text{TFP}_t = Y_t/(K_t^{\alpha} N_t^{1-\alpha})$.

[15]In Panel 2 of Figure 1 interest tax is included with LIT.

static projection. In terms of tax scoring this implies a one dollar increase in static revenue projection raises only 48 cents in net revenue when accounting for dynamic responses.

Corporate income tax (CIT) Figure 3 displays the dynamic effects of the corporate tax (CIT) increase on four key variables: excess burden, tax revenue, capital stock and output. Figure 8 in Appendix 5.4 presents the impacts on other variables including expected after tax return on assets, capital stock by firm productivity, labor income and labor supply by APC.

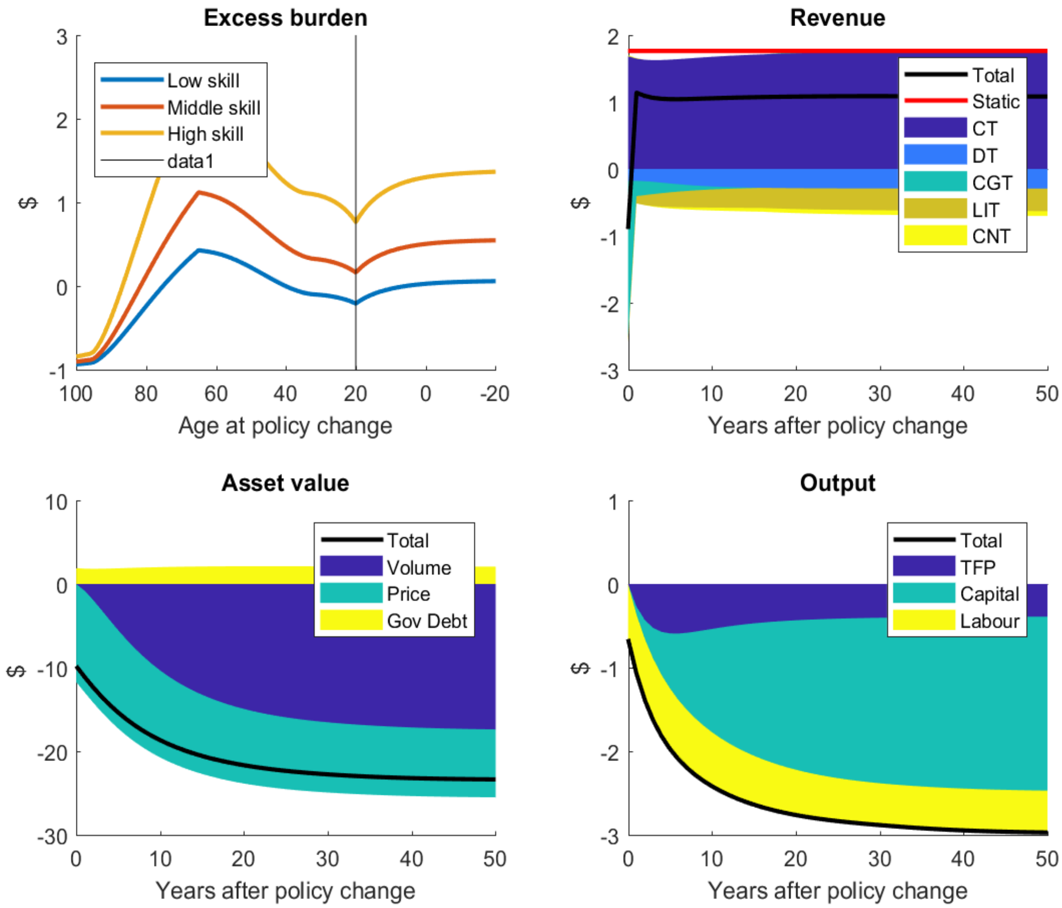

Figure 3: **The impacts of corporate tax (CT) increase.** Note that, the CT rate is permanently adjusted to raise net present value (NPV) revenue increase by the equivalent of $1 per period.

The CIT increase distorts the firm's incentive to invest lowering the capital stock and asset prices. Raising the CIT rate lowers cash flow available for dividends or equity buy-backs which subsequently lowers the value of and the return on equity as seen in Panel 3 and 1 of Figures 3 and 8, respectively. In response firms invest less and as the capital stock decreases the marginal product of capital increases raising the rate of return. The rate of return does not return to pre-policy change values as in this model with life cycle household saving as capital supply is not perfectly elastic to the rate of return.

The capital stock decrease combined with lower labor hours and aggregate TFP results in decreased output. Aggregate TFP falls as the output of high productivity firms falls by more than for low productivity firms. High productivity firms undertake proportionally more investment and the CT increase causes the capital stock of high productivity firms to fall proportionally more as shown in Panel 2 of Figure 8. Therefore, after the policy change lower productivity firms produce proportionally more output and TFP falls. However the TFP decrease accounts for only around one sixth of the output fall unlike the DT increase where the TFP decrease accounts for around two thirds of the output change. Overall the output decrease is larger per dollar of net revenue for the CIT increase than for the DT increase.

As in the DT increase, household's respond to lower wages and rates of return and higher transfers by reducing both labor and capital supply. Panel 3 of Figure 8 shows labor supply decreasing as the substitution effect from lower wages is larger than the accompanying income effect and also as labor supply decreases due to the positive income effect of higher transfers. Households also shift the timing of labor supply backwards across their life in response to lower rates of return. This is matched by decreased saving.

The aggregate welfare loss per dollar of revenue is smaller for the CIT increase than for the DT increase as the productivity fall is smaller. The distribution of the welfare impacts of the CIT increase are similar to the DT increase, as shown in Panel 1 of Figure 3. The falls in equity prices and wages again drive the welfare declines. Household near retirement are negatively affected by equity price decline and young and future households are affected by wage decreases.

The CIT revenue must increase by around $2 in order to raise one dollar of net revenue, as shown in Panel 2 of Figure 3. The CIT increase is to offset by decreases in LIT, DT and an initial fall in CGT tax. Even though output declines over time CIT is relatively flat as the decrease in output is offset by declines in depreciation deductions. The tax increase would be projected to raise $1.76 if a static methodology were used. In terms of tax scoring this implies a one dollar increase in static revenue projection raises only 57 cents in net revenue when accounting for dynamic responses.

