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The firm-level and aggregate effects of corporate payout policy☆

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HIGHLIGHTS

- Firms optimally choose between dividends and buybacks in our DGE model.
- Share buybacks and dividends respond flexibly to policy and non-policy shocks.
- Tax reform effects differ by payout flexibility and shock type.
- Fixed payout assumptions misrepresent macroeconomic adjustment.

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ABSTRACT

This paper presents a novel study on the significance of corporate payout policy in shaping firms' financial decision-making and, in turn, the macroeconomy. To this end, we add to the literature by allowing households and firms to choose share buybacks optimally. We then explore the implications of various shocks commonly affecting them, such as dividend income, investment, and tax shocks. The latter include corporate income, capital gains, and dividend income taxes. We find that the model predictions cohere well with the data when applying the non-policy shocks. We also find that tax reform's aggregate and welfare effects are overstated when share buybacks are not optimally chosen as assumed in the relevant literature.

1. Introduction

Corporate payout policy, comprising dividend payments and share buybacks, continues to be a focus in both the financial press and the academic literature. This is not only due to the information it conveys to the market relating to investment/growth opportunities and cash-flow volatility but also because of the substantial increase in corporate payouts over the past decade (see Miller and Rock, 1985; Chetty and Saez, 2010; Michaely et al., 2021; Michaely and Moin, 2022).

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After the observed drop in dividend payments in the early 2000s, corporate payouts have been rising, with share buybacks reaching historic highs in the early 2020s (see Almeida et al., 2016; Gutiérrez and Philippon, 2017; Fama and French, 2001; Kahle and Stulz, 2021; Chang et al., 2023). Moreover, further studies have shown that the decisions of corporate managers play a crucial role in adjusting share buybacks, as they are often reluctant to cut dividends and prefer to maintain dividend payments smoothly over time (see Brav et al., 2005; Jagannathan et al., 2000).

Given the significant rise in corporate payouts over the past decade, it is essential to probe into how payout policy influences corporate investment and, consequently, the aggregate economy. This research aims to provide comprehensive answers to the following questions. How do firms adapt their payout policy in the face of exogenous non-policy shocks, and what are the macroeconomic consequences? How do these answers change when firms' payout policy is limited to only dividends or share repurchases?[1] How do firms adjust their payout policy in the face of exogenous policy reforms, and what are their macroeconomic outcomes, including their impact on aggregate welfare?

We focus on dividend earnings, investment efficiency, and tax policy shocks (see Ramey (2016) for an exhaustive review of the main shocks considered in the macroeconomic literature). Although our primary interest is in the effects of policy shocks, particularly tax reforms, we also examine the implications of non-policy shocks to check how the model performs vis-à -vis the data. Ramey points out that the most important non-policy shocks relate to technology, like the investment-related one we consider here. Another non-policy shock we examine refers to shareholders' dividend income, which can arise for a variety of reasons outside the control of firms.[2] On the other hand, policy shocks relating to tax-spending decisions have always been at the heart of academic and policy debates (see, e.g. Gourio and Miao, 2010, 2011; Chang et al., 2023; Chodorow-Reich et al., 2024).

To address these questions, we develop a deterministic dynamic general equilibrium model that introduces a separate market for pre-existing equity shares (see, e.g. Gourio and Miao, 2010, 2011; Karabarbounis and Neiman, 2012, 2014; Chen et al., 2017; Chang et al., 2023). This market allows for the simultaneous optimal choice of dividend repayments and share buybacks and thus offers a less restrictive relationship between dividends and profits than in the studies cited above, which either assume different mixes of dividends and buybacks or postulate that dividends are a constant fraction of firms' profits. Critically, our firm-level data analysis undertaken below provides empirical support for this extension. In particular, it reveals that while dividends can be positively or not related to profits, as in the existing literature, they can also be negatively related depending on the shocks affecting the economy and the time horizon considered.

Considering non-policy shocks, we find that when shareholders' dividend income exogenously falls, firms find it optimal to adjust their dividend payments to counteract the shock and cut share repurchases significantly to finance their investments. Moreover, under a positive shock to investment efficiency, firms redistribute their resources from both payout channels to investment to exploit the increased returns on investment. Finally, our model shows that optimally chosen dividends and share repurchases can exhibit a negative correlation, aligning with the empirical results below.

Moving now to our main interest, we also contribute to the aforementioned research on the effects of tax reforms provided by Gourio and Miao (2010, 2011), who study dividends and capital gains tax reforms, and Chang et al. (2023), who consider corporate tax reform only. Here, we experiment with tax cuts on corporate profits, capital gains, and dividend income, all of which are currently under debate in the context of the current election cycle in the U.S. Also, by examining the role of firms' optimal mix of payout policies, we more generally contribute to the literature related to assessing the effects of corporate tax reforms (see, e.g., Chodorow-Reich et al., 2024; Auerbach and Gale, 2022; Gale, 2019; Barro and Furman, 2018; Gale et al., 2018).[3]

Based on a 20 % permanent drop in respective tax rates, our results imply that corporate tax cuts have the most potent effect on the aggregate economy, followed by capital gains and then dividend tax cuts. For instance, focusing on the steady-state only, GDP increases by about 1.2 %, 0.7 % and 0 % for corporate, capital gains and dividend tax cuts, respectively. But there are trade-offs. Firstly, tax cuts are not a free lunch since they must be financed via changes in public spending, debt or some combination of the two. In particular, we find that the fiscal costs of corporate tax cuts are the highest, followed by dividend and capital gains cuts. For example, the required changes in public spending and debt to finance these reforms include roughly (i) a 2 % fall in public spending and a 1.2 % rise in public debt for the corporate tax, (ii) a 0.5 % rise in public spending and a 0.7 % rise in public debt for the capital gains tax, and (iii) a 0.8 % fall in public spending and 0 % rise in public debt for the dividend tax.

A second trade-off involves allocating GDP gains from tax cuts between consumption and investment. Corporate tax cuts score much better in terms of investment, capital, employment, and GDP but worse than cuts in capital gains taxes in terms of consumption. On the other hand, a dividend tax reform generally has negligible effects on all of these aggregates since firms have to meet the increased appetite of their shareholders for dividends, which comes at the cost of funds used for investment. Given that consumption is a significant driver of welfare, this trade-off explains our finding that capital gains tax cuts yield greater welfare than cuts in corporate taxes. For example, we find that when lifetime utility depends on consumption only, the compensating consumption supplement is about (i) 0.22 % for the capital gains tax, (ii) 0.07 % for the corporate tax, and (iii) 0.03 % for the dividend tax.

[1] Note that in 2022, of the firms using some form of payout policy, 38 % used both dividends and share buybacks, 13 % used dividends only, and 48 % used share buybacks only. Fig. 9 below details how these shares evolved from 1990 to 2022.

[2] For example, changes in the composition of firms in the market (see Fama and French, 2001), the arrival of new information (see Harakeh et al., 2019), and changes in the firm's ownership structure (see, e.g. Ngo et al., 2020).

[3] Chodorow-Reich et al. (2024) extend the canonical neoclassical model of the firm in various directions, but they do not consider the payout mix. They also provide an extensive literature review on the implications of changes in corporate taxes.

Finally, when we compare our results to those of the above literature by restricting dividends to be proportional to profits, we find that all tax reductions overstate the beneficial effects on the real economy and welfare relative to our model. In particular, in the restricted model, GDP increases by about 1.9 %, 1.1 % and 0.36 % for corporate, capital gains and dividend tax cuts, respectively. Additionally, the compensating consumption supplement is about (i) 0.3 % for the capital gains tax, (ii) 0.6 % for the corporate tax, and (iii) 0.1 % for the dividend tax. Our interpretation is that this happens because the assumption that dividends are a constant fraction of profits in each period works like an automatic stabiliser, which releases funds for investment.

We organise the rest of the paper as follows. Section 2 provides the data analysis. Section 3 sets out the model, Section 4 covers the calibration, Sections 5 and 6 discuss the non-policy and policy shocks, respectively, and Section 7 concludes.

2. Firm-level data analysis

Corporate payout policy, comprised of dividends and share buybacks, relates to and interacts with most of a firm's financial and investment decisions. The commonly accepted narrative related to dividends is that they respond slowly to earnings changes. In particular, managers are generally only willing to increase them when they expect a permanent increase to be sustained via future earnings. Additionally, they typically attempt to avoid any reduction in dividends and appear willing to incur significant costs to prevent disclosing a potential negative signal to the market (e.g., Brav et al., 2005; Aivazian et al., 2006; Leary and Michaely, 2011; Farre-Mensa et al., 2024). Nevertheless, since payout policy also involves repurchases, firms must consider both channels simultaneously. For example, Leary and Michaely (2011) found that firms that engage in share repurchasing tend to smooth dividends more than firms that do not repurchase at all. They also show that share repurchases are more volatile than dividends.

The results of these studies suggest that payout policy, earnings/profits and investments are interconnected and should not be considered in isolation. However, as pointed out in the introduction, the literature tends to either set dividends equal to a share of earnings/profits (see Chang et al., 2023) or isolate the decision-making between share repurchases and dividends by exogenously fixing one of the two payout policy channels (see Gourio and Miao, 2010, 2011; Karabarbounis and Neiman, 2012, 2014; Chen et al., 2017). To empirically assess the implications of these assumptions and the simultaneous co-movement of payout policy, profits and corporate investment, we next estimate a Panel Vector Autoregressive (PVAR) model.

2.1. Panel VAR model

Given the above discussion, our PVAR model will consider four variables: share repurchases, dividend payments, profits and investment, each as a share of total assets to control for scaling effects, as in Fama and French (2002).[4] We collect annual firm-level data for all publicly listed firms at the major U.S. stock exchanges, NYSE, AMEX, and NASDAQ, for the period 1990–2022, yielding a sample of 66,748 firm-year observations. See Appendix A for more details on the firm-level data sources, collection, and the cleaning process.

We use Stata to estimate the PVAR model with an unbalanced panel. In particular, this model fits a multivariate panel regression of each dependent variable on lags of itself and on lags of all other dependent variables using generalised method of moments (GMM).[5] Our PVAR model is estimated using two lags following Hansen's J-statistic, which rejected the null for the first lag, indicating that the overidentifying restrictions are valid. Moreover, we find that the second lag is preferable to the third based on the MMSC-Bayesian (MBIC), MMSC-Akaike (MAIC), and MMSC-Hannan and Quinn (MQIC) information criteria. We further find that the PVAR is stable as all its eigenvalues lie within the unit circle. Finally, Granger causality tests indicate that all included variables cause each other in the PVAR. The only exception is that profits do not appear to affect share repurchases significantly.[6]

2.1.1. Impulse responses

Next, we consider the generalised impulse responses from the PVAR model for a temporary one-unit increase to each of the four variables considered with 1000 Monte Carlo simulations. In Figs. 1–4, the first two rows contain the impulse responses (IRs) for investment, buybacks, dividends and profits, all as a share of assets with 95 % confidence intervals. In the final row, to better understand the relationship between dividends and profits, we plot their corresponding IR functions in the same graph with two scales and then their correlation at each point in time in the final subplot.

Starting with the positive temporary investment shock, in Fig. 1, we observe that both payout channels, i.e., buybacks and dividends, will fall before returning to zero as the investment shock dissipates, indicating the transfer of resources from payout to investment. Profits, in turn, increase due to the higher investment in the early periods and fall back to zero after 20 years. The higher level of investment and the decrease in dividends suggest a trade-off between investment and dividends, as Brav et al. (2005) pointed out. Finally, in the last row of Fig. 1, both figures show that profits and dividends are negatively correlated for the entire shock horizon under a temporary investment shock.

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[4] Scaling of the financial variables helps control for the variability in the size of the firms included in the panel estimations.

[5] Specifically, we use the "pvar" package in Stata following Abrigo and Love (2016). Note that Koop et al. (1996) state "Generalized Impulse Response Functions (GIRFs) in Panel VAR (PVAR) models should begin from zero at period $t = 0$, unless there is implemented a specific transformation or normalization that shifts the baseline. GIRFs account for historical correlations between variables. The expected value of the response at $t = 0$ should remain at zero because the system has not evolved yet. Therefore, the impact of a shock is interpreted differently compared to Orthogonalized IRFs (OIRFs) that are derived from Cholesky decomposition, where the shock is applied immediately at $t = 0$. If GIRFs do not start at zero it suggests a misalignment in shock timing, or a scaling issue in the computation, or a normalization error in the model estimation."

[6] We report details relating to these diagnostic tests in Appendix B.

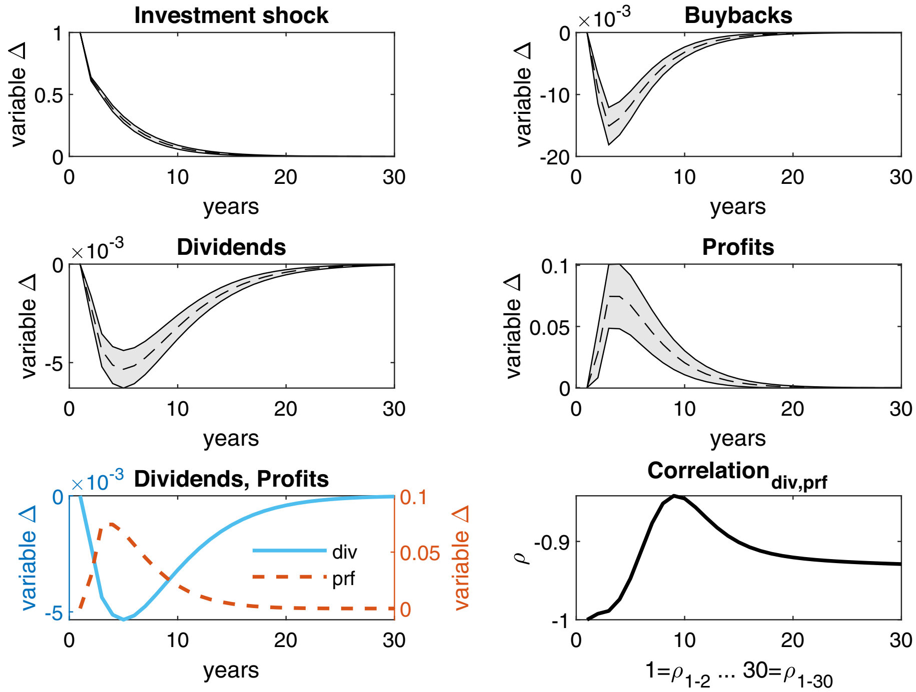

Fig. 1. One-period unit increase in investment.

