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On the Macroeconomic and Fiscal Effects of the Tax Cuts and Jobs Act

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Abstract

There is substantial disagreement about the consequences of the Tax Cuts and Jobs Act (TCJA) of 2017, which constitutes the most extensive tax reform in the United States in more than 30 years. Using a large-scale two-country dynamic general equilibrium model with nominal rigidities, we find that the TCJA increases GDP by about 2% in the medium-run and by about 2.5% in the long-run. The short-run impact depends crucially on the degree and costs of variable capital utilization, with GDP effects ranging from 1 to 3%. At the same time, the TCJA does not pay for itself. In our analysis, the reform decreases tax revenues and raises the debt-to-GDP ratio by about 15 percentage points in the medium-run until 2025. We show that combining the TCJA with spending cuts can dampen the increase in government indebtedness without reducing its expansionary effect.

Keywords: Tax reform, corporate taxes, capital taxes, labor income taxes, spending cuts, fiscal stimulus.

JEL Classification: E62, E63, E65.

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1 Introduction

The Tax Cuts and Jobs Act (TCJA) of 2017 constitutes the most extensive change of the U.S. tax system in more than 30 years. The most prominent element is the immediate and permanent reduction of the statutory tax rate on corporate profits from 35% to 21%. It also includes a temporary allowance for investment expensing of certain classes of capital and other changes that affect the tax base. These changes lower the effective marginal tax rate on new investment. Further important provisions aim to influence the behavior of multinational companies. These provisions encourage repatriation of profits and limit possibilities for profit shifting out of the United States. Finally, the bill also lowers personal income tax rates. For example, the top rate declines from 39.6% to 37%. However, these income tax cuts will largely expire by the end of 2025.

The Trump Administration expects the TCJA to lead to a substantial boost in GDP as well as a significant increase in employment and wages. Furthermore, it anticipates the bill to be revenue-neutral due to its expansionary effects. The Council of Economic Advisors (2017, 2018) estimates that the corporate income tax cut alone would generate an increase in GDP of between 1.3 and 1.6% in the short run and 2 to 4% in the long run based on a review of the empirical literature on the effects of tax changes.

The aim of this paper is to assess the impact of the TCJA on the economy. To this end, we use a structural macroeconomic model with microeconomic foundations and price and wage rigidities. This allows us to quantify the impact on GDP, consumption and investment in the United States, while accounting for general equilibrium effects. We also analyze the tax reform's implications concerning U.S. government debt as well as spillovers to the euro area. Finally, we consider alternative tax reform scenarios that would achieve the same GDP impact while resulting in a smaller increase in the government debt-to-GDP ratio.

Our model is a New Keynesian dynamic stochastic general equilibrium (DSGE) model of the U.S. and euro area economies. We build on the model developed in Coenen et al. (2008) and extend it to account for the features of the TCJA. The model structure has many similarities with the New-Area-Wide Model used at the European Central Bank (Christoffel et al., 2008). It can be classified as a New Keynesian DSGE model of the second generation (Binder et al., 2019). As such, it considers optimizing forward-looking households and firms that are making decisions in an environment characterized by monopolistic competition, nominal wage and price rigidities, and other real economic frictions and adjustment costs. Monetary policy has temporary real effects. The model also includes features such as habit formation that are typically associated with behavioral economics as well as constraints on access to financial instruments for some households.

The fiscal sector of the model accounts for taxation on labor income, capital income, dividends and consumption. We extend the model by introducing the share of the capital stock that is eligible for depreciation allowances as an additional fiscal choice variable. Thus, our analysis is capable of differentiating statutory and effective capital tax rates. We match the path of fiscal policy instruments to evidence available for the TCJA. In particular, we take into account the reduction of the statutory corporate tax rate together with estimates of the path for the effective corporate tax rate and the average effective personal income tax rate.

Our model simulations yield the following ceteris-paribus results. As a consequence of the reduction in statutory and effective tax rates, U.S. GDP increases by about 2.5% in the long-run. This would be within the range claimed by the CEA for the corporate tax cut, but below its mid-point. Yet, the tax reduction comes at the cost of higher government indebtedness. The government debt-to-GDP ratio rises by close to 9 percentage points in the long-run. If the reduction in effective tax rates were to be permanent, the long-run effect on GDP in our model comes to a bit more than 5.5%, with the debt-to-GDP ratio stabilizing close to 19 percentage points above the initial level.