Capital gains tax (CGT) Figures 4 and 9 present the effects of the capital gains tax (CGT) increase on key aggregate variables.

A rise in the CGT rate affects firms' investment incentives, so that it shifts the allocation of capital to higher productivity firms and increases aggregate TFP. A higher CGT rate reduces the value of capital gains for households and increases the value of capital losses. This incentivizes firms in the equity financing regime to either reduce equity buy-backs or increase issuance and to increase investment. Firms in the equity financing regime are predominantly firms that have recently received a positive productivity shocks and are therefore generally higher productivity. Higher investment leads to a higher capital stock and therefore over time the output and labor demand of higher productivity firms. As the share of output produced by higher productivity firms increases so does aggregate TFP.

As shown in Panel 3 of Figure 4, the overall capital stock declines and equity prices fall;

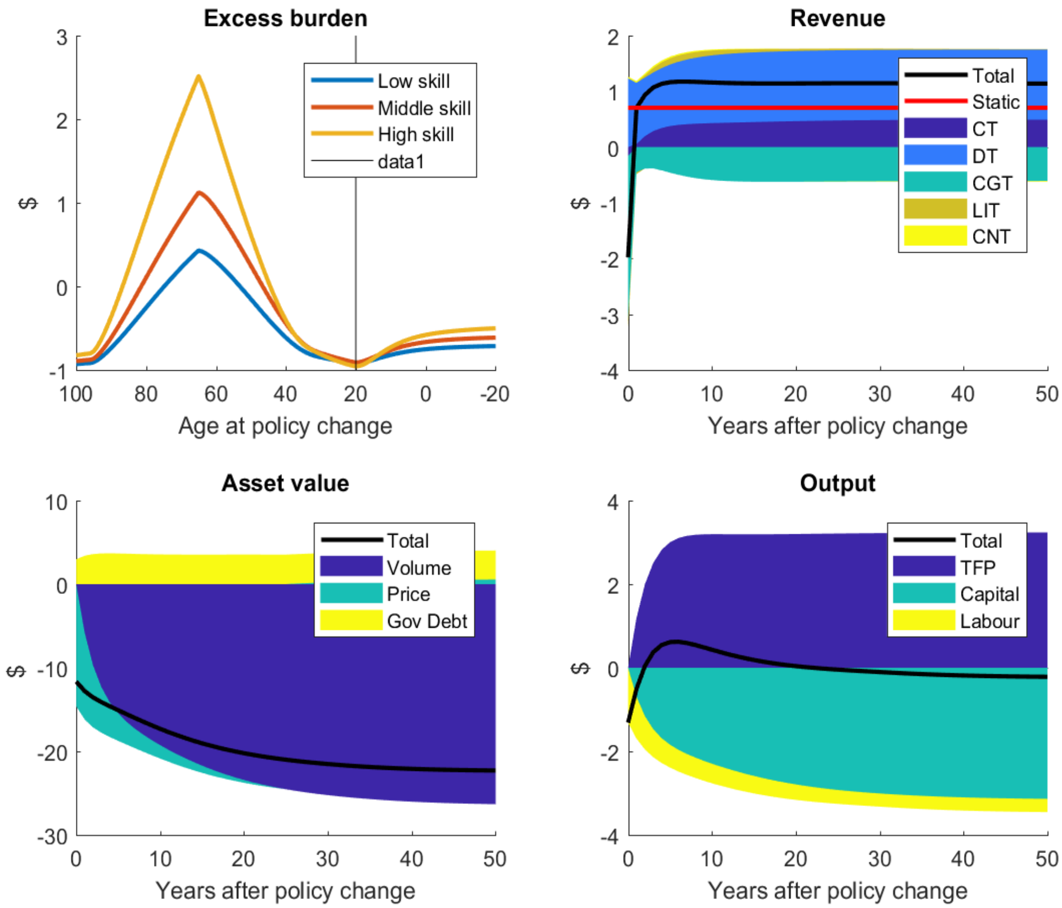

Figure 4: **The impacts of capital gains tax (CGT) increase.** Note that, the CGT rate is permanently adjusted to raise net present value (NPV) revenue increase by the equivalent of $1 per period.

however, more capital is allocated to higher productivity firms. Increasing the CGT rate increases the effective discount households put on future returns. As such, in aggregate firms invest less and pay out a greater share of cash flow as returns and the capital stock decreases. The value of total equity falls but the price of equity per unit of capital increases as aggregate TFP increases.

Total output increases as the fall in the capital stock and small fall in labor hours is more than offset by the increase in TFP. Labor hours decrease marginally as substitution towards labor from the increase in wages is more than offset by the positive income effect of the extra transfers, as shown in Panel 3 Figure 9.

Aggregate welfare increases due to higher wages and transfers despite welfare falling for wealthy households due to the equity price fall, as seen in Panel 1 of figure 4. The increase in transfers benefits all households while the increase in wages benefits households with more time remaining in the labor force.

Raising the CGT rate causes CGT revenue to fall and the revenue from other sources to increase, as seen in Panel 2 of Figure 4. As discussed above, raising the CGT rate causes firm to reduce equity buy-backs and increase issuance reducing capital gains. However revenue overall increases as dividends and output increase. Static analysis would project to policy change to raise 70 cents implying a tax scoring estimate of $1.42.

Dividend tax and capital gains tax (DT&CGT) Figures 5 and 10 present the dynamic effects of an equal increase in both dividend tax and capital gains tax (DT&CGT) rates. We find that it has similar impacts to the corporate tax (CIT) when analyzing the DT&CGT increase. We highlight the differences between this policy and the CIT increase.