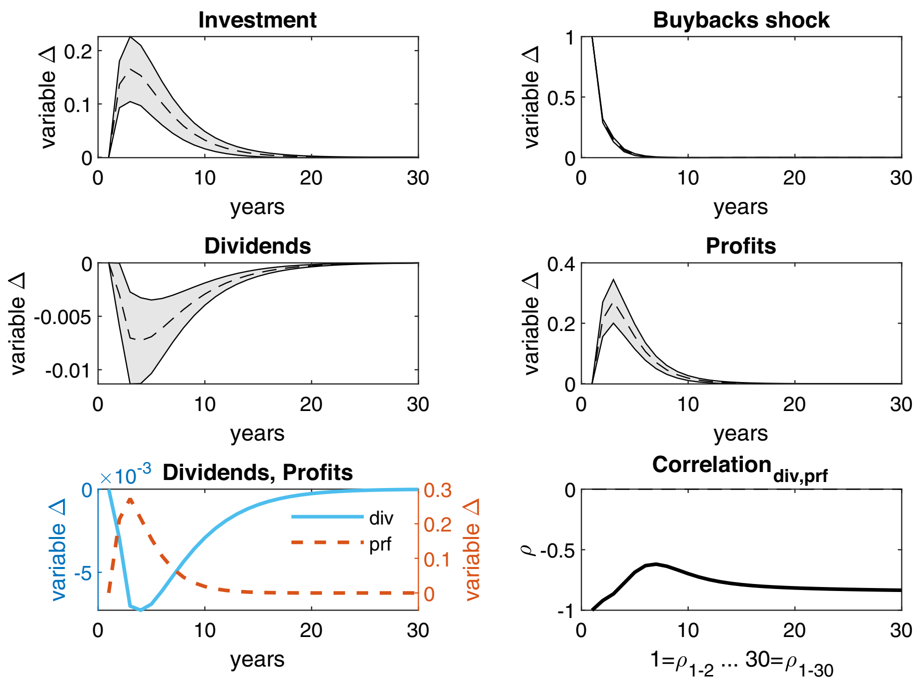

Fig. 2. One-period unit increase in buybacks.

Fig. 2 shows an initial substitution from dividends under the positive temporary shock to share repurchases. We can see that this shift releases resources to undertake more investments, which will increase profits.

We again find that for this shock, dividends and profits correlate negatively throughout the shock. Finally, the results in this Figure further suggest that share repurchases can be used as a substitute for dividend payments to maintain a smoother reaction to dividends, as Farre-Mensa et al. (2024) pointed out.

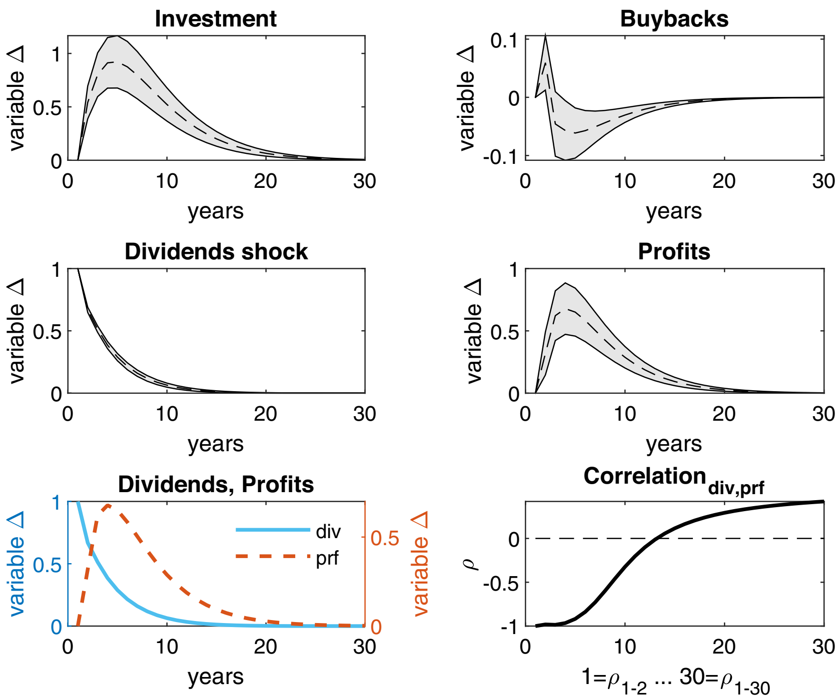

Fig. 3. One-period unit increase in dividends.

Similarly, under a temporary positive shock to dividends, in Fig. 3, we observe that share repurchases drop after an initial positive reaction. The increase in dividends is followed by a rise in investment and profits, indicating the positive signalling effect due to higher dividends (see, e.g. Leary and Michaely, 2011). Finally, we observe a strong negative correlation between profits and dividends in the short-run, which turns positive after 15 years.

Under a positive temporary profits shock, Fig. 4 shows that firms will increase investment, keep share repurchases unchanged, and cut dividends. The increase in profits leads to a lower incentive by firms to provide a signal to the market via higher dividends. As profits and investment decline, dividends increase but at a slower rate compared to profits, revealing their smoothing pattern and a declining positive correlation between these two variables after the initial periods of the shock. The fact that the shock to profits does not significantly affect share repurchases is also consistent with the Granger causality results discussed above.

Overall, the impulse response exercises reveal that the correlation between profits and dividends is shock-dependent and, thus, not fixed over time. Therefore, imposing a predetermined relationship between dividends and earnings in the model setup does not cohere well with the data. Moreover, the impulse responses from the PVAR show that both channels of payout policy may adjust when the firm faces a shock, suggesting that firms use both payout channels actively. Considering the above, our DGE model will incorporate these empirical facts by allowing firms to optimally choose share repurchases and dividends, thus allowing an unconstrained relationship between the latter and profits.

3. Model

The model consists of households, firms and the government. Households choose sequences of consumption, labour supply and new purchases of sovereign bonds and equity shares. They can also choose to sell back to firms a fraction of equity shares purchased in the past. Firms finance investment through retained earnings and changes in the value of equity. They can also buy back a fraction of equity shares issued in the past. In other words, as stated above, a distinct feature of our model is that we have a separate market for repurchased equity shares, which functions like any other market, implying that we have a supply side, a demand side and a related market clearing price.[7] The government finances its spending by imposing taxes on income from work, dividends, capital gains from shareholdings, and corporate profits. Labour income, dividend income and capital gain taxes are levied on households, while corporate profit taxes are collected from firms. Any difference between spending and tax revenues is covered by sovereign bond issuance.

[7] Our setup differs from, e.g. Gourio and Miao (2011), Karabarbounis and Neiman (2012), Chang et al. (2023), who assume that buybacks reduce the number of shares, which, in turn, leads to an increase in their price in the primary market. In other words, in the above papers, households benefit from buybacks by enjoying higher-valued shares, which come without cost. Also, in this setup, households do not choose the fraction of outstanding shares they want to sell, so there is no supply side for outstanding shares or an associated market-clearing price.

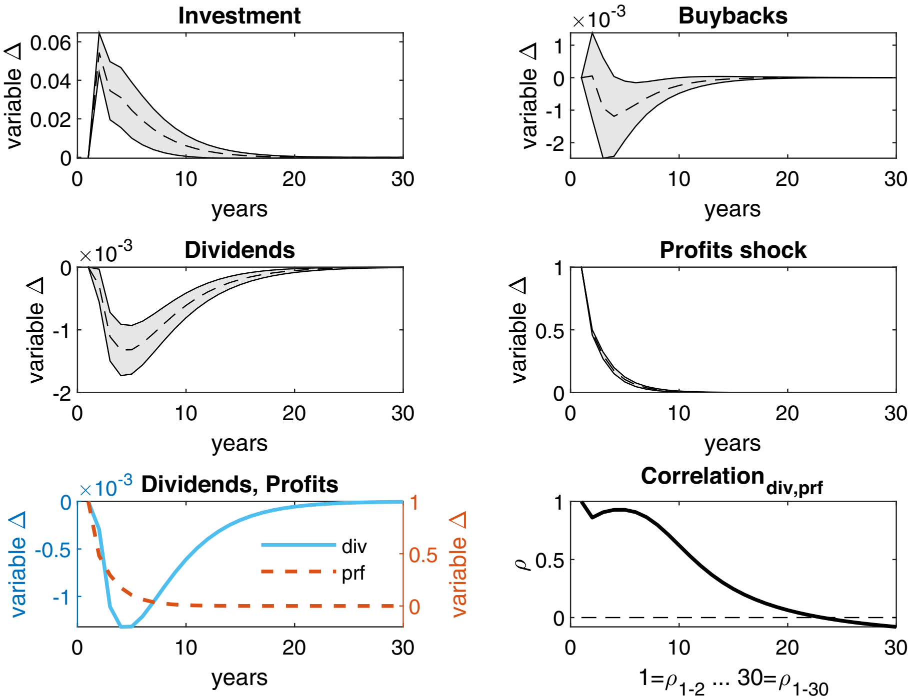

Fig. 4. One-period unit increase in profits.

3.1. Households

There are N identical households. Each household maximises:

$$\sum_{t=0}^{\infty} \beta^t u\left(c_t, l_t\right), \tag{1}$$

where c_t is private consumption, l_t is work hours and $0 < \beta < 1$ is the time discount factor. The period utility function (see also, e.g. Ríos-Rull et al., 2012; Ramey, 2020) is given by:

$$u\left(c_t, l_t\right) = \log c_t - \mu \frac{\left(l_t\right)^{1+\frac{1}{\nu}}}{1+\frac{1}{\nu}}, \tag{2}$$

where $\mu \geq 0$ is a preference parameter, and $\nu > 0$ is the Frisch elasticity of labour supply.

The budget constraint of each household is:

$$c_t + b_t + p_t^s s_t + \Phi_t^e \equiv \left(1-\tau_t^y\right) w_t l_t + \left[1 + \left(1-\tau_t^y\right) r_{t-1}^b\right] b_{t-1} + g_t + \left[\left(1-\tau_t^d\right)\left(1-e_t\right) d_t + \left(1-e_t\right) p_t^s + e_t p_t^e - \tau_t^k \left\{\left(1-e_t\right) p_t^s + e_t p_t^e - p_{t-1}^s\right\}\right] s_{t-1}. \tag{3}$$

In particular, the household enters period t with a given number of shares carried over from the previous period, s_{t-1}.It keeps a fraction $0 \leq (1-e_t) \leq 1$ of them, which earns a dividend d_t and whose current market price is p_t^s. At the same time, it can sell the rest, $0 \leq e_t \leq 1$, back to the firm at a price p_t^e, which might differ from p_t^s.[8] Notice that there is a well-defined trade-off when the household chooses e_t in the sense that, when it sells shares carried over from $t-1$, it receives p_t^e for each share sold but, at the same time, it forgoes dividend income d_t and the right to sell the share in the regular market at p_t^s had it kept these shares. Also, $0 \leq \tau_t^y, \tau_t^d, \tau_t^k < 1$ are tax rates on income from labour and bonds, dividends and capital gains respectively, while, g_t is an income transfer from the

[8] Both p_t^s and p_t^e are endogenous, market-determined variables in our model. The former is determined in the regular market, while the latter is determined in the buyback market.

government. Notice that, as in Gourio and Miao (2010, 2011), we assume capital gains are taxed on accrual rather than realisation.[9] Finally, $\Phi_t^e \equiv \frac{\chi}{2}\left(e_t s_{t-1}\right)^2$ refers to transactions costs associated with participation in the buyback market for equity shares. [10]

The first-order conditions (FOCs) for l_t, b_t, s_t, and e_t give the supply of labour, the demand for public bonds, the demand for shares, and the supply of pre-existing shares to the buyback market, respectively:

$$\mu(l_t)^{\frac{1}{v}} = \frac{\left(1-\tau_t^y\right) w_t}{c_t}, \tag{4}$$

$$\frac{c_{t+1}}{c_t} = \beta[1 + \left(1-\tau_{t+1}^y\right) r_t^b], \tag{5}$$

$$\frac{c_{t+1}}{c_t} = \beta\left[\frac{\left(1-\tau_{t+1}^d\right)\left(1-e_{t+1}\right) d_{t+1} + \left(1-e_{t+1}\right) p_{t+1}^s + e_{t+1}p_{t+1}^e}{p_t^s} - \frac{\tau_{t+1}^k \left\{\left(1-e_{t+1}\right) p_{t+1}^s + e_{t+1}p_{t+1}^e - p_t^s\right\} + \chi(e_{t+1})^2 s_t}{p_t^s}\right], \tag{6}$$

$$p_t^e = p_t^s + \left(\frac{1-\tau_t^d}{1-\tau_t^k}\right) d_t + \frac{\chi e_t s_{t-1}}{1-\tau_t^k}, \tag{7}$$

where the last condition implies that p_t^e exceeds p_t^s to compensate the investor for the dividends foregone when shares are sold in the buyback marketas well as the associated transaction cost incurred.

If we combine Eqs. (6) and (7), we have the no-arbitrage condition, which will be used in the firm's problem below:

$$\left(1-\tau_{t+1}^d\right)\left(1-e_{t+1}\right) d_{t+1} + \left(1-\tau_{t+1}^k\right)[\left(1-e_{t+1}\right) p_{t+1}^s + e_{t+1}p_{t+1}^e - p_t^s] - \chi(e_{t+1})^2 s_t = \left(1-\tau_{t+1}^y\right) r_t^b p_t^s. \tag{8}$$

3.2. Firms

There are N identical firms. The gross profit of each firm is defined as sales minus labour costs:

$$\pi_t^g \equiv y_t - w_t l_t. \tag{9}$$

The firm uses gross profit for retained earnings, r_t^e, the payment of corporate profit taxes to the government, $\tau_t^c(\pi_{i,t}^g - \delta k_{t-1})$,[11] dividends to those shareholders who have kept their shares, $(1-e_t)d_t s_{t-1}$, the cost of repurchasing outstanding shares from shareholders, $e_t p_t^e s_{t-1}$, and various adjustment/transaction costs:

$$\pi_t^g \equiv r_t^e + \tau_t^c(\pi_t^g - \delta k_{t-1}) + \left(1-e_t\right) d_t s_{t-1} + e_t p_t^e s_{t-1} + \Phi_t^k + \Phi_t^d + \Phi_t^e, \tag{10}$$

where Φ_t^k, Φ_t^d and Φ_t^e denote, respectively, investment installation costs, dividend adjustment costs and share buyback costs.[12] Also, $0 \le \tau_t^c < 1$ is the corporate tax rate.

New investment is financed by retained earnings and changes in the value of equity:

$$i_t \equiv k_t - (1-\delta)k_{t-1} \equiv r_t^e + p_t^s s_t - \left(1-e_t\right) p_t^s s_{t-1}. \tag{11}$$

Combining (9)–(11), we obtain the budget constraint of the firm:

$$\left(1-\tau_t^c\right)\left(y_t - w_t l_t\right) + p_t^s(s_t - s_{t-1}) + \tau_t^c \delta k_{t-1} \equiv \left(1-e_t\right) d_t s_{t-1} + e_t(p_t^e - p_t^s)s_{t-1} + i_t + \Phi_t^k + \Phi_t^d + \Phi_t^e. \tag{12}$$

We now turn to the firm's objective. We define the value of the firm at the beginning of $t+1$ as:

$$V_{t+1} \equiv \left[\left(1-e_{t+1}\right) p_{t+1}^s + e_{t+1}p_{t+1}^e - \frac{\chi(e_{t+1})^2 s_t}{1-\tau_{t+1}^k} + \frac{\left(1-\tau_{t+1}^d\right)\left(1-e_{t+1}\right) d_{t+1}}{1-\tau_{t+1}^k}\right] s_t. \tag{13}$$

This definition is consistent with the terms related to income from shares on the RHS of the household budget constraint in (3). It is also consistent with the related literature (see, e.g. Gourio and Miao, 2010, 2011; Chang et al., 2023), except that here the income from the sale of outstanding shares is not a free lunch. In particular, as said above, the household may receive $\left(e_{t+1}p_{t+1}^e\right)$ from this sale, but this comes at the cost of sacrificing the associated income had she kept the shares as captured by $\left(-e_{t+1}p_{t+1}^s\right)$ and $\left(-e_{t+1}d_{t+1}\right)$.

[9] If capital gains are taxed on realisation, the tax base would be $(e_t p_t^e - p_{t-1}^s)s_{t-1}$. Since this term becomes negative in most of our solutions, we follow Gourio and Miao (2010, 2011). See also the discussion in Turnovsky (2000).

[10] It is well recognised that asset markets are well short of being perfect. Key frictions include transaction costs such as fees and commissions to brokers and dealers, execution costs, etc. ((e.g., see Altug and Labadie, 2008, chapter 15.2) for a discussion). Fabozzi et al. (2009) also note that these costs generally depend on the number of shares traded. Hence, our specification for the transaction cost function.

[11] That is, the tax base of corporate taxes is gross profit (sales minus labour costs) less capital depreciation expenses.

[12] The functions for Φ_t^k and Φ_t^d will be specified below. Regarding the function for Φ_t^e, we will assume, for simplicity, that transaction costs paid by firms when they buy pre-existing shares are identical to transaction costs paid by households when they sell pre-existing shares.

Finally, it is worth mentioning that this definition is equivalent to the discounted market value of the firm's equity at the end of t (see Appendix C for details).

Using the arbitrage condition (8) from the household's problem above and working as in the related literature, the value of the firm at the beginning of the current period is (see Appendix C for derivation):

$$V_t = \frac{\left(1-\tau_t^d\right)}{\left(1-\tau_t^k\right)}\left(1-e_t\right)d_t s_{t-1} + e_t(p_t^e - p_t^s)s_{t-1} - \frac{\chi e_t)^2 s_{t-1}}{1-\tau_t^k} + \frac{V_{t+1}}{1+\frac{\left(1-\tau_{t+1}^y\right)r_t^b}{\left(1-\tau_{t+1}^k\right)}}\frac{s_{t-1}}{s_t}, \tag{14}$$

which is maximized subject to the firm's budget constraint, motion of capital and production function[13]:

$$\left(1-e_t\right)d_t s_{t-1} \equiv \left(1-\tau_t^c\right)\left(y_t - w_t l_t\right) + p_t^s\left(s_t - s_{t-1}\right) + \tau_t^c \delta k_{t-1} - e_t\left(p_t^e - p_t^s\right)s_{t-1} - i_t - \Phi_t^k - \Phi_t^d - \Phi_t^e, \tag{15}$$

$$i_t \equiv k_t - (1-\delta)k_{t-1}, \tag{16}$$

$$y_t \equiv A k_{t-1}^a l_t^{1-a}, \tag{17}$$

where we define the transaction and adjustment cost functions as $\Phi_t^k \equiv \frac{\theta}{2}\frac{(i_t)^2}{k_{t-1}}$;$\Phi_t^d \equiv \frac{\phi}{2}\left(\frac{d_t}{\pi_t} - \rho_d\frac{d_{t-1}}{\pi_{t-1}}\right)^2$ and net-of-tax gross profits as $\pi_t \equiv \left(1-\tau_t^c\right)\left(y_t - w_t l_t\right)$. The capital adjustment cost function, Φ_t^k, follows Gourio and Miao (2010, 2011), Cooper and Haltiwanger (2006), whereas, the function for Φ_t^d captures the associated adjustment costs when firms change their dividend payments as a share of their profits between two consecutive periods. This function mimics the empirical result of Lintner (1956) dividend smoothing, as well as Brav et al. (2005) finding that firm managers consider maintaining stable dividends a top priority.

Following the related literature (see, e.g. Gourio and Miao, 2010, 2011; Chang et al., 2023), we assume that the firm supplies shares inelastically, implying that their number is $s_t = 1$ at each t. Then the first-order conditions d_t, l_t, i_t, k_t and e_t, giving the supply of dividends and the demand for labour, investment, capital and share buybacks in the buyback market are respectively:

$$v_t\left[(1-e_t) + \phi\left(\frac{d_t}{\pi_t} - \rho_d\frac{d_{t-1}}{\pi_{t-1}}\right)\frac{1}{\pi_t}\right] = \left(\frac{1-\tau_t^d}{1-\tau_t^k}\right)(1-e_t) + \frac{v_{t+1}\phi}{\left[1+\frac{\left(1-\tau_{t+1}^y\right)r_t^b}{1-\tau_{t+1}^k}\right]}\left(\frac{d_{t+1}}{\pi_{t+1}} - \rho_d\frac{d_t}{\pi_t}\right)\frac{\rho_d}{\pi_t}, \tag{18}$$

$$w_t = \frac{(1-a)y_t}{l_t}, \tag{19}$$

$$m_t = v_t\left(1+\theta\frac{i_t}{k_{t-1}}\right), \tag{20}$$

$$\begin{aligned} m_t = {} & \frac{m_{t+1}}{\left[1+\frac{(1-\tau_{t+1}^y)r_t^b}{1-\tau_{t+1}^k}\right]}(1-\delta) + \frac{v_{t+1}}{\left[1+\frac{(1-\tau_{t+1}^y)r_t^b}{1-\tau_{t+1}^k}\right]}\left[(1-\tau_{t+1}^c)\frac{a y_{t+1}}{k_t} + \tau_{t+1}^c\delta + \theta\left(\frac{i_{t+1}}{k_t}\right)^2 + \phi\left(\frac{d_{t+1}}{\pi_{t+1}} - \rho_d\frac{d_t}{\pi_t}\right)\frac{d_{t+1}}{(\pi_{t+1})^2}\frac{\left(1-\tau_{t+1}^c\right)a y_{t+1}}{k_t}\right] \\ & - \frac{v_{t+2}}{\left[1+\frac{(1-\tau_{t+1}^y)r_t^b}{1-\tau_{t+1}^k}\right]\left[1+\frac{(1-\tau_{t+2}^y)r_{t+1}^b}{1-\tau_{t+2}^k}\right]}\phi\left(\frac{d_{t+2}}{\pi_{t+2}} - \rho_d\frac{d_{t+1}}{\pi_{t+1}}\right)\frac{\rho_d d_{t+1}}{(\pi_{t+1})^2}\frac{\left(1-\tau_{t+1}^c\right)a y_{t+1}}{k_t}, \end{aligned} \tag{21}$$

$$v_t\chi e_t + \frac{2\chi e_t}{1-\tau_t^k} = v_t d_t + (1-v_t)(p_t^e - p_t^s) - \left(\frac{1-\tau_t^d}{1-\tau_t^k}\right)d_t. \tag{22}$$

Note that v_t is the Lagrangian multiplier associated with the firm's budget constraint, and m_t is the Lagrangian multiplier related to the firm's motion of capital[14]:

[13] Notice that, leaving aside the way of modeling buybacks, our equation for dividends in (15), combined with the motion of capital in (16), and hence the objective of the firm in (14), are the same as in the literature (see, e.g. Altug and Labadie, 2008, Eqs. 10.91–10.92, McGrattan and Prescott, 2005, Eq. (4) combined with Eq. (6), Gourio and Miao, 2010, Eq. (9) combined with Eq. (7) and Gourio and Miao, 2011, Eq. (7) combined with Eq. (2)).

[14] Note that the firm chooses simultaneously both dividends and buybacks (which differs from Gourio and Miao, 2010, 2011; Karabarbounis and Neiman, 2012; Chang et al., 2023). Regarding dividends, they are an expense for the firm but are valued by its owners (see the firm's value function). Regarding buybacks, the firm's trade-off is symmetrically opposite to that of the household, as discussed above.

3.3. Government budget and resource constraints

Finally, the government budget constraint and the aggregate resource constraints are given, respectively, by:

$$\tau_t^d(1-e_t)d_t + \tau_t^y[w_t l_t + r_{t-1}^b b_{t-1}] + \tau_t^k[(1-e_t)p_t^s + e_t p_t^e - p_{t-1}^s]s_{t-1} + \tau_t^c\left(y_t - w_t l_t\right) + b_t \equiv \left(1+r_{t-1}^b\right)b_{t-1} + g_t + \tau_t^c \delta k_{t-1}, \tag{23}$$

$$c_t + i_t \equiv y_t - \Phi_t^k - \Phi_t^d - 2\Phi_t^e, \tag{24}$$

where, we drop the latter when solving the model since it is not an independent identity.

3.4. Macroeconomic equilibrium and model solution

The macroeconomic system thus consists of 14 equations in the time-paths of $c_t, l_t, p_t^s, p_t^e, r_t^b, d_t, y_t, w_t, k_t, i_t, e_t, v_t, m_t, g_t$ (see Appendix D for details). Notice that we keep the public debt to GDP ratio constant as in the data so that any exogenous changes in tax policy will be financed by changes in g_t, a lump-sum fiscal instrument in our model. This will allow us to make our results easily comparable to those in the neoclassical literature on tax reforms. It practically means that, by construction, we are generous to the implications of tax cuts. Nevertheless, as we shall see, even in this case, there are severe tradeoffs.

Note that we will solve the model in a deterministic framework. Thus, our simulations will describe, under perfect foresight, the economy's path as it returns to the initial steady state (for temporary shocks) or a new steady state (for permanent shocks). This solution methodology executed in Dynare is described, e.g., in the Dynare Reference Manual (2025, section 4.12). [15] Further note that the effects of tax policy reforms, which are the focus of our paper, are normally studied in deterministic economic environments. In other words, typically, the economy is assumed to switch to a new tax policy mix permanently, and this happens under certainty (see, e.g., Lucas, 1990; Garcia-Mila et al., 2009; Correia, 2010, and the papers cited therein).[16]

4. Calibration

To conduct our quantitative analysis of the U.S. economy, we calibrate the structural parameters of the model to match key data targets using the most extended available time series and the values of policy instruments based on the most recent available data. In addition to data from the Bureau of Economic Analysis (BEA), Compustat, Congressional Budget Office (CBO), Tax Foundation and OECD, our quarterly calibration also draws on related studies from the literature. Further details on the sources for the data, referred to below, are reported in Appendix A.

4.1. Structural parameters

Table 1 lists the model's structural parameters. The productivity parameters A and Z are normalised to unity. Capital's share, α, is the average value from 1929–2023 reported in the BEA National Income and Product Accounts. Following most of the literature, the discount rate value, β, targets a post-tax annual return on bonds, r^b, of 4 %. The mean depreciation rate of capital, δ, between 1925–2022 is calculated using the BEA Fixed Asset Accounts. We pin down μ by imposing that work-time is equal to 31 % (see, e.g. Cooley and Prescott, 1995) and the value of the Frisch elasticity, ν, follows the one used in Malley and Philippopoulos (2023) and is based on Ríos-Rull et al. (2012). Finally, the persistence parameter for dividends, $\rho_d = 0.68$, in the adjustment costs function for dividends is obtained from an estimated AR(1) regression of the dividends to profit ratio.

Table 1
Structural parameters.

	Value	Definition	Source/target
A	1.000	TFP	normalisation
α	0.300	Capital's share of output	data
β	0.990	Time discount factor	$\frac{1}{\beta}-1 = 0.01$
δ	0.011	Depreciation rate of capital	data
μ	11.35	Labour effort weight in utility	$l = 0.31$
ν	0.720	Frisch elasticity of labour supply	literature
ϕ	60.78	Dividend adjustment costs	$\frac{e(p^e)}{\pi} = 0.088$
θ	41.60	Investment installation costs	$\frac{i}{\pi} = 0.623$
χ	0.041	Share repurchase transaction costs	$\frac{d}{\pi} = 0.13$
ρ_d	0.680	Persistence dividends	data
Z	1.000	MEI	Normalisation

[15] An advantage of a perfect foresight setting is that the model's nonlinear equilibrium conditions can be numerically solved directly without approximating them around the steady state.

[16] Of course, there are exceptions. For instance, Davig et al. (2010) assume that policy bounces between two regimes governed by an exogenous transition matrix. However, they address a different policy issue: the two regimes considered are stabilisation versus non-stabilisation of public debt.

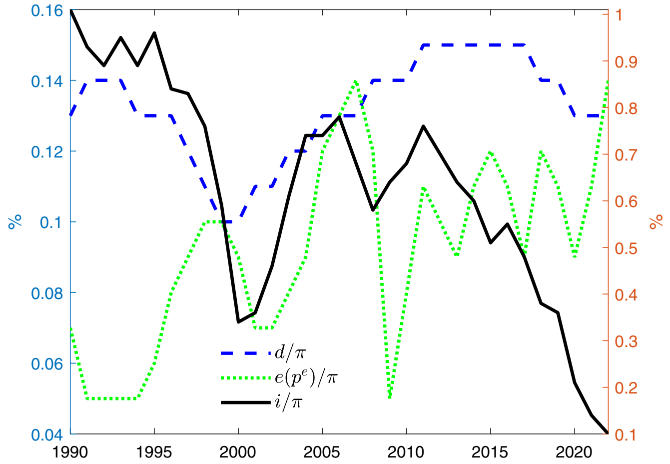

Fig. 5. Corporate finance ratios (1990–2022).
Note that the investment to after-tax profits ratio, i/π, is reported on the right-axis.