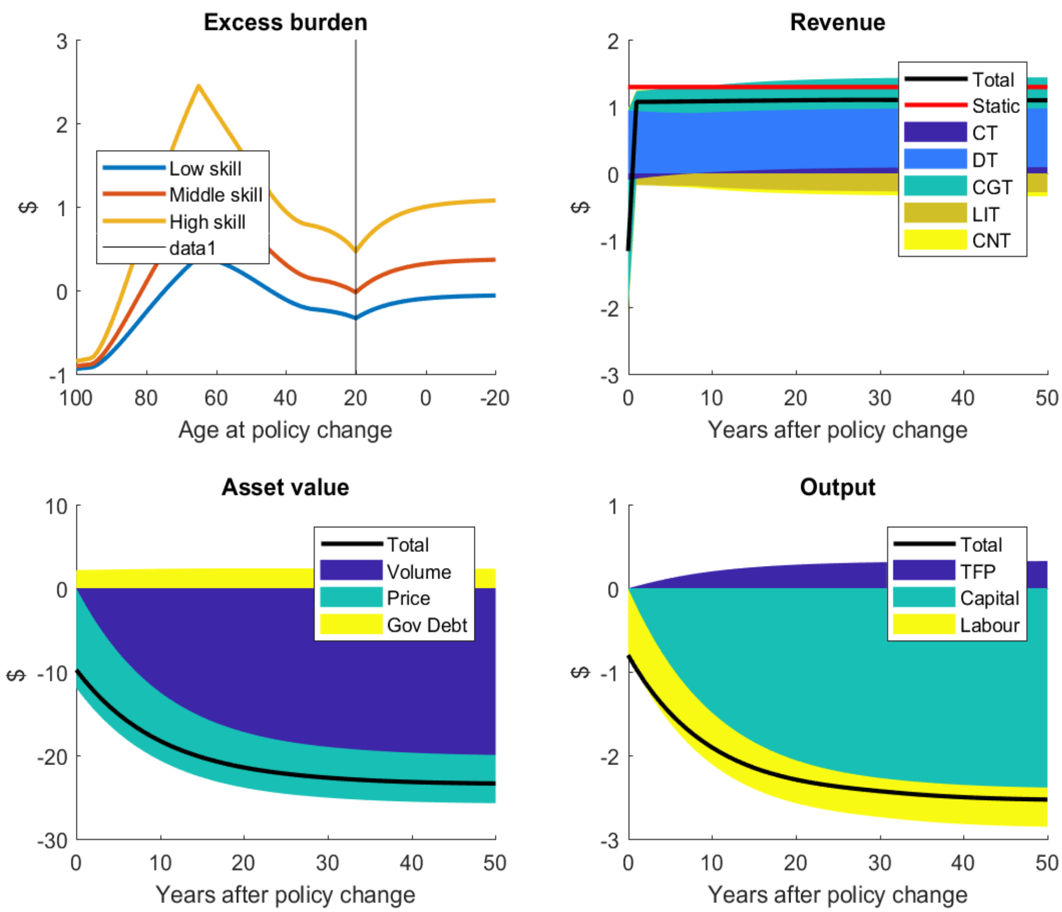

Figure 5: **The impacts of dividend tax and capital gains tax (DT&CGT) increase.** Note that, the DT&CGT rates are permanently adjusted to raise net present value (NPV) revenue increase by the equivalent of $1 per period.

The DT&CGT are charged on dividends plus capital gains. Dividends plus capital gains equals the firms cash flow plus equity price changes. Taxing equity price changes creates an incentive for firms to decrease their value by decreasing their capital stock. Conversely, the CIT is charged revenue minus wages and depreciation which equals cash flow plus net investment. As such the DT&CGT act like cash flow tax plus a tax on equity price changes and the CT acts like a cash flow tax plus a tax on net investment. As with the CIT, an increase in the DT&CGT reduces the capital stock can be seen in panel 3 of Figure 5. As the

CIT operates through the investment channel high productivity firms undertake proportionally more investment. The capital stock of higher productivity firms declines proportionally than for low productivity firms. Conversely, an increase in the DT&CGT reduces the capital stock of low productivity firms by proportionally more than for high productivity firms as can be seen in panel 2 of Figure 10. In the model, low productivity firms hold capital to maintain their value in expectation of future positive productivity shocks. Higher taxes on capital price changes reduce the incentive for these low productivity firms to hold onto capital. As such the capital stock of low productivity firms falls proportionally more.

The changes in the distribution of capital between the DT&CGT and CIT increases largely explain the differences in the impacts. The DT&CGT shifts the distribution of capital to higher productivity firms giving a slight increase in TFP. Conversely, the CIT shifts the distribution of capital to lower productivity firms giving a slight decrease in TFP.

The capital stock decline is larger for the DT&CGT increase than for the CIT increase however the output decrease is smaller as shown in panel 4 of Figure 5. Under the DT&CGT increase the decline in the capital stock is partly offset by the small rise in TFP. The TFP increase also means that wages do not fall by as much. Therefore, labor hours decline by slight less under the as shown in panel 3 of Figure 10

The aggregate welfare loss per dollar of revenue is smaller for the DT&CGT increase than for the CIT increase again explained by the TFP change. The distribution of the welfare impacts of the DT&CGT increase are similar to the CIT increase, as shown in Panel 1 of Figure 5. However the TFP change mainly affect welfare through wages and less so through asset prices. As such the welfare of change retired households is also the same under the DT&CGT and CIT increases; however, the welfare loss for working and future households is larger for the CIT increase than for the DT&CGT increase.

Labor income tax (LIT) For comparison, we compute marginal excess burden for the labor income tax. Figures 6 and 11 present the dynamic effects of the labor income tax (LIT) increase. The MEB of the LIT serve as a reference point for comparing the MEBs of the capital taxes.

The LIT increase results in lower after-tax wages causing households to substitute towards leisure. As such labor hours fall causing the before tax wage to increase initially, as seen in Panel 3 of Figure 11. Initially the increase in wages reduces firms' capital demand however the fall in after tax labor income also reduces households income available for saving and capital supply declines. In the long run the capital supply decline dominates and interest rates increase as shown in Panel 1 of Figure 11.The increase in the long run interest rate lowers labor demand and before tax wages also fall in the long run.