Table 2
Policy parameters.

Coef.	Value	Definition	Source/target
τ^d	0.248	Dividend tax rate	Data
τ^k	0.178	Capital gains tax rate	CBO estimate
τ^c	0.210	Federal corporate tax rate	Statutory
τ^y	0.248	Income tax rate	data
ρ_i	0.900	AR(1) coef.$i = \tau_d, \tau_k, \tau_c$,	Literature
$\frac{b}{y}$	1.217	Public debt share of final output	Data

The various targets for the corporate finance ratios, $\frac{e(p^e)}{\pi}$, $\frac{i}{\pi}$, $\frac{d}{\pi}$, in our model are obtained using data from Compustat for publicly listed firms at the major U.S. stock exchanges from 1990–2022.[17] Fig. 5 shows the evolution of these variables, where the targets reported in Table 1 reflect the period averages for these variables. We can see that the dividend-to-profits ratio is the least volatile series with a $\sigma = 0.016$ and fluctuates between 0.13 and 0.15, followed by the buybacks-to-profit ratio, which fluctuates between 0.05 and 0.14 ($\sigma = 0.027$). Finally, the investment-to-profits ratio is the most volatile, with a $\sigma = 0.239$ and fluctuates between 0.1 and 1.01.

These facts are consistent with the related literature showing that managers are reluctant to cut dividends (and even fail to deliver an expected dividend increase) while being more flexible in adjusting buybacks (e.g. Jagannathan et al., 2000). Chang et al. (2023) also find that share buybacks, as a fraction of after-tax corporate profits, are ten times more volatile than dividends.

In Fig. 5, we further observe a downward trend in investment over after-tax earnings, which can be explained by the increasing ownership concentration in specific industries and the decline in the productivity and competition in the traded goods sector in the U.S. (e.g. Gutiérrez and Philippon, 2017; Covarrubias et al., 2019).

4.2. Policy parameters

Policy parameters are listed in Table 2. Regarding tax rates, (i) τ^d is set equal to the income tax rate as in the papers of Gourio and Miao (2010, 2011); (ii) τ^k is based on an estimate provided by the CBO (2014); (iii) τ^c is a statutory rate set in 2017; and (iv) τ^y is the 2022 value of the employee net average tax rate, i.e. The net tax on labour income paid directly by the employee. The persistence parameters for the various exogenous tax rates generally follow the literature, e.g., Malley and Philippopoulos (2023). Finally, the gross federal debt to GDP ratio of 121.7 % is the 2023 value reported in the St. Louis Fed FRED database.

5. Non-policy shocks

We next evaluate the firm-level and aggregate effects of several critical non-policy shocks households and firms face, in particular, shocks to dividend income and the marginal efficiency of investment.

[17] See Appendix A for further details.

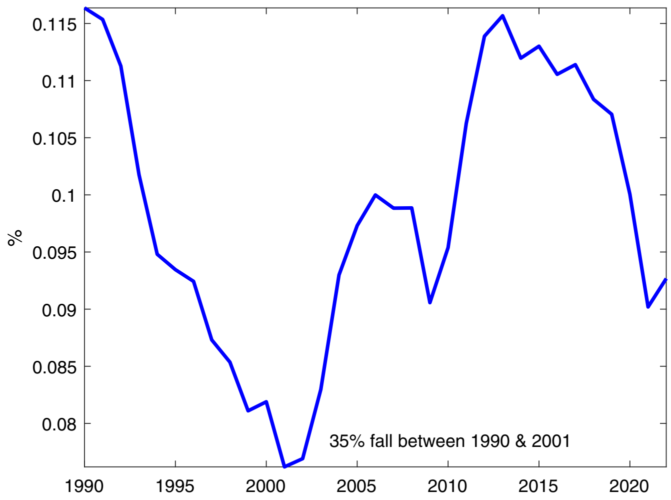

Fig. 6. Dividends per share (1990–2022).

5.1. Dividend income shock

It is well known that firms paying dividends are reluctant to lower them due to the associated negative signal to the market and their value (Brav et al., 2005). However, dividend income can be affected by several exogenous reasons, as outlined in the introduction and further discussed below. Thus, it is essential to understand how firms react to an exogenous negative shock to the dividend income of the household and the subsequent aggregate effects.

To implement this shock, we add a multiplicative shock, ω_t, to the household's earnings from dividends in its budget constraint (3). This will naturally also affect the household's no-arbitrage condition (8) and thus the firm's value function (14) and, in turn, its relevant equilibrium conditions (see Appendix E for details).

To obtain a dividend shock size that coheres with recent data, Fig. 6 shows the evolution of dividends per share from 1990 to 2022 using data from Compustat. The figure shows that dividends experienced a 35 % fall between 1990 and 2001 and roughly the same percent rise between 2001 and 2013, thereafter falling roughly 13.5 % by 2022.

The observed reduction of dividends from 1990 to 2001 in our data sample is unsurprising as it has been documented in the corporate finance literature (e.g., Grullon and Michaely, 2002; DeAngelo et al., 2004). In addition, Fama and French (2001) show that the fraction of public U.S. firms paying dividends dropped from 66.5 % in 1978 to 20.8 % in 1999. They partially attribute this drop to a shift in the population of publicly traded firms toward small firms with low profitability and substantial growth opportunities, which tend not to pay dividends. Another driving force of the reduction in dividends is the considerable increase in share repurchases (buybacks) during the same period (Grullon and Michaely, 2002).

Motivated by the observed reduction of about 35 % in dividends per share from 1990 to 2001, in Fig. 7, we impose a similar drop in our model over 12 years.[18] Specifically, we implement a gradual shock to dividend income, ω_t, that generates an aggregate drop in effective dividends, $\omega_t d_t$, of 35 % in 48 periods (quarters in our model). The reduction in dividend income between consecutive periods is dictated by the $AR(1)$ coefficient estimated at 0.96 in our sample. In particular, the shock translates to about a 1.26 % reduction in effective dividends per share (relative to the steady-state) in the first period of the shock and a 35 % reduction (relative to the steady-state) in the 48th period. The slow adjustment of effective dividends per share is also known in the corporate finance literature as the dividend smoothing effect, which indicates that dividend payments do not deviate significantly (upwards or downwards) from one period to another (see, for example, Lintner, 1956; Brav et al., 2005; Asimakopoulos et al., 2021).

Fig. 7 shows the impulse response functions to this shock. We can see that the adverse dividend income shock makes shares less desirable, and this leads to a fall in their price, p_t^s, in the primary market, which also leads to lower buyback prices, p_t^e (see Eq. 7). On impact, firms immediately meet the exogenous negative shock to dividend income with an increase in the dividends, d_t, which they distribute to shareholders to counteract this negative exogenous and unanticipated shock to households' effective dividend income, $\omega_t d_t$. Firms further finance this initial increase in d_t by a cut in share buybacks, e_t, and a reduction in capital investment, i_t.

But, after these impact effects, firms gradually cut their dividend payments and, at the same time, reduce their share repurchases even further to increase their spending on capital investment, i_t. Notice that the magnitude of dividend reduction is not as considerable as the share repurchases reduction, indicating corporations' preference towards maintaining a smooth dividend payment at the expense of more volatile buybacks; this result is again consistent with the empirical finance literature that has shown the preference for firms to keep dividends smooth and use share repurchases on an ad-hoc basis for their payout policy (see, e.g., Farre-Mensa et al., 2024 and references therein). The higher level of capital investment eventually leads to higher capital stock, k_t, and aggregate output,

[18] The nonlinear system of equilibrium conditions in Appendices D and E is solved deterministically under perfect foresight using Dynare.

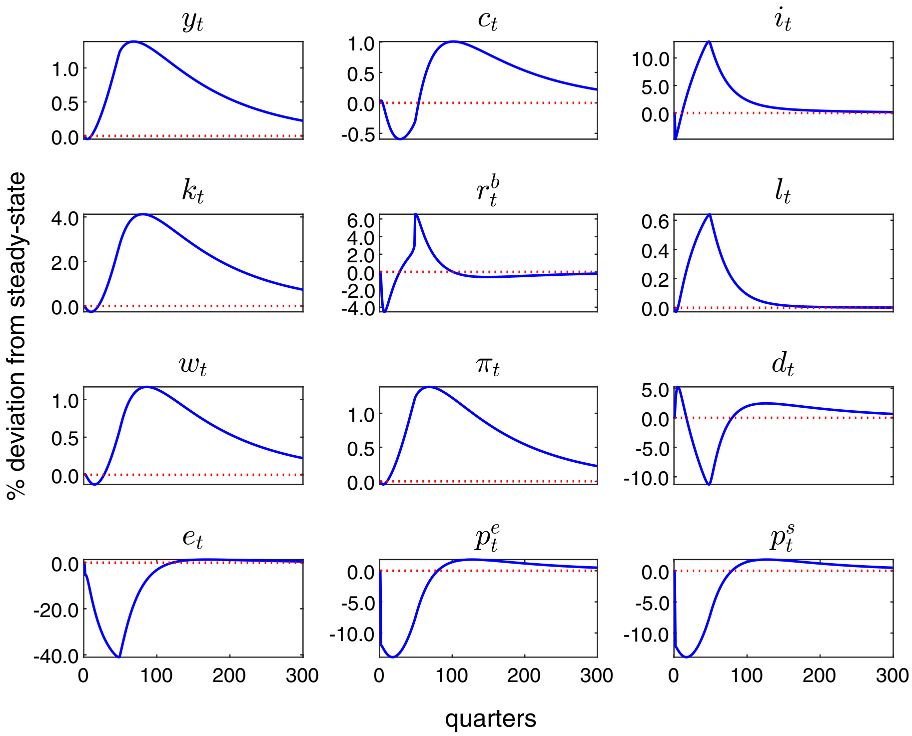

Fig. 7. 35 % fall in effective dividends over 12 years.

y_t, increasing the demand for labour, the wage rate, and household consumption reaching a new higher equilibrium. All this happens until the shock fades away and the economy returns to its initial steady-state.

Overall, we observe that the negative household dividend income shock is counteracted by firms with a significant reduction in share repurchases to keep the dividend income of their shareholders relatively smooth over time. This flexible use of share buybacks and distributed dividends as payout policies enables the firms to increase capital investment and profits further, leading to increased consumption. This experiment contributes to the related literature by extending our understanding of how firms behave when households' dividend income deteriorates and what the spill-over effects are on the aggregate economy when dividends are not equal to a fraction of profits, as shown by Chang et al. (2023). In addition, these impulse responses show that our DGE model can match the facts we uncovered in the PVAR analysis, with dividends and share repurchases being used simultaneously by the firm and with profits and dividends exhibiting a negative correlation.

5.2. *Investment shock*

The relationship between financing payout policy and capital investment has drawn much attention in the literature (Farre-Mensa et al., 2024). For example, Chang et al. (2023) show that buybacks dampen the expansionary effect of corporate tax cuts. Nguyen et al. (2021) find that higher buybacks lead to lower levels of investment, and D'Mello and Shroff (2002) find that firms use share repurchases to correct for firm under-valuation. Therefore, examining the spill-over effects of an exogenous change in investment efficiency on payout policy decision-making and the macroeconomy when firms experience different degrees of payout policy flexibility is essential.

To implement a shock to marginal efficiency of investment (MEI), following Ramey (2016, p. 141), we introduce an exogenous $AR(1)$ process for Z, where Z affects the transformation between investment and installed capital (see Eqs. D.7 and D.11 in Appendix D), and use the econometric estimates of its $AR(1)$ parameter, $\rho_Z = 0.826$, and standard deviation, $\sigma_z = 0.0302$, from Sims and Wolff (2018). In Fig. 8, we impose an exogenous permanent shock of 1σ.

Fig. 8 shows that the positive MEI shock leads to increased capital investment. This increase in capital investment is funded by a drop in dividend payouts during the initial periods, which also leads to an initial decline in share and buyback prices (see Eq. 7). However, share prices start rising again when the increase in profits is sufficiently high to sustain the newly increased levels of dividends, capital investment and buybacks. Equilibrium labour will increase until the income due to the higher payout policy and the wage rate are sufficient for the households to sustain a higher level of consumption (see Eq. 4).

In summary, the impulse response analysis of the MEI shock indicates that in the short-run, firms will cut down both payout channels to finance investment. Therefore, the impulse responses show once again that in the short-run, the reactions of dividends and profits are opposite, which is in line with the empirical PVAR results presented previously.

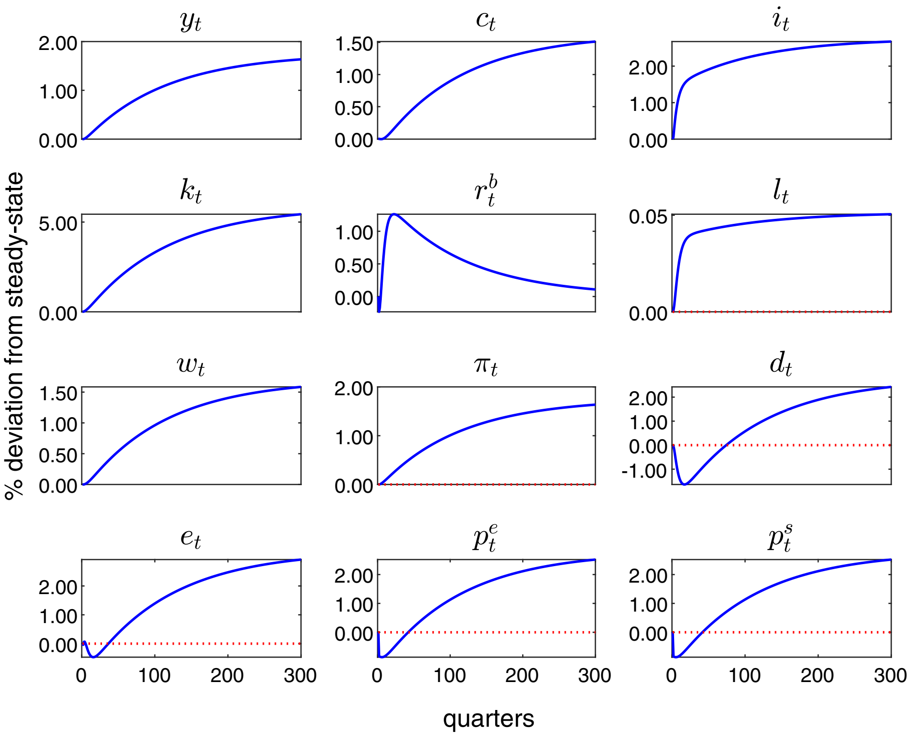

Fig. 8. 1σ Permanent shock to MEI.
Note: The right-axis, when used, is for the constant dividends case.

5.3. Special cases

As discussed in the introduction, not all firms engage in both forms of payout policy covered by the model developed above. As Skinner (2008) pointed out, three types of firm payout policies have emerged, in particular, firms that pay dividends and make share repurchases (as analysed above), firms that make share repurchases only, and firms that pay dividends only. He further notes that firms that only pay dividends are increasingly rare. Fig. 9 plots each category as a share of total U.S.-listed firms from 1990 to 2022 to obtain a quantitative sense of this breakdown.

In particular, the first row of Fig. 9 shows that firms not engaging in any payout policy have fallen from 45 % in 1990 to 32 % in 2022. Firms only using dividends have also experienced a significant drop from 24 % in 1990 to 9 % in 2022. In contrast, those firms using both types of payout policy have risen slightly from 18 % in 1990 to 26 % in 2022. Finally, share buybacks have increased substantially, from 13 % in 1990 to 33 % in 2022.

To concentrate on the firms that conduct payout policy both in the form of dividends and buybacks, as in our theoretical model, the second row of Fig. 9 excludes firms with no payouts at all, with the remaining shares renormalised to sum to unity in each period. These plots show that in 2022, 38 % of firms use both types of payout policy as in our model, 13 % of firms do not trade in the buyback market for shares but pay dividends, and 48 % do not pay dividends but trade in the buyback market. Given the quantitative importance of the last two categories, we will next study these two special case models alongside our more general base model for the dividend and investment shocks considered above.[19]

To ensure that all models have the same steady-state we proceed as follows. When analysing the case with constant buybacks, we set $e_t = e$ and $p_t^e = p^e$ for all t and drop the first-order conditions for the household's supply of shares inthe buyback market, Eq. (7), and the firm's demand from this market, Eq. (22), see also Eqs. (D.4) and (D.13) in Appendix D. Likewise, when considering constant dividends, we set $d_t = d$ and $p_t^s = p^s$ for all t and drop the first-order conditions for the household's demand for dividends, Eq. (6), and the firm's supply of dividends, Eq. (18), see also Eqs. (D.3) and (D.9) in Appendix D.

5.3.1. Dividend income shock: special cases

Fig. F1 in Appendix F shows that when firms keep their share buybacks constant over time, the outcomes exhibit some minor differences in the short-run and are very similar in the long-run to the full-model. In contrast, when firms do not adjust their dividend

[19] See Chang et al. (2023), who employ the same method when considering the constant-buybacks case alongside their base model.

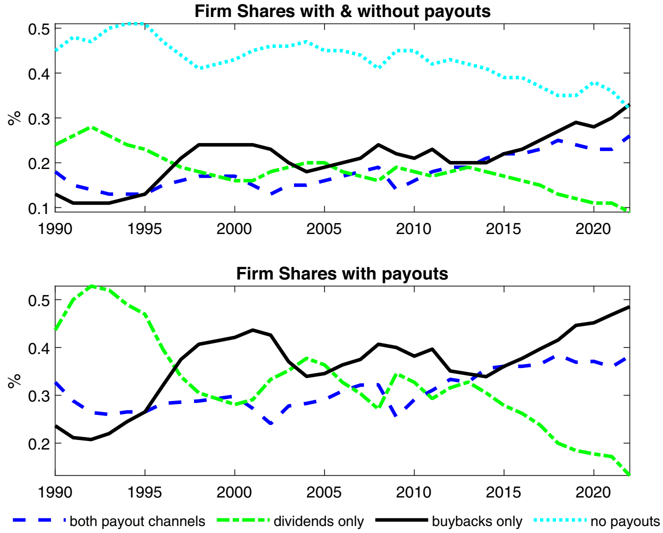

Fig. 9. Firm payout policy (1990–2022).

payments to the shock, there are considerable differences relative to the full-model. In particular, keeping the firm's dividend payments flat delivers worse outcomes during the early period characterized by the adverse exogenous shock to the dividend income earned by shareholders. Still, this policy becomes superior once this adverse shock fades away. Thus, it is better to keep dividends constant in the medium-term because the latter, combined with a relatively slow rise in buybacks, can boost profits, investment, capital accumulation, output and consumption. This finding is similar to the empirical studies in corporate finance that show the importance of dividend smoothing over time (see, e.g. Brav et al., 2005; Farre-Mensa et al., 2024).

5.3.2. Investment shock: special cases

Fig. F2 in Appendix F shows that when firms cannot adjust their share buybacks, we observe similar output, profit, consumption and capital investment reactions as in the full-model. The only marginal difference between these two cases is that labour is initially below the full-model level and reaches a higher new steady-state in the long-run. This way, households can compensate for the lost income from share repurchases and maintain the same level of consumption across the transition path as in the full-model case. In contrast, when firms cannot adjust their dividends, we observe a slower reaction in capital investment, leading to a delayed increase in output, consumption, capital stock and profits relative to the full-model. These reactions are because even if firms cut their share buybacks significantly, up to about 100 %compared to the full-model case, this cannot lead to a sharp increase in capital investment. However, in the medium term, this substitution effect away from financing payout policies (dividends and buybacks) towards capital investment helps firms sustain higher output and profits, so the constant dividend policy becomes superior. This finding is consistent with the finding from the dividend income shock studied in the previous subsection and similar to the empirical studies in corporate finance that show the importance of smooth dividend payments over time and the volatile and flexible use of share repurchases by firms (see, e.g., Farre-Mensa et al., 2024).

6. Policy shocks

Motivated by the current policy discussion in the U.S. (see, e.g. The Economist, 2024) and past tax reforms in the U.S. (Jobs and Growth Tax Relief Reconciliation Act of 2003 and Tax Cuts and Jobs Act of 2017), in this section, we examine the impact of permanent 20 % tax cuts in corporate income, capital gains, and dividend income which is also in line with other studies in the related literature (i.e., Gourio and Miao, 2011; Chang et al., 2023). In all cases, the tax cuts are financed by changes in non-distortionary government transfer payments and/or public debt, which are adjusted to satisfy the government budget constraint. [20]

In addition, to understand the quantitative implications of introducing a separate market for pre-existing equity shares relative to the literature cited above, we will also solve our model for the restricted case in which firms' buybacks are not a choice variable. To this end, following Chang et al. (2023), we assume that dividends are proportional to the firm's profits:

$$d_t \equiv \xi[(1-\tau_t^c)(y_t - w_t l_t) + \tau_t^c \delta k_{t-1} - \Phi_t^k - \Phi_t^d - \Phi_t^e], \tag{25}$$

which implies that when we use this rule in the firm's budget constraint, buybacks follow:

$$e_t \equiv (1-\xi)[(1-\tau_t^c)(y_t - w_t l_t) + \tau_t^c \delta k_{t-1} - \Phi_t^k - \Phi_t^d - \Phi_t^e] - i_t, \tag{26}$$

[20] Recall that the debt-to-output ratio is kept constant, $b_t = \bar{b}y_t$, so that, when output changes, the level of debt also changes proportionally.

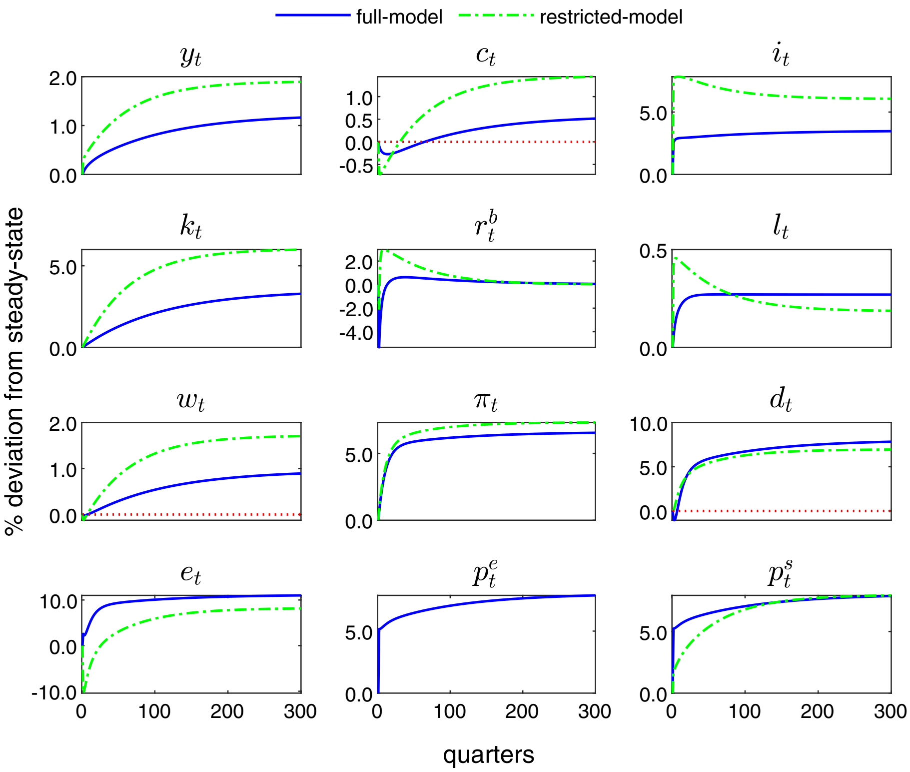

Fig. 10. Permanently reduce τ^c by 20 % from 0.21 to 0.168.

where $0 < \xi < 1$ is a calibrated parameter and $\Phi_t^e = 0$ since households and firms no longer choose buybacks.[21]

We stress that this restricted model remains as in Section 3 above in all other respects. Therefore, any differences between the full-model and this special case are driven only by this assumption about firms' payout policy. Notice that we call this model restricted because we now constrain dividends and, hence, buybacks to obey the above rules (see Appendix H for the equilibrium conditions of this model).

6.1. Corporate tax cut

Fig. 10 shows impulse response functions when the economy transitions from the initial steady-state to the new steady-state due to the permanent cut in the corporate tax rate. As can be seen, a permanent cut in the corporate tax rate exerts a direct positive effect on firms' net of tax gross profit, $\pi_t \equiv \left(1 - \tau_t^c\right)\left(y_t - w_t l_t\right)$, and this allows them not only to increase capital investment (and hence their capital stock) but also to finance an increase in both dividends and buybacks. The increase in per share dividend makes shares more attractive to households, which translates to more robust demand for them and higher share prices both in the primary and the secondary market. A higher capital stock and aggregate output increase the demand for labour and drive up the wage rate. Households' consumption falls slightly on impact as savings in shares rise. However, consumption increases as the beneficial effects of higher disposable income and stronger real economic activity kick in. As a result, GDP also rises, although a comparison of increases in investment and consumption implies that the primary source of the rise in GDP is investment.

Finally, a comparison of the full-model to the restricted-model reveals that the beneficial effects of the corporate tax cut upon the macro economy are more robust in the latter (see, for example, the paths of i_t, k_t, $y_t$and c_t in Fig. 10). This happens because, when dividends restricted to be a constant fraction of profits, as in Eq. (25) above, more funds are available for capital investment than in the full-model. Moreover, contrary to the full-model, firms' spending on buybacks initially falls rather than rises in the restricted-model, which releases more funds for capital investment.

Table 3 compares the percent difference between the terminal and the initial steady-state. As can be seen and consistent with the impulse responses above, the cut in the corporate tax rate has an expansionary effect on all key macroeconomic variables in both models. Also, notice that the 20 % permanent cut in the corporate tax is financed by a roughly 2 % fall in government transfer spending, g, and a 1.2 % rise in debt, b, in the full-model. In contrast, g falls by approximately 1.8 %, and b rises by about 1.9 % in

[21] Note that (25) is like equation (19) in Chang et al. (2023) if we also make use of equations (16)–(18) in their paper. Gourio and Miao (2011) do not use such a rule. Instead, they study different payout regimes, meaning different combinations of dividends and buybacks.

Table 3
%Δ from initial steady-state due to τ^c cut.

y	k	l	c	i	π	g	b
Full-model							
1.223	3.449	0.269	0.580	3.449	6.403	−2.018	1.231
Restricted-model							
1.890	5.871	0.184	1.450	5.872	7.070	−1.838	1.890

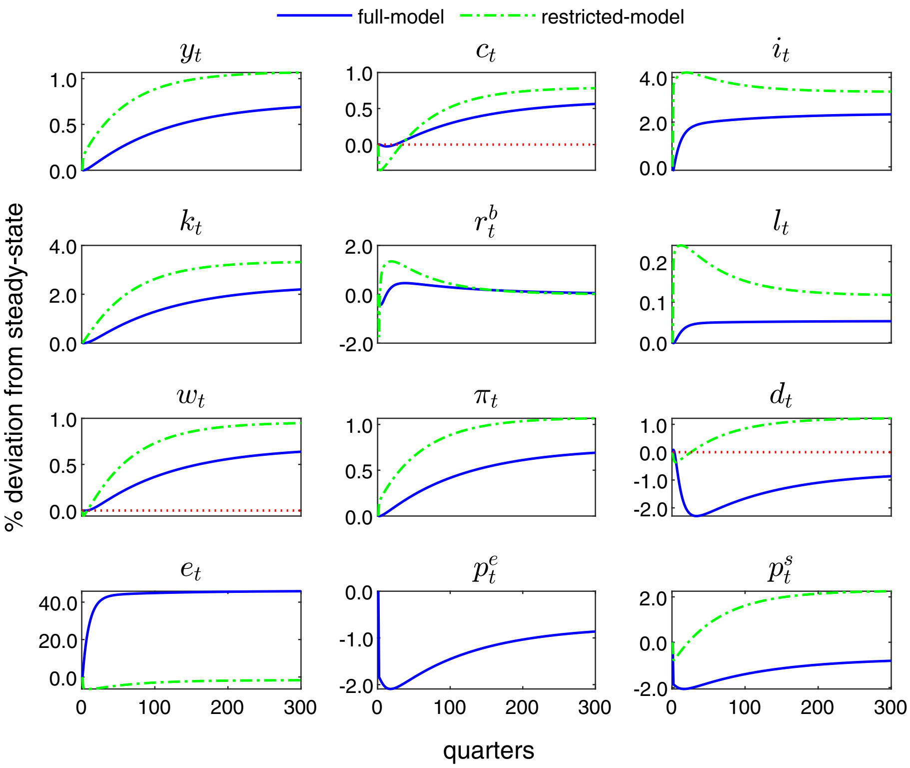

Fig. 11. Permanently reduce τ^k by 20 % from 0.178 to 0.142.

the restricted-model. In both models, however, despite the quantitative differences, the corporate tax cut is not a free lunch; spending has to fall, and debt has to rise.