The aggregate MEB is smaller for the LIT than for the CIT or the DT with welfare losses largely reflecting income patterns, as shown in Panel 1 of Figure 6. The smaller aggregate distortion can also be observed in smaller capital stock, labor hours and output changes. The

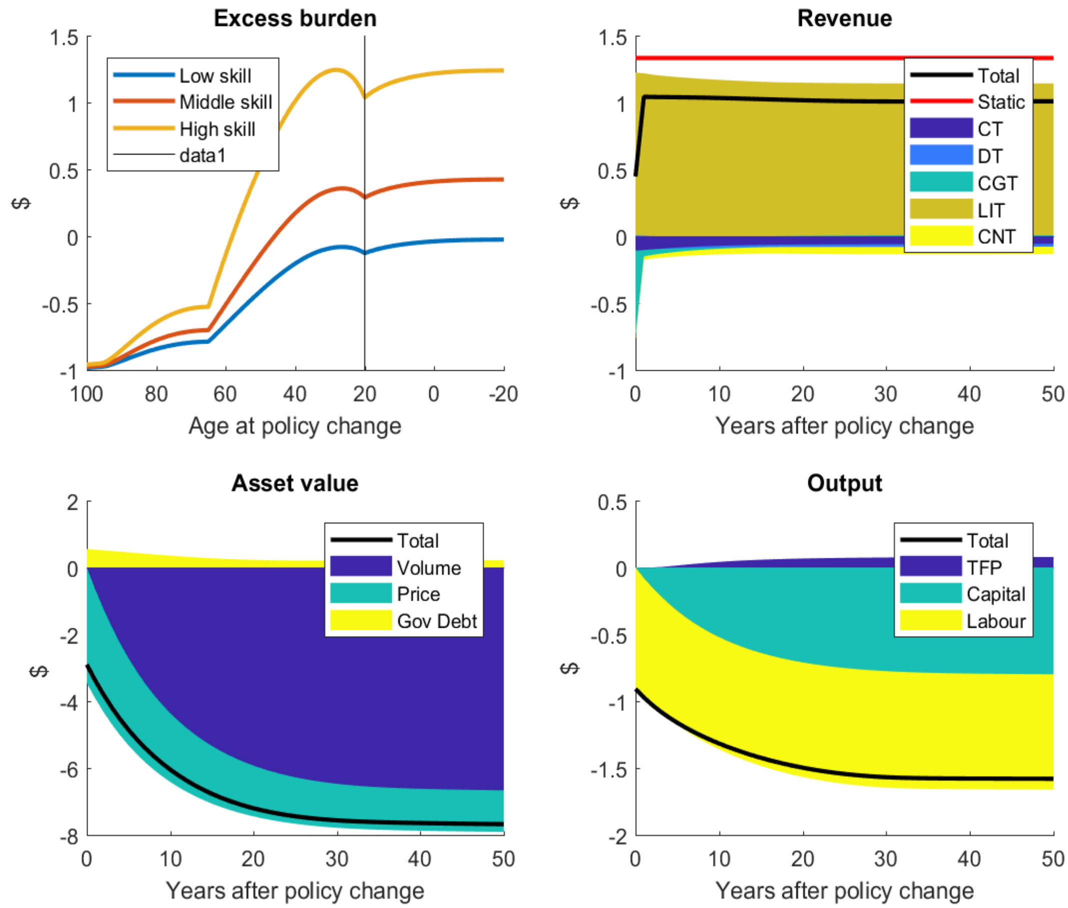

Figure 6: **The impacts of labor income tax (LIT) increase.** Note that, the LIT rate is permanently adjusted to raise net present value (NPV) revenue increase by the equivalent of $1 per period.

welfare losses under LIT increase come through both lower wages and lower equity prices with differences across households reflecting exposure to these two forces.

Unlike for the DT and CIT rate increases, the increase in the LIT revenue is only marginally offset by falls in other revenue streams as shown in Panel 2 of Figure 6.

Additional figures and table

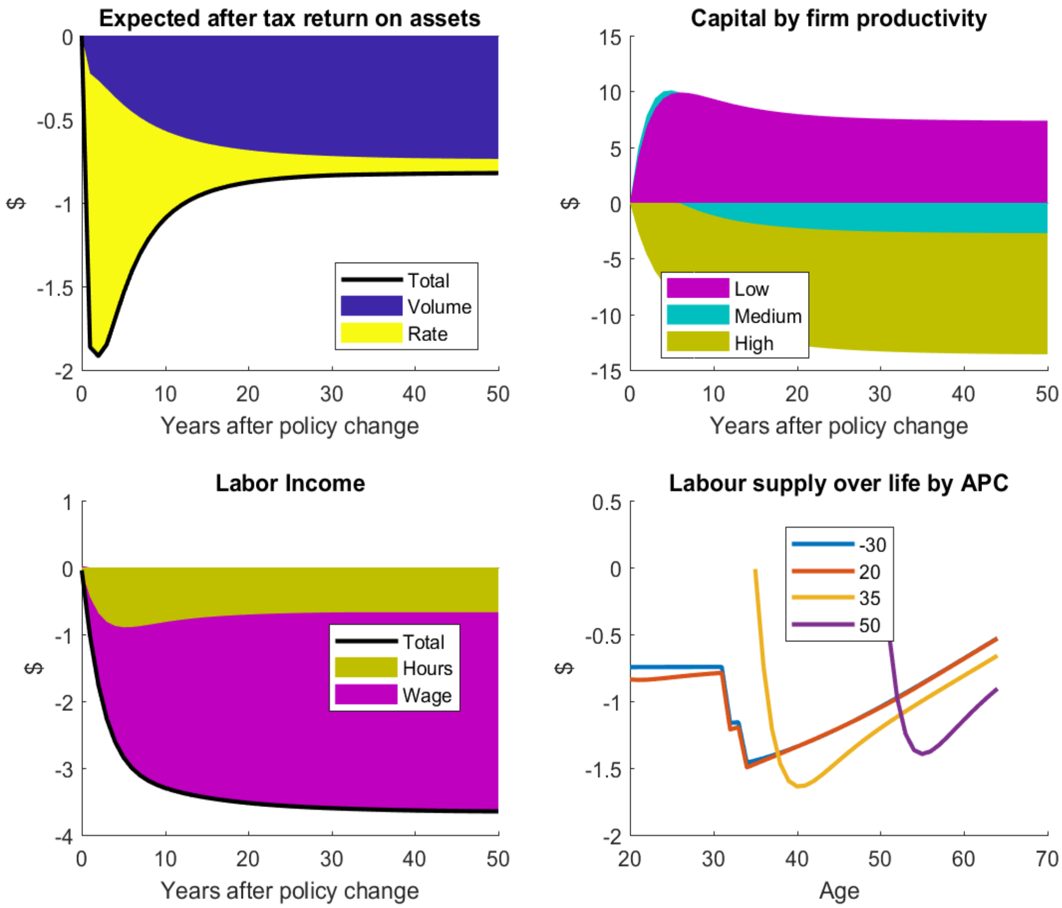

Figure 7: **The impacts of dividend tax (DT) increase.** Note that, the DT rate is permanently adjusted to raise net present value (NPV) revenue increase by the equivalent of $1 per period.