6.2. Capital gains tax cut

Fig. 11 shows that a permanent cut in the tax rate on households' capital gains gives them an extra incentive to sell their outstanding shares in the secondary market to take advantage of this tax reform (see the upward jump of e_t). At the same time, firms can reduce dividends since shareholders are now more interested in selling than keeping their shares. These developments lead to a fall in share prices in the secondary and primary markets. Notice that this result aligns with Gourio and Miao (2011) and uncovers a substitution effect between the two payout channels when share sellbacks become more desirable to shareholders due to the lower capital gains tax. In turn, the released funds from the decrease in dividends more than outweigh the funds spent for the increase in buybacks, so that firms can finance an increase in capital investment spending (and hence their capital stock), which is good for work hours, the wage rate and the economy's GDP. Households can also increase consumption thanks to higher disposable income driven by the tax cut and more robust economic activity.

Finally, a comparison of the full-model to the restricted-model reveals that, again, the beneficial macro effects from the tax cut are stronger under the latter (see the paths of i_t, k_t, $y_t$and c_t in Fig. 11). This happens because, in the restricted-model, buybacks do not rise as in the full-model, allowing for higher profits and more capital investment. Notice that dividends also rise since they are forced to be proportional to profits in the restricted-model.

Focusing next on steady-state solutions, comparing the capital gains tax cut in Table 4 to corporate tax cuts in Table 3 reveals that, although both benefit real economic activity, there are also differences. For example, from Tables 3 and 4, we can see that the cut in corporate taxes clearly has more substantial effects on investment, capital, labour, and eventually GDP than the cut in capital

Table 4
%Δ from initial steady-state due to τ^k cut.

y	k	l	c	i	π	g	b
Full-model							
0.744	2.355	0.053	0.617	2.355	0.744	0.426	0.747
Restricted-model							
1.069	3.293	0.116	0.792	3.293	1.069	−0.376	1.069

gains tax. On the other hand, the cut in capital gains has a stronger effect on consumption, at least in the full-model. [22] These findings should not be surprising as corporate taxes are taxes on firms' profits and can thus directly affect the accumulation of productive factors (capital and labour). In contrast, taxes on capital gains (or taxes on dividend income, as will be shown next) are taxes on household income from shares, so their effects on production decisions can only be indirect. Finally, notice that in the full-model, the fiscal cost is in the form of higher debt only since government transfers can rise.

6.3. Dividend income tax cut

Fig. 12 shows what happens during the transition when there is a permanent cut in the tax rate on households' dividend income. Since the net income from keeping shares rises, the fraction of shares that households sell in the secondary market falls (see the drop in e_t), and, at the same time, share prices in both the primary and secondary markets rise. Firms can cut the per-share dividend, d_t, in the very short term since the net of tax dividend income has increased anyway thanks to the tax cut. Still, they are quickly forced to bring it back to its initial level to satisfy their shareholders, whose appetite for holding shares has risen because of permanently lower dividend income taxes.

All this means that the beneficial effects on firms' profits and capital investment do not last long. That is, on the side of firms, higher dividends crowd out investment spending. This reaction, in turn, also hurts the demand for labour and wages. Households' consumption falls on impact because the dividend tax cut stimulated savings. Still, after this, it remains above its initial steady-state

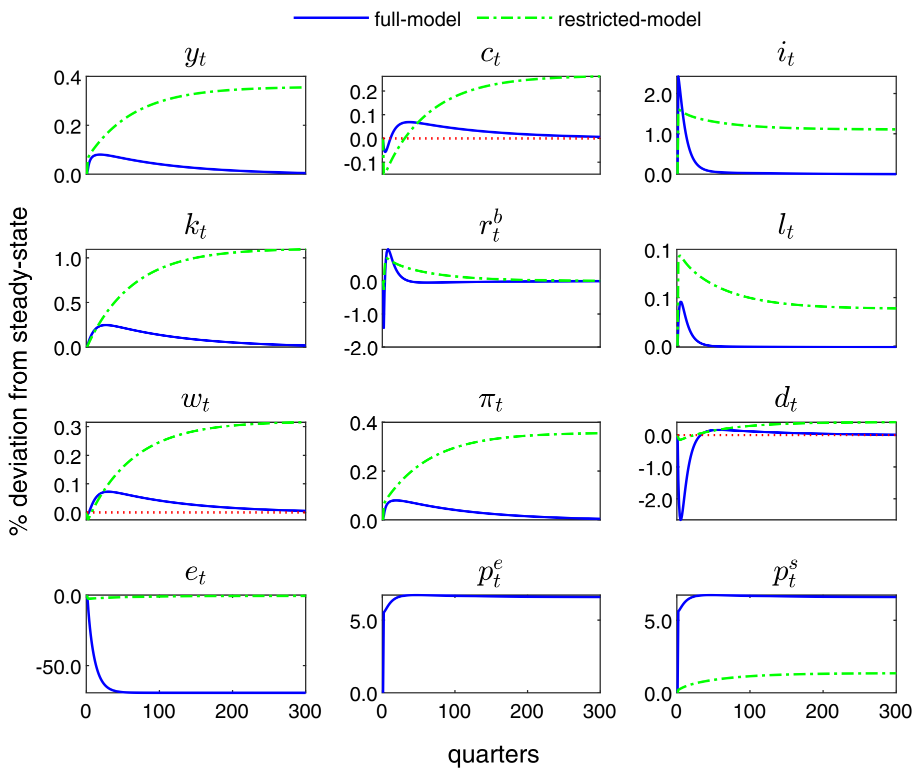

Fig. 12. Permanently reduce τ^d by 20 % from 0.248 to 0.198.

[22] By contrast, consumption is also higher under the corporate tax cut in the restricted model because, in this model, dividend income is tied to profits and hence to the aggregate economic activity, and these are higher undercuts in corporate taxes.

Table 5
%Δ from initial steady-state due to τ^d cut.

y	k	l	c	i	π	g	b
Full-model							
−0.003	−0.007	−0.001	−0.001	−0.007	−0.003	−0.753	−0.003
Restricted-model							
0.357	1.100	0.039	0.265	1.101	0.357	−0.315	0.357

most of the time, thanks to increased household disposable income. However, quantitatively, the rise in consumption is tiny relative to all other cases. As seen in Fig. 12, output follows the consumption path.

The above results are generally in line with the related empirical literature. For example, Yagan (2015) finds that, even though the 2003 dividend tax cut was associated with a modest increase in the dividends paid to shareholders, it had no real impact on firms' decision-making, such as investment or employee compensation. These findings suggest that taxation of dividends has little material effect on firms' behaviour in the long-run. Moreover, Farre-Mensa et al. (2014) conclude that dividend taxation studies on firms' decisions regarding "real" outcomes, such as investment, R&D and compensation, are limited and require further analysis.

Finally, comparing the full-model to the restricted-model delivers the same central message as above. Namely, the beneficial macro effects from the dividend tax cut are more substantial in the restricted-model (see the paths of i_t, k_t, $y_t$and c_t in Fig. 12). Now, the restricted-model delivers results that differ not only quantitatively, as in the previous cases of tax cuts, but also qualitatively. In particular, profits increase so much under the restricted model relative to the full-model that the increase in investment, capital, consumption, and output becomes long-lasting, although this increase is smaller overall than in all other cases of tax cuts studied above. However, it is worth emphasising that the full-model is more empirically relevant under this policy reform. Hence, the restricted model generates artificial results due to the imposed payout restrictions.

Table 5 presents steady-state results for the full- and the restricted-model under cuts in dividend income taxes. The messages are the same as those along the transition path. In addition, a fiscal cost is again associated with the tax cut (see the fall in transfers in both models).

6.4. *Lifetime utility of tax reforms*

Table 6 reports the percent gain/loss in discounted lifetime utility expressed in terms of consumption equivalent units denoted as φ (see Appendix G for the derivation of φ in our model). Note that this table reports two versions of φ: when only consumption matters and when both consumption and leisure matter to the household. We do so because, in several cases, a regime might look superior only because of fewer work hours.

Concentrating first on the full-model, in terms of ranking, our results in Table 6 show that the capital gains tax reform yields the most significant gain in lifetime utility. This is irrespective of whether leisure matters or not. It is worth stressing here that work hours rise or leisure falls in the case of cuts in τ^k (see Fig. 11 and Table 4), which means that the increase in consumption is substantial enough to more than offset the adverse welfare implications of more work. Regarding the other two tax reforms, the welfare implications of cuts in corporate and dividend taxes are smaller. However, their differences depend on whether leisure matters: the cut in corporate taxes is better when only consumption matters (since it has a much more significant effect on the real economy), but it is worse when leisure is incorporated since higher economic activity means more work. Thus, corporate, dividend income, and capital gains tax cuts change positions depending on what happens to leisure and how GDP gains are allocated between consumption and investment.

Turning to the restricted-model when dividends are proportional to profits, we can see that lifetime utility is, as expected, higher than in the full-model. Moreover, in contrast to the welfare ranking in the latter, in the restricted-model, welfare is highest for cuts in the corporate tax, followed by the capital gains tax and then dividends tax, irrespective of whether leisure enters utility.

6.5. *Current policy*

Recent developments in the U.S. in 2025 have reinforced the relevance of our modelling framework. The renewed push for permanent tax cuts - particularly in corporate, capital gains, and dividend taxation - comes amid historically high public debt, raising questions about such policies' macroeconomic and fiscal sustainability. Our analysis is motivated by these current proposals and

Table 6
Lifetime utility, (φ%).

	Full-model		Restricted-model	
	$\varphi(c)$	$\varphi(c,l)$	$\varphi(c)$	$\varphi(c,l)$
τ^c	0.065	−0.111	0.565	0.374
τ^k	0.222	0.191	0.294	0.183
τ^d	0.034	0.030	0.101	0.063

Note: $\varphi(c)$ is when $\mu = 0$ in utility.

past reforms, such as the 2003 Jobs and Growth Tax Relief Reconciliation Act and the 2017 Tax Cuts and Jobs Act, both aimed at stimulating growth through capital and corporate tax reductions. These policy debates reflect core mechanisms in our model, particularly the role of financing, whether through reduced public spending or alternative taxation.

Shifts in corporate behaviour, especially the growing use of share buybacks over dividends, further support the need for models that allow firms to adjust their payout mix endogenously. Earlier models assuming fixed payout rules (e.g., Gourio and Miao, 2010; Karabarbounis and Neiman, 2014) miss these firm-level responses with macroeconomic consequences. Our approach, which introduces a separate market for pre-existing equity and allows optimal firm-level decisions over dividends and share repurchases, provides a more flexible and empirically grounded framework. This is particularly important considering recent findings showing that rigid payout assumptions tend to overstate the economic and welfare effects of tax reforms (e.g., Asimakopoulos et al., 2024; Chodorow-Reich et al., 2024; Farre-Mensa et al., 2014).

7. Conclusions

This paper presents a novel study on the significance of corporate payout policy in shaping firms' financial decision-making and, in turn, the macroeconomy. We explored this in the presence of various shocks commonly experienced by households and firms, such as dividend income, investment shocks, and tax reforms affecting corporate income, capital gains, and dividends.

A general result is that the payout mix, namely dividend payments and share buybacks, is essential to both firm and economy-wide outcomes. More specifically, when an exogenous adverse shock hits shareholders' dividend income, firms find it optimal to counteract it with an increase in dividend payments, where a reduction in share repurchases finances the latter, and this mix can lead to higher capital investment and profits during the duration of the shock. Under an investment efficiency shock, firms should redistribute their resources from payout to investment and exploit the increased returns to investment.

We found that tax cuts in corporate and capital gains can help the economy significantly. However, there are tradeoffs. Thus, social and political value judgments must be made. For instance, all tax cuts are associated with fiscal costs and cannot be self-financed. And the stronger the positive effect of tax cuts on GDP, the bigger their budgetary cost. Also, cuts in corporate taxes mainly stimulate profits and investment and less consumption, while the opposite holds for reductions in capital gains taxes. Finally, we found that when households and firms do not optimally use their payout policy mix, the aggregate and welfare effects of tax reform are overstated.

We close with caveats and extensions. Here, we built upon the canonical neoclassical model, which features perfect competition, market clearing, and rational forward-looking agents. Although these might be strong assumptions in the real world, we did so deliberately to make our results comparable to much of the literature. On the other hand, we realise that some simplifying assumptions of this model are particularly restrictive regarding the subject studied and hence deserve further investigation. For instance, here we worked with homogeneous households. However, the distributional implications of corporate payout policies can be significant when one distinguishes, as in the data, between those who own assets and shares and those who do not (see, e.g., Lansing, 2015 for a model of asset pricing under concentrated asset ownership in the US). Also, here we assumed that firms finance their investment only by retained earnings and shares traded in the regular and buyback markets. It would be interesting to incorporate the other two main types of corporate financing, i.e., corporate bond issuance and bank loans. These, especially the addition of private banks, could naturally allow us to add central banking and how the latter's credit policy affects bank loans to firms and hence firms' payout policies. We leave these extensions for future work.

CRediT authorship contribution statement

Stylianos Asimakopoulos: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **James Malley:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Apostolis Philippopoulos:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Appendix A. Data sources

1. The data employed in the PVAR are obtained using variables from Compustat for publicly listed firms at the major U.S. stock exchanges NYSE, AMEX, and NASDAQ excluding financial firms and utilities (Standard Industrial Classification (SIC) codes 6000–6999 and 4900–4999, respectively) because of their statutory capital requirements and other regulatory restrictions (e.g. Grullon and Michaely, 2002; DeAngelo et al., 2004). We also excluded observations with negative data for total assets (at), long-term and short-term expenditures ($capx, ivst$), dividends (dvt), share repurchases ($prstkc$), and market capitalization ($csho$ and $prccf$). Our final sample includes an unbalanced panel of 66,748 firm-year observations. Finally, we winsorized the 5th and 95th percentile of the ratios to eliminate the influence of outliers.
   (a) Dividends over assets are calculated as the ratio of total dividends (dvt) divided by total assets (at).
   (b) Share repurchases over assets are calculated as the ratio of the cash flow of purchases of common stock ($prstkc$) divided by total assets (at).
   (c) Investment to assets is calculated as the sum of short-term and long-term investments ($ivst + capx$) divided by total assets (at).