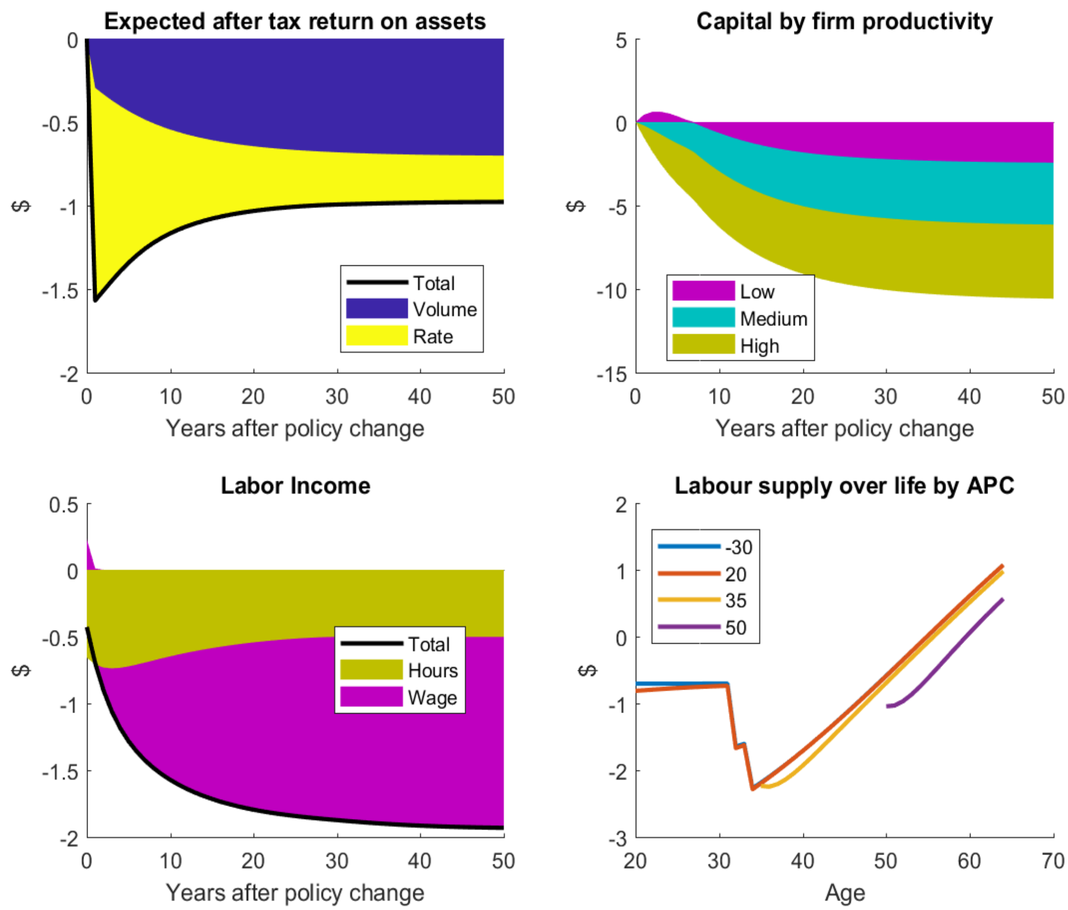

Figure 8: **The impacts of corporate tax (CT) increase.** Note that, the CT rate is permanently adjusted to raise net present value (NPV) revenue increase by the equivalent of $1 per period.

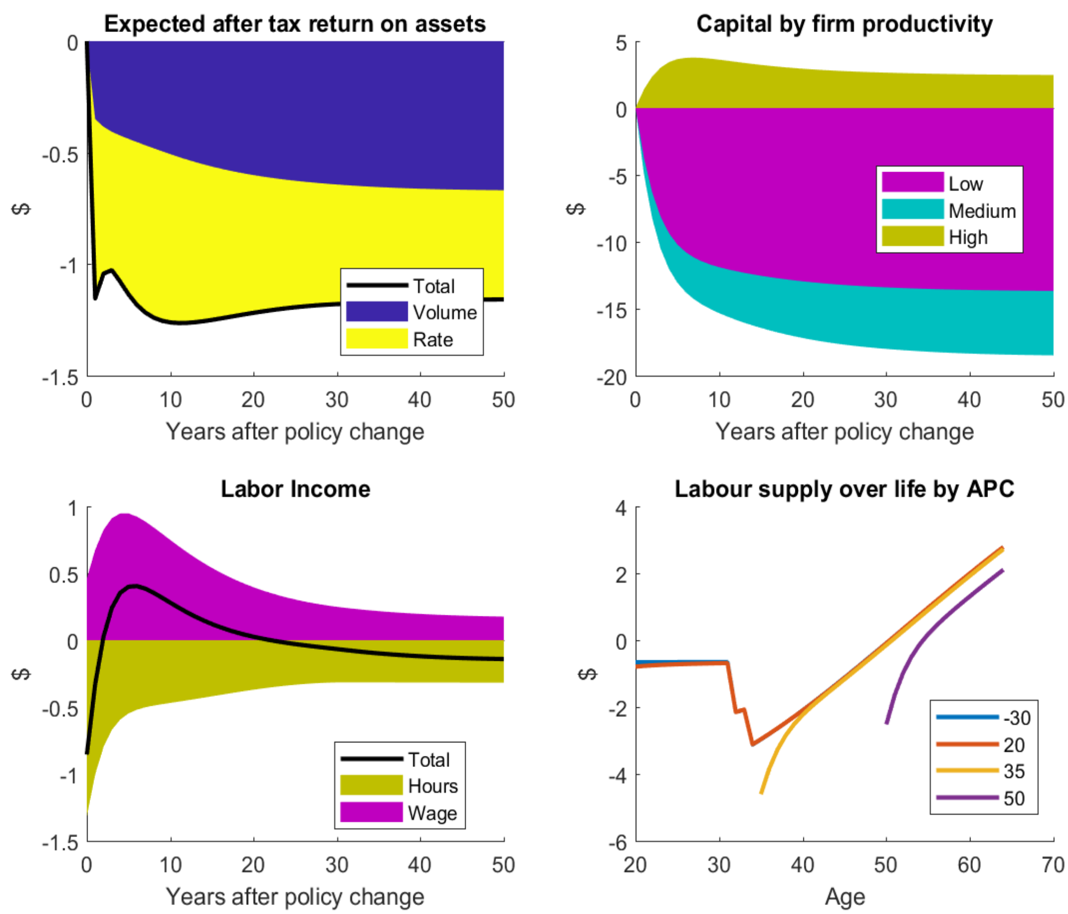

Figure 9: **The impacts of capital gains tax (CGT) increase.** Note that, the CGT rate is permanently adjusted to raise net present value (NPV) revenue increase by the equivalent of $1 per period.