   (d) Profits to assets ratio is calculated as the after tax earnings ($ebitda - txt$) divided by total assets (at).
2. The average net capital share, $\alpha = 0.3$, is from BEA National Accounts Table 1.10, Gross Domestic Income (GDI) by Type (1929–2023). This share is computed as (GDI) net of consumption of fixed capital, taxes on production and imports net of subsidies.
3. The average capital depreciation rate on fixed assets, $\delta = 0.011$ or 0.0454 annually, is calculated using BEA Fixed Asset Accounts Table 1.1., Current-Cost Net Stock of Fixed Assets and Consumer Durable Goods (1925–2022) and Table 1.3., Current-Cost Depreciation of Fixed Assets and Consumer Durable Goods (1925–2022).
4. The targets for the corporate finance ratios in our model are obtained using the same unbalanced panel dataset as in the PVAR.
   (a) Dividends per share are calculated from Compustat as the annual average of the ratio of total dividends (dvt) divided by the number of common outstanding shares ($csho$).
   (b) The target for the average buyback to profit ratio, $\frac{e(p^e)}{\pi} = 0.088$, is calculated from Compustat as the cash flow of purchases of common stock ($prstkc$) divided by after tax earnings (calculated as $ebitda - txt$).
   (c) The target for the average investment to profit ratio, $\frac{i}{\pi} = 0.623$, is calculated from Compustat as the average of the sum of short-term and long-term investments ($ivst + capx$) divided by after tax earnings.
   (d) The target for the average dividend to profit ratio, $\frac{d}{\pi} = 0.13$, is calculated from Compustat as the average of total dividends (dvt) divided by after tax earnings.
   (e) The persistence parameter for dividends, $\rho_d = 0.68$, is obtained from an estimated AR(1) regression of the dividends to profit ratio.
5. To calculate the firm shares, we use again the publicly listed firms at the major U.S. stock exchanges NYSE, AMEX, and NASDAQ, excluding financial firms and utilities (Standard Industrial Classification (SIC) codes 6000–6999 and 4900–4999, respectively) because of their statutory capital requirements and other regulatory restrictions. In this case though we only exclude observations with negative data for total assets (at), dividends (dvt), and share repurchases ($prstkc$). Our final sample for the calculation of the firm shares includes an unbalanced panel of 170,581 firm-year observations.
6. The federal corporate tax rate, $\tau^c = 0.21$, is stipulated by the 2017 Tax Cuts and Jobs Act (TCJA), see `taxfoundation.org/data/all/state/combined-federal-state-corporate-tax-rates-2022/`.
7. The dividend tax rate, $\tau^d = 0.248$, is set equal to the income tax rate following the papers of Gourio and Miao (2010, 2011).
8. The capital gains tax rate, $\tau^k = 0.178$, is an estimate by the CBO, see www.cbo.gov/sites/default/files/113th-congress-2013-2014/reports/49817-taxingcapitalincome0.pdf.
9. The income tax rate, $\tau^y = 0.248$, for 2022 is from the OECD, see `oecd.org/tax/ tax-policy/taxing-wages-united-states.pdf`. The net average tax rate is employee personal income tax and employee social security contributions net of family benefits to gross wages.
10. The debt to GDP ratio, $\frac{b}{y} = 1.217$, for 2023 is from the Fred database and refers to gross federal debt as a share of GDP; see `fred.stlouisfed.org/series/GFDEGDQ188S`.

Appendix B. PVAR diagnostic tests

See Tables B.1, B.2 and B.3.

Table B.1
Selection order criteria.

lag	J-test	J p-value	MBIC	MAIC	MQIC
1	188.81	3.02e − 14	− 487.66	60.812	− 113.01
2	41.374	0.739	− 465.98	− 54.626	− 185.00
3	17.028	0.986	− 321.21	− 46.973	− 133.89

Table B.2
Eigenvalues.

	1	2	3	4
Modulus	0.7672	0.7672	0.5850	0.4421
	5	6	7	8
Modulus	0.1476	0.1246	0.1246	0.0990

Table B.3
PVAR granger-causality wald test.

Equation	Excluded	χ^2	p-value
Investment			
	Buybacks	40.535	0.000
	Dividends	54.135	0.000
	Profits	226.38	0.000
Buybacks			
	Investment	91.247	0.000
	Dividends	49.070	0.000
	Profits	1.437	0.487
Dividends			
	Investment	103.37	0.000
	Buybacks	10.484	0.000
	Profits	63.076	0.000
Profits			
	Investment	41.729	0.000
	Buybacks	62.154	0.000
	Dividends	34.029	0.000

Appendix C. The value function of the firm

In Eq. (13) of the main text, we defined the value of the firm at the beginning of $t+1$ as:

$$V_{t+1} \equiv \left[\left(1-e_{t+1}\right) p^s_{t+1} + e_{t+1} p^e_{t+1} - \frac{\chi (e_{t+1})^2 s_t}{1-\tau^k_{t+1}} + \frac{\left(1-\tau^d_{t+1}\right)\left(1-e_{t+1}\right) d_{t+1}}{1-\tau^k_{t+1}} \right] s_t. \tag{C.1}$$

Recall that the no-arbitrage condition from the household's problem in (8) is:

$$\left(1-\tau^d_{t+1}\right)\left(1-e_{t+1}\right) d_{t+1} + \left(1-\tau^k_{t+1}\right)\left[\left(1-e_{t+1}\right) p^s_{t+1} + e_{t+1} p^e_{t+1} - p^s_t\right] - \chi (e_{t+1})^2 s_t = \left(1-\tau^y_{t+1}\right) r^b_t p^s_t. \tag{C.2}$$

Using this condition in (C.1), we get:

$$\frac{V_{t+1}}{1+\frac{(1-\tau^y_{t+1}) r^b_t}{\left(1-\tau^k_{t+1}\right)}} = p^s_t s_t, \tag{C.3}$$

so that the firm's value at the beginning of $t+1$ is the discounted value of its market equity value at the end of t (see also the early literature as summarized by e.g. Turnovsky (2000).

Adding and subtracting the terms $e_t p_t s^s_t$, $e_t p^e_t s_t$, $\frac{\chi(e_t s_{t-1}) e_t s_t}{(1-\tau^k_t)}$ and $\frac{(1-\tau^y_t)(1-e_t) d_t s_t}{(1-\tau^k_t)}$ on the RHS of (C.3), and since by definition at each t:

$$V_t \equiv \left[\left(1-e_t\right) p^s_t + e_t p^e_t - \frac{\chi\left(e_t s_{t-1}\right) e_t}{(1-\tau^k_t)} + \frac{\left(1-\tau^d_{t+1}\right)\left(1-e_t\right) d_t}{\left(1-\tau^k_t\right)} \right] s_{t-1}, \tag{C.4}$$

we obtain:

$$V_t = \frac{\left(1-\tau^d_t\right)}{\left(1-\tau^k_t\right)}\left(1-e_t\right) d_t s_{t-1} + e_t (p^e_t - p^s_t) s_{t-1} - \frac{\chi\left(e_t s_{t-1}\right) e_t}{1-\tau^k_t} + \frac{V_{t+1}}{1+\frac{\left(1-\tau^y_{t+1}\right) r^b_t}{\left(1-\tau^k_{t+1}\right)}} \frac{s_{t-1}}{s_t}, \tag{C.5}$$

which is Eq. (14) in the main text.

Appendix D. Equilibrium conditions

Household

$$c_t + b_t + p^s_t + \Phi^e_t \equiv \left(1-\tau^y_t\right) w_t l_t + \left[1+\left(1-\tau^y_t\right) r^b_{t-1}\right] b_{t-1} + g_t + \left(1-\tau^d_t\right)\left(1-e_t\right) d_t + \left(1-e_t\right) p^s_t + e_t p^e_t - \tau^k_t \left\{\left(1-e_t\right) p^s_t + e_t p^e_t - p^s_{t-1}\right\} \tag{D.1}$$

$$\frac{c_{t+1}}{c_t} = \beta\left[1+\left(1-\tau^y_{t+1}\right) r^b_t\right] \tag{D.2}$$

$$\frac{c_{t+1}}{c_t}=\beta\left[\frac{\left(1-\tau^d_{t+1}\right)\left(1-e_{t+1}\right)d_{t+1}+\left(1-e_{t+1}\right)p^s_{t+1}+e_{t+1}p^e_{t+1}}{p^s_t}-\frac{\chi(e_{t+1})^2}{p^s_t}-\frac{\tau^k_{t+1}\left\{\left(1-e_{t+1}\right)p^s_{t+1}+e_{t+1}p^e_{t+1}-p^s_t\right\}}{p^s_t}\right] \tag{D.3}$$

$$p^e_t=p^s_t+\left(\frac{1-\tau^d_t}{1-\tau^k_t}\right)d_t+\frac{\chi e_t}{1-\tau^k_t} \tag{D.4}$$

$$\mu(l_t)^{\frac{1}{v}}=\frac{\left(1-\tau^y_t\right)w_t}{c_t} \tag{D.5}$$

Firm

$$(1-e_t)d_t=(1-\tau^c_t)(y_t-w_tl_t)+\tau^c_t\delta k_{t-1}-e_t(p^e_t-p^s_t)-i_t-\Phi^k_t-\Phi^d_t-\Phi^e_t \tag{D.6}$$

$$Z_ti_t\equiv k_t-(1-\delta)k_{t-1} \tag{D.7}$$

$$y_t\equiv Ak^a_{t-1}l^{1-a}_t \tag{D.8}$$

$$v_t\left[\left(1-e_t\right)+\phi\left(\frac{d_t}{\pi_t}-\rho_d\frac{d_{t-1}}{\pi_{t-1}}\right)\frac{1}{\pi_t}\right]=\left(\frac{1-\tau^d_t}{1-\tau^k_t}\right)\left(1-e_t\right)+\frac{v_{t+1}\phi}{\left[1+\frac{\left(1-\tau^y_{t+1}\right)r^b_t}{1-\tau^k_{t+1}}\right]}\left(\frac{d_{t+1}}{\pi_{t+1}}-\rho_d\frac{d_t}{\pi_t}\right)\frac{\rho_d}{\pi_t} \tag{D.9}$$

$$w_t=\frac{(1-a)y_t}{l_t} \tag{D.10}$$

$$Z_tm_t=v_t\left(1+\theta\frac{i_t}{k_{t-1}}\right) \tag{D.11}$$

$$\begin{aligned}m_t={}&\frac{m_{t+1}}{\left[1+\frac{(1-\tau^y_{t+1})r^b_t}{1-\tau^k_{t+1}}\right]}(1-\delta)+\frac{v_{t+1}}{\left[1+\frac{(1-\tau^y_{t+1})r^b_t}{1-\tau^k_{t+1}}\right]}\left[(1-\tau^c_{t+1})\frac{ay_{t+1}}{k_t}+\tau^c_{t+1}\delta+\theta\left(\frac{i_{t+1}}{k_t}\right)^2+\phi\left(\frac{d_{t+1}}{\pi_{t+1}}-\rho_d\frac{d_t}{\pi_t}\right)\frac{d_{t+1}}{(\pi_{t+1})^2}\frac{\left(1-\tau^c_{t+1}\right)ay_{t+1}}{k_t}\right]\\&-\frac{v_{t+2}}{\left[1+\frac{(1-\tau^y_{t+1})r^b_t}{1-\tau^k_{t+1}}\right]\left[1+\frac{(1-\tau^y_{t+2})r^b_{t+1}}{1-\tau^k_{t+2}}\right]}\phi\left(\frac{d_{t+2}}{\pi_{t+2}}-\rho_d\frac{d_{t+1}}{\pi_{t+1}}\right)\frac{\rho_d d_{t+1}}{(\pi_{t+1})^2}\frac{\left(1-\tau^c_{t+1}\right)ay_{t+1}}{k_t}\end{aligned} \tag{D.12}$$

$$v_t\chi e_t+\frac{2\chi e_t}{1-\tau^k_t}=v_td_t+(1-v_t)(p^e_t-p^s_t)-\left(\frac{1-\tau^d_t}{1-\tau^k_t}\right)d_t \tag{D.13}$$

Government

$$\tau^d_t(1-e_t)d_t+\tau^y_t[w_tl_t+r^b_{t-1}b_{t-1}]+\tau^k_t[\left(1-e_t\right)p^s_t+e_tp^e_t-p^s_{t-1}]+\tau^c_t\left(y_t-w_tl_t\right)+b_t\equiv\left(1+r^b_{t-1}\right)b_{t-1}+g_t+\tau^c_t\delta k_{t-1} \tag{D.14}$$

where in the above equations we use: $\Phi^k_t\equiv\frac{\theta}{2}\frac{(i_t)^2}{k_{t-1}}$;$\Phi^d_t\equiv\frac{\phi}{2}\left(\frac{d_t}{\pi_t}-\rho_d\frac{d_{t-1}}{\pi_{t-1}}\right)^2$; $\Phi^e_t\equiv\frac{\chi}{2}\left(e_t\right)^2$, and $\pi_t\equiv\left(1-\tau^c_t\right)\left(y_t-w_tl_t\right)$. Also, as discussed in the main text, Z_t in (D.7) and (D.11) is the MEI shock. Therefore, we have 14 equations in the paths of c_t, l_t, p^s_t, p^e_t, r^b_t, d_t, y_t, w_t, k_t, i_t, e_t,v_t,m_t,b_t (or g_t instead of b_t).

Appendix E. Dividend shock

Adding a multiplicative shock, ω_t, to household income from dividends in its budget constraint, (D.1), leads to the following changes in the equilibrium conditions presented in Appendix D.

$$c_t + b_t + p_t^s + \Phi_t^e \equiv \left(1 - \tau_t^y\right) w_t l_t + [1 + \left(1 - \tau_t^y\right) r_{t-1}^b] b_{t-1} + g_t + \left(1 - \tau_t^d\right)\left(1 - e_t\right)\omega_t d_t + \left(1 - e_t\right) p_t^s + e_t p_t^e - \tau_t^k \left\{\left(1 - e_t\right) p_t^s + e_t p_t^e - p_{t-1}^s\right\} \tag{D.1'}$$

$$\frac{c_{t+1}}{c_t} = \beta \left[\frac{\left(1 - \tau_{t+1}^d\right)\left(1 - e_{t+1}\right)\omega_{t+1} d_{t+1} + \left(1 - e_{t+1}\right) p_{t+1}^s + e_{t+1} p_{t+1}^e}{p_t^s} - \frac{\chi (e_{t+1})^2}{p_t^s} - \frac{\tau_{t+1}^k \{\left(1 - e_{t+1}\right) p_{t+1}^s + e_{t+1} p_{t+1}^e - p_t^s\}}{p_t^s}\right] \tag{D.3'}$$

$$p_t^e = p_t^s + \left(\frac{1 - \tau_t^d}{1 - \tau_t^k}\right)\omega_t d_t + \frac{\chi e_t}{1 - \tau_t^k} \tag{D.4'}$$

$$(1 - e_t)\omega_t d_t \equiv (1 - \tau_t^c)(y_t - w_t l_t) + \tau_t^c \delta k_{t-1} - e_t(p_t^e - p_t^s) - i_t - \Phi_t^k - \Phi_t^d - \Phi_t^e \tag{D.6'}$$

$$v_t \left[\left(1 - e_t\right)\omega_t + \phi\left(\frac{d_t}{\pi_t} - \rho_d \frac{d_{t-1}}{\pi_{t-1}}\right)\frac{1}{\pi_t}\right] = \left(\frac{1 - \tau_t^d}{1 - \tau_t^k}\right)\left(1 - e_t\right)\omega_t + \frac{v_{t+1}\phi}{\left[1 + \frac{\left(1 - \tau_{t+1}^y\right) r_t^b}{1 - \tau_{t+1}^k}\right]}\left(\frac{d_{t+1}}{\pi_{t+1}} - \rho_d \frac{d_t}{\pi_t}\right)\frac{\rho_d}{\pi_t} \tag{D.9'}$$

$$v_t \chi e_t + \frac{2\chi e_t}{1 - \tau_t^k} = v_t \omega_t d_t + (1 - v_t)(p_t^e - p_t^s) - \left(\frac{1 - \tau_t^d}{1 - \tau_t^k}\right)\omega_t d_t \tag{D.13'}$$

$$\tau_t^d (1 - e_t)\omega_t d_t + \tau_t^y [w_t l_t + r_{t-1}^b b_{t-1}] + \tau_t^k [\left(1 - e_t\right) p_t^s + e_t p_t^e - p_{t-1}^s] + \tau_t^c \left(y_t - w_t l_t\right) + b_t \equiv \left(1 + r_{t-1}^b\right) b_{t-1} + g_t + \tau_t^c \delta k_{t-1} \tag{D.14'}$$

Appendix F. Special cases

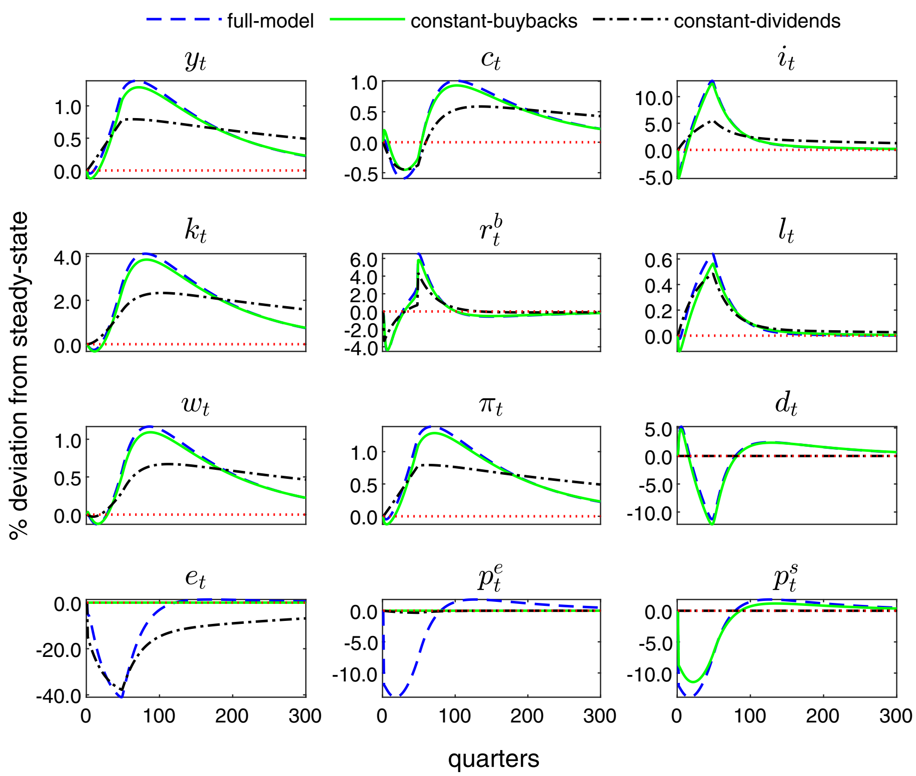

Fig. F1. 35 % fall in effective dividends over 12 years.

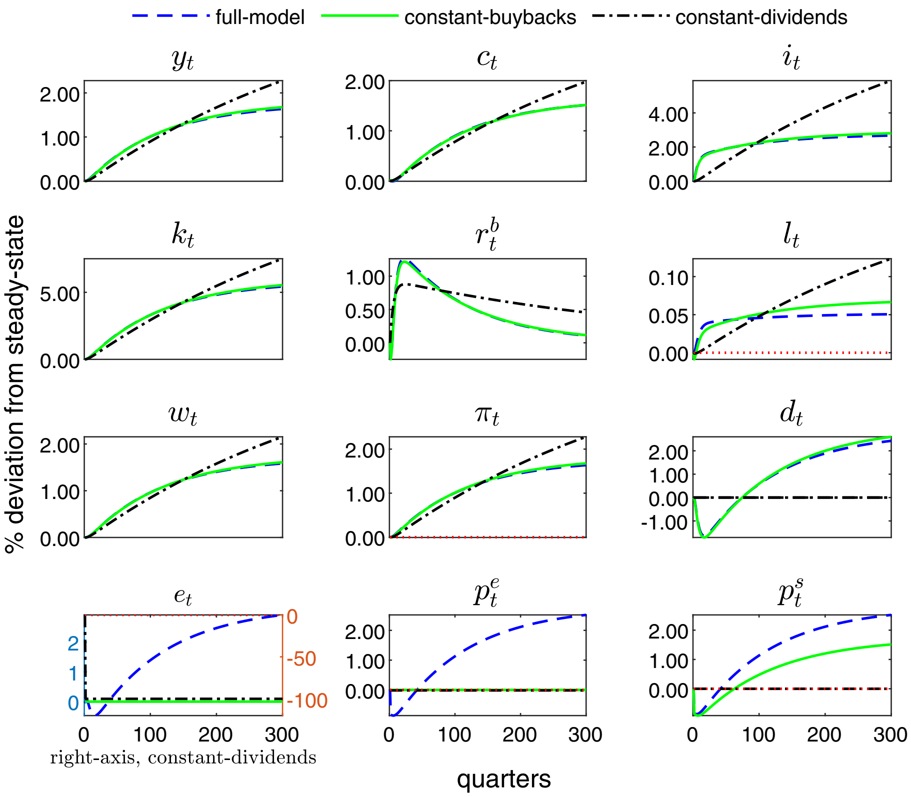

Fig. F2. 1σ Permanent shock to MEI.

Appendix G. Social welfare

To calculate social welfare, W_t, we work as in, e.g. Schmitt-Grohé and Uribe (2007), Sims and Wolff (2018), Malley and Philippopoulos (2023), by adding a Bellman-type recursive specification of welfare to our equilibrium conditions:

$$W_t = u_t + \beta W_{t+1} \text{ or } W_{t+1} = \frac{W_t - u_t}{\beta}, \tag{G.1}$$

where, u_t is the period utility function in Eq. (2) and, by definition, the value function at say $t = 0$ is $W_0 = \sum_{t=0}^{T} \beta^t \left(\log c_t - \mu \frac{(l_t)^{1+\frac{1}{\nu}}}{1+\frac{1}{\nu}} \right)$ which is the PDV of lifetime utilities.

For our quantitative analysis, we define the status quo welfare as the value had we stayed forever in the initial steady-state (ss), i.e., $W_{ss} = \frac{u_{ss}}{1-\beta}$. In contrast, to assess the welfare accruing from various exogenous policy reforms starting in period 1, we compute the time path of $\{W_t\}_{t=0}^{\infty}$ and use its value at $t = 1$ (which is the first period of the reformed economy), W_1, to measure the discounted life-time utility due to policy changes. Then, working as in the related literature, we define a permanent and constant over time consumption subsidy, φ, provided at the status quo regime that solves the equation:

$$W_1 = \frac{\log[(1+\varphi)c_{ss}] - \mu \frac{(l_{ss})^{1+\frac{1}{\nu}}}{1+\frac{1}{\nu}}}{1-\beta} = \frac{\log(1+\varphi) + u_{ss}}{1-\beta} = \frac{\log(1+\varphi)}{1-\beta} + W_{ss}, \tag{G.2}$$

which gives for φ:

$$\varphi = \left(e^{(1-\beta)(W_1 - W_{ss})} - 1 \right) \times 100. \tag{G.3}$$

Appendix H. Equilibrium conditions (restricted-model)

$$c_t + b_t + p^s_t \equiv \left(1-\tau^y_t\right) w_t l_t + \left[1 + \left(1-\tau^y_t\right) r^b_{t-1}\right] b_{t-1} + g_t + \left(1-\tau^d_t\right) d_t + p^s_t + e_t - \tau^k_t \left(p^s_t + e_t - p^s_{t-1}\right) \tag{H.1}$$

$$\frac{c_{t+1}}{c_t} = \beta \left[1 + \left(1-\tau^y_{t+1}\right) r^b_t\right] \tag{H.2}$$

$$\frac{c_{t+1}}{c_t} = \beta\left[\frac{\left(1-\tau^d_{t+1}\right)d_{t+1} + p^s_{t+1} + e_{t+1} - \tau^k_{t+1}\left(p^s_{t+1} + e_{t+1} - p^s_t\right)]}{p^s_t}\right] \tag{H.3}$$

$$\mu(l_t)^{\frac{1}{v}} = \frac{\left(1-\tau^y_t\right)w_t}{c_t} \tag{H.4}$$

$$i_t \equiv k_t - (1-\delta)k_{t-1} \tag{H.5}$$

$$y_t \equiv Ak^a_{t-1}l^{1-a}_t \tag{H.6}$$

$$d_t \equiv \xi\left[\left(1-\tau^c_t\right)\left(y_t - w_t l_t\right) + \tau^c_t \delta k_{t-1} - \Phi^k_t - \Phi^d_t\right] \tag{H.7}$$

$$e_t \equiv \left(1-\xi\right)\left[\left(1-\tau^c_t\right)\left(y_t - w_t l_t\right) + \tau^c_t \delta k_{t-1} - \Phi^k_t - \Phi^d_t\right] - i_t \tag{H.8}$$

$$v_t\left[1+\xi\phi\left(\frac{d_t}{\pi_t} - \rho_d\frac{d_{t-1}}{\pi_{t-1}}\right)\frac{1}{\pi_t}\right] + (1-\xi)\phi\left(\frac{d_t}{\pi_t} - \rho_d\frac{d_{t-1}}{\pi_{t-1}}\right)\frac{1}{\pi_t} = \frac{1-\tau^d_t}{1-\tau^k_t} + \frac{\left[v_{t+1}\xi + \left(1-\xi\right)\right]}{\left[1+\frac{\left(1-\tau^y_{t+1}\right)r^b_t}{1-\tau^k_{t+1}}\right]}\phi\left(\frac{d_{t+1}}{\pi_{t+1}} - \rho_d\frac{d_t}{\pi_t}\right)\frac{\rho_d}{\pi_t} \tag{H.9}$$

$$w_t = \frac{(1-a)y_t}{l_t} \tag{H.10}$$

$$m_t = v_t\xi\theta\frac{i_t}{k_{t-1}} + \left[1 + (1-\xi)\theta\frac{i_t}{k_{t-1}}\right] \tag{H.11}$$

$$\begin{aligned} m_t = {} & \frac{m_{t+1}}{\left[1+\frac{(1-\tau^y_{t+1})r^b_t}{1-\tau^k_{t+1}}\right]}(1-\delta) + \frac{[v_{t+1}\xi + (1-\xi)]}{\left[1+\frac{(1-\tau^y_{t+1})r^b_t}{1-\tau^k_{t+1}}\right]}\left[(1-\tau^c_{t+1})\frac{ay_{t+1}}{k_t} + \tau^c_{t+1}\delta + \theta\left(\frac{i_{t+1}}{k_t}\right)^2 + \phi\left(\frac{d_{t+1}}{\pi_{t+1}} - \rho_d\frac{d_t}{\pi_t}\right)\frac{d_{t+1}}{(\pi_{t+1})^2}\frac{\left(1-\tau^c_{t+1}\right)ay_{t+1}}{k_t}\right] \\ & - \frac{[v_{t+2}\xi + (1-\xi)]}{\left[1+\frac{(1-\tau^y_{t+1})r^b_t}{1-\tau^k_{t+1}}\right]\left[1+\frac{(1-\tau^y_{t+2})r^b_{t+1}}{1-\tau^k_{t+2}}\right]}\phi\left(\frac{d_{t+2}}{\pi_{t+2}} - \rho_d\frac{d_{t+1}}{\pi_{t+1}}\right)\frac{\rho_d d_{t+1}}{(\pi_{t+1})^2}\frac{\left(1-\tau^c_{t+1}\right)ay_{t+1}}{k_t} \end{aligned} \tag{H.12}$$

$$\tau^y_t(w_t l_t + r^b_{t-1}b_{t-1}) + \tau^d_t d_t + \tau^k_t(p^s_t + e_t - p^s_{t-1}) + \tau^c_t(y_t - w_t l_t) + b_t \equiv (1+r^b_{t-1})b_{t-1} + g_t + \tau^c_t\delta k_{t-1} \tag{H.13}$$

where in the above equations we use: $\Phi^k_t \equiv \frac{\theta}{2}\frac{(i_t)^2}{k_{t-1}}$; $\Phi^d_t \equiv \frac{\phi}{2}\left(\frac{d_t}{\pi_t} - \rho_d\frac{d_{t-1}}{\pi_{t-1}}\right)^2$; and $\pi_t \equiv \left(1-\tau^c_t\right)\left(y_t - w_t l_t\right)$. Therefore, we have 13 equations in the paths of $c_t, l_t, p^s_t, r^b_t, d_t, y_t, w_t, k_t, i_t, e_t, v_t, m_t, g_t$ (or b_t instead of g_t).

Data availability

Data will be made available on request.

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