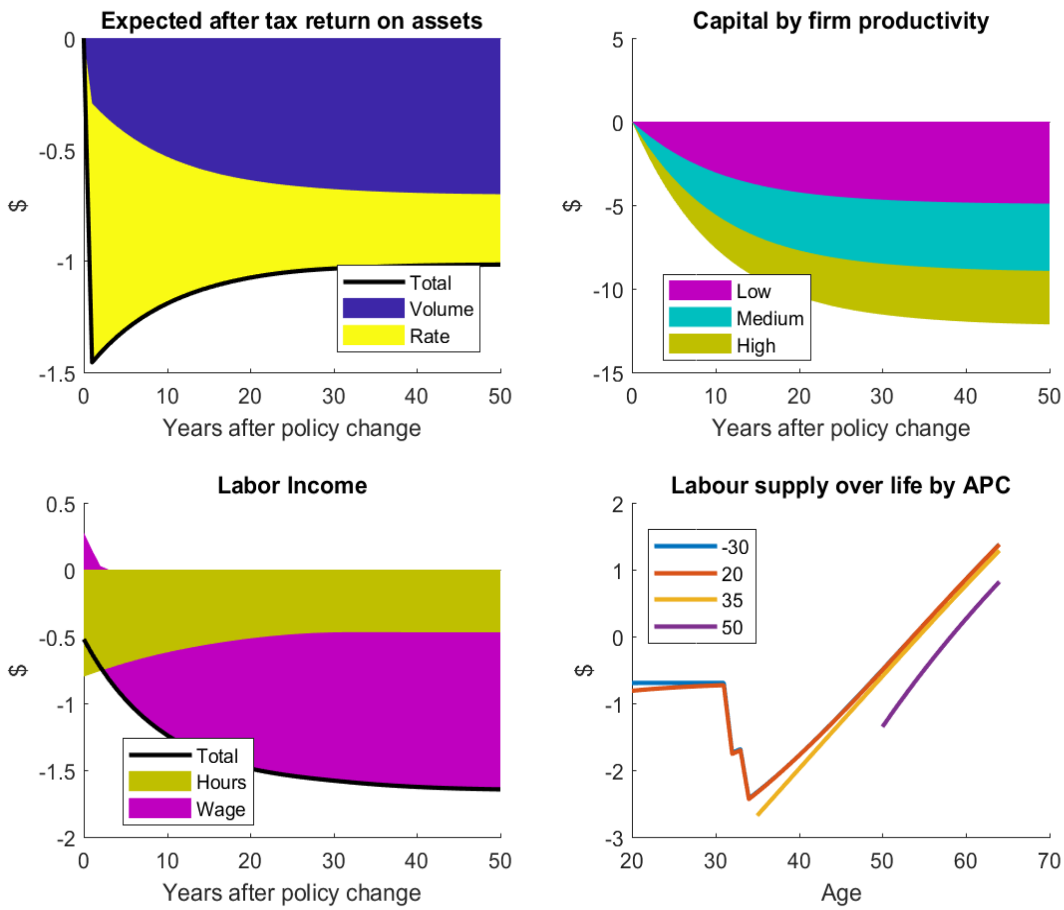

Figure 10: **The impacts of dividend tax and capital gains tax (DT&CGT) increase.** Note that, the DT&CGT rates are permanently adjusted to raise net present value (NPV) revenue increase by the equivalent of $1 per period.

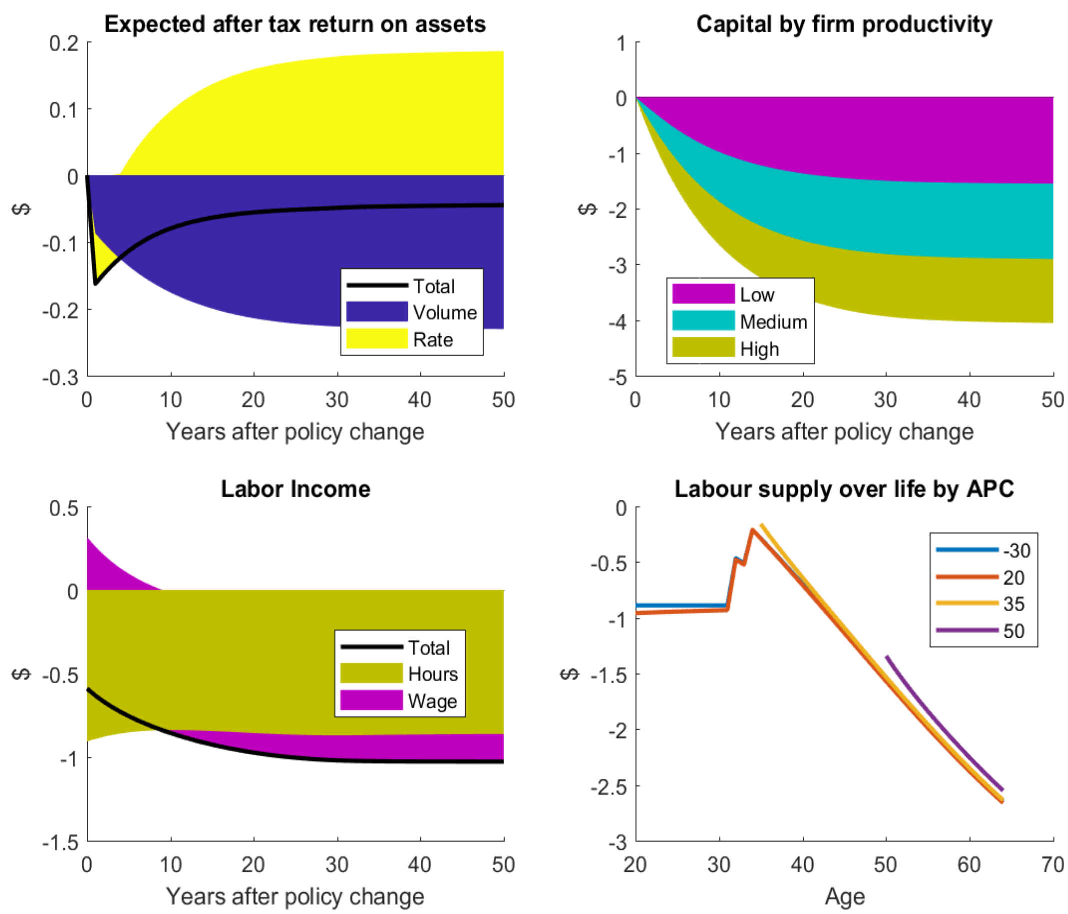

Figure 11: **The impacts of labor income tax (LIT) increase.** Note that, the LIT rate is permanently adjusted to raise net present value (NPV) revenue increase by the equivalent of $1 per period.

5.5 Appendix E: Additional results from the corporate tax reform

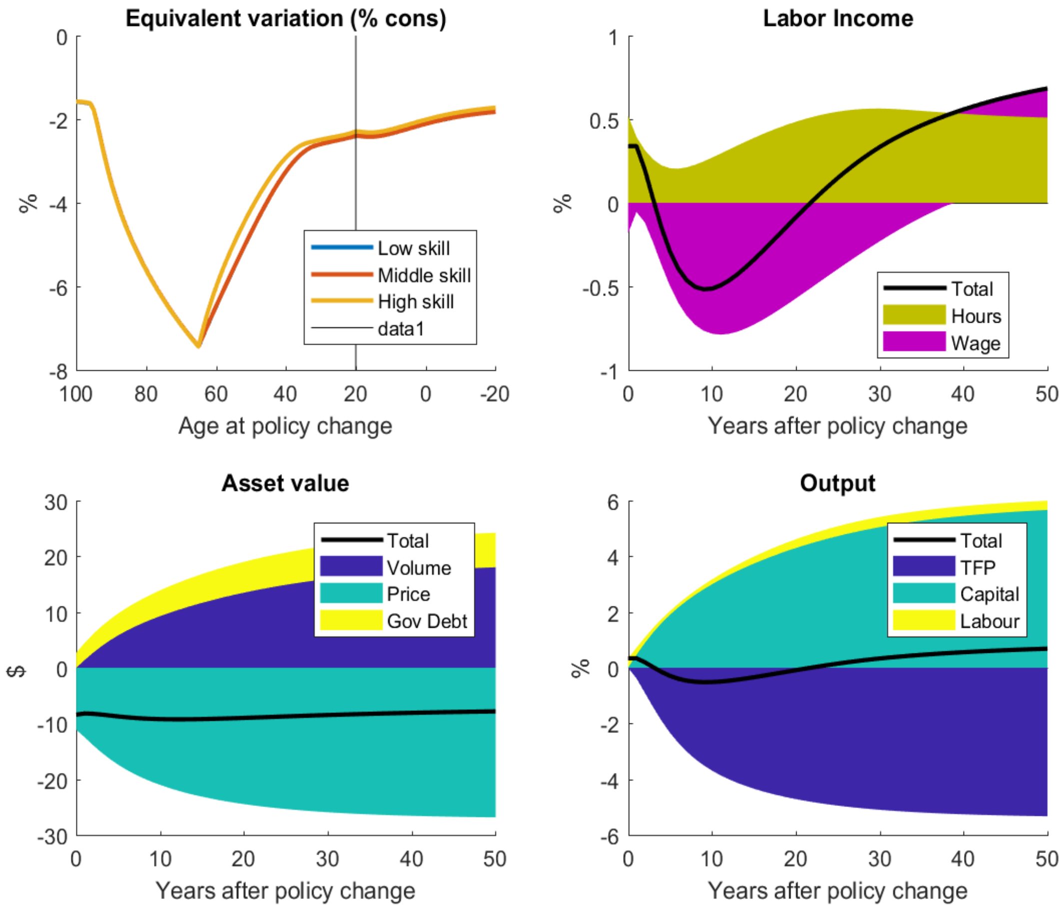

Figure 12: **The impacts of reducing corporate tax (CT) and raising dividend tax (DT).** Note that, the CT rate is permanently reduced to 12 per cent and net present value (NPV) revenue is kept constant in (NPV) by permanently raising DT to 80.3 per cent.

Dividend tax(DT) Table 11 presents the welfare effects of replacing corporate tax with dividend tax where corporate tax is cut to various level and offset by increase dividend tax rate. Firstly, the dividend tax revenue base is not large enough to fully replace the corporate tax. Secondly, this policy change is universally unpopular amongst all living households for all cuts. This unpopularity is largely explained by the total factor productivity decrease that the increase in dividend tax rate causes, as explained in section 3.

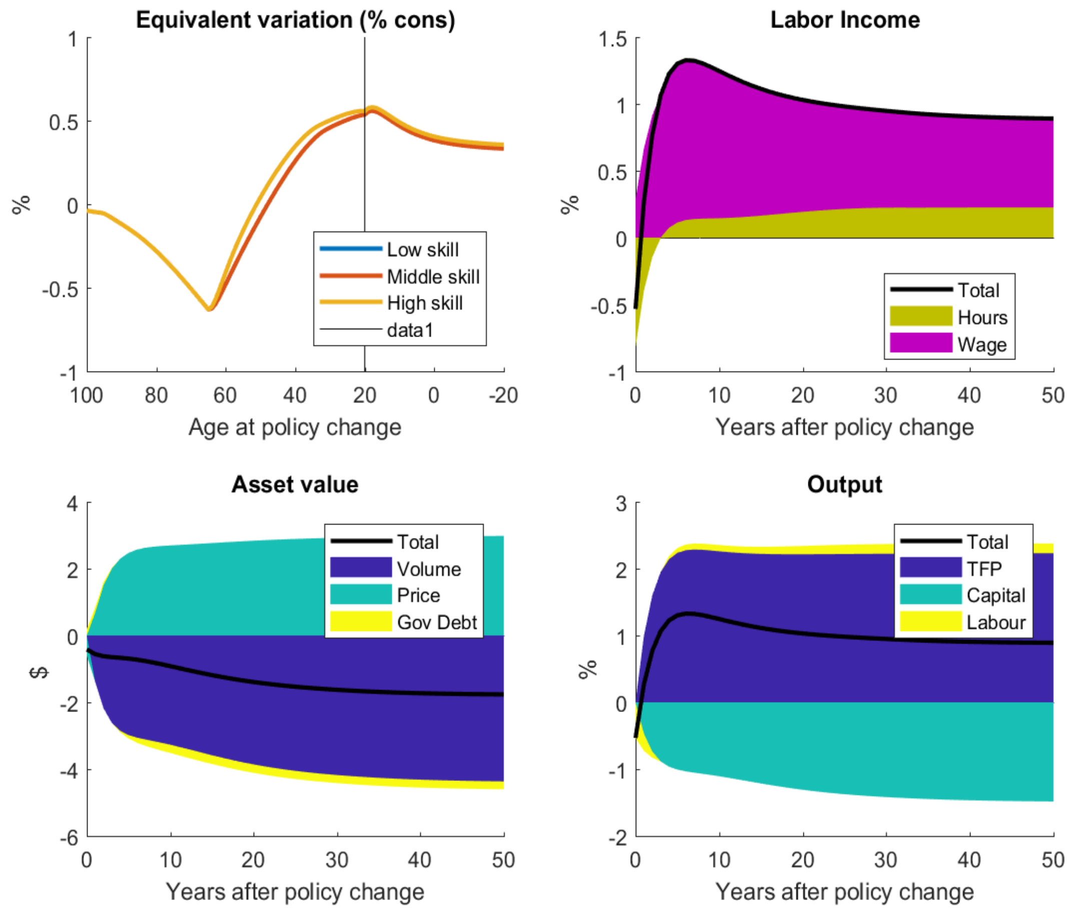

Figure 13: **The impacts of reducing corporate tax (CT) and raising dividend tax and capital gains tax (DT& CGT).** Note that, the CT rate is permanently reduced to 0 per cent and net present value (NPV) revenue is kept constant in (NPV) by permanently raising DT&CGT to 53.2 per cent.

Corporate tax rate (%)	-0	-8	16	24	32
Output change (%)	-	-	-	-1	-0.6
Welfare change (%)	-	-	-	-3.66	-0.56
Retired welfare Δ (%)	-	-	-	-6.37	-0.35
Working welfare Δ (%)	-	-	-	-4.43	-0.51
Future welfare Δ (%)	-	-	-	-2.14	-0.65
Low skill Δ (%)	-	-	-	-3.76	-0.56
Medium skill Δ (%)	-	-	-	-3.76	-0.56
High Skill Δ (%)	-	-	-	-3.53	-0.55
Population support (%)	-	-	-	0	0
τ^d (%)	-	-	-	96.7	30.1

Table 11: The welfare effects of the corporate tax cuts financed by dividend tax.

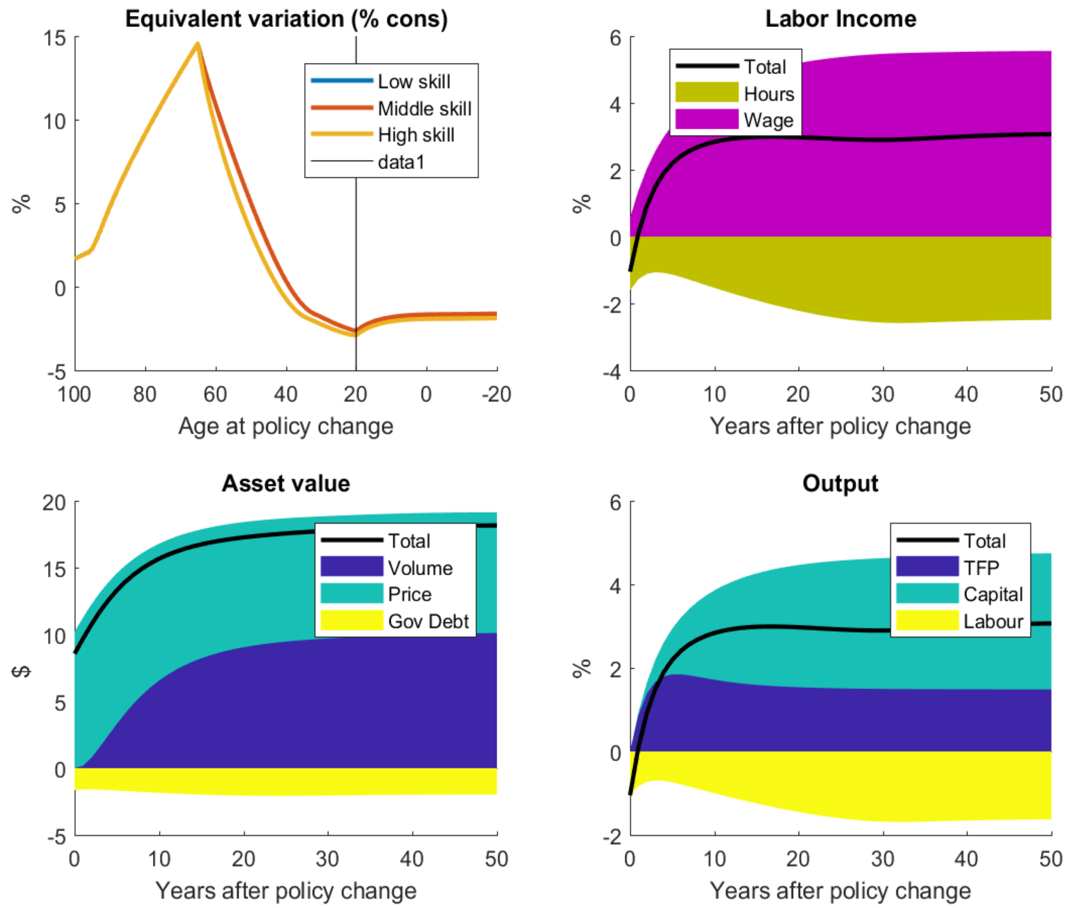

Figure 14: **The impacts of reducing corporate tax (CT) and raising labor income tax (LIT).** Note that, the CT rate is permanently reduced to 0 per cent and net present value (NPV) revenue is kept constant in (NPV) by permanently raising LIT to 33.8 per cent.