Short-to-medium run effects are found to depend importantly on the extent to which capital utilization is variable. In the version of our model with variable capital utilization, GDP increases by almost 3% in 2019 and then falls back to a level of about 2% above the starting point by 2022. Investment and consumption both rise on impact by about 1% (in terms of GDP). The capital stock only rises slowly. The rapid increase in production is made possible by a surge in capital utilization and hours worked. Wages go up, such that labor supply rises accordingly. As a result, consumption can increase along with investment. Due to lower tax revenue, the primary deficit rises substantially and the debt-to-GDP ratio goes up by a bit more than 15 percentage points by 2025.

If we restrict the model parameterization such that capital utilization remains constant, the short- to medium run effects of the tax cut on consumption and investment turn out to be quite different. Consumption initially declines such that more savings can be channeled towards investment. Thus, the capital stock increases more quickly than with variable capital utilization. GDP rises more slowly but steadily over a period of about five years. By that time it comes close to the long-run impact, which is, of course, the same for both versions of the model.

The assumption of variable capital utilization was originally introduced in a real-business-cycle (RBC) macroeconomic framework by Greenwood et al. (1988). It has become a standard ingredient of medium-size DSGE models that are estimated to fit U.S. economic data. Christiano et al. (2005) show that variable capital utilization serves to dampen sharp movements of the rental rate of capital following shocks. This reduces the investment response and helps to explain empirically observed inertia in inflation and output following monetary policy shocks. With regard to the effects of changes in tax rates, our results with variable capital utilization help to explain some findings in the empirical literature on tax reforms. For example, recent studies by the OECD (Arnold

2011, OECD 2010) suggest that a lower share of corporate taxes in total tax revenue would raise GDP growth significantly, with the effect being estimated under a constant capital stock. Such an effect would require variable capital utilization.

Monetary policy has only a modest influence on GDP dynamics following the tax cut. This is because the tax cut raises the economy's long-run potential and has only moderate effects on inflation. Near-term spillover effects to the euro area range from near zero under constant capital utilization to around 1% of GDP under variable capital utilization.

The rest of the paper is organized as follows. First, we briefly discuss some related literature. Section 3 reviews selected elements of the TCJA in a bit more detail. Section 4 provides an overview of the main features of the model and discusses how the tax changes are modeled. In Section 5, we present the baseline results regarding the impact of the TCJA under the assumptions of constant and variable capital utilization. Section 6 presents further sensitivity analysis, while Section 7 considers alternative tax reform scenarios. Section 8 concludes.

2 Some related literature

This paper builds on and extends a literature investigating the quantitative effects of fiscal stimulus measures in state-of-the-art structural macroeconomic models. This includes stimulus measures enacted in the last decade as well as proposals that did not pass U.S. Congress. For example, Cogan et al. (2010), Coenen et al. (2012) and Drautzburg and Uhlig (2015) evaluate the fiscal multiplier associated with the American Recovery and Reinvestment Act (ARRA) of 2009 under the Obama administration. Cogan et al. (2013a,b) investigate the macroeconomic effects of the 2012 Budget Resolution passed by the U.S. House of Representatives and the House Budget Committee Plan of 2013.

Auerbach (2018) and Slemrod (2018) provide thorough overviews of the tax cut and reform measures implied by the TCJA against the background of the history and political economy of the U.S. tax system. A number of studies aim to gauge the overall effects of the TCJA quantitatively. Barro and Furman (2018) use a simple neoclassical model to estimate a long-run increase of GDP per capita by 0.9% and a revenue reduction by 0.5% of GDP. If the tax cuts under the TCJA were made permanent, their results imply an increases of GDP by 3.1% and a reduction of revenues by 0.7% of GDP. The Penn Wharton Budget Model (2017a) employs an overlapping-generations-framework and finds that output increases by 0.7-1.6% until 2040. Over the same period, government debt rises by 2.2 to 3.5 trillion U.S. Dollars, that is, appproximately 11 to 17% of current U.S. GDP. The Joint Committee on Taxation (2017b) averages over a range of methods. It obtains a long-run GDP effect close to zero, while revenues decrease by 0.5% of GDP over a ten-year window. The Tax Foundation (2018) uses a static general equilibrium model to estimate a long-run stimulative effect on GDP of 1.7% (2.6% with permanent provisions). Bhattarai et al. (2018) employ a closed-economy real-business cycle model. Their model suggests that the capital tax cut alone would generate a long-term increase of output by 8.4%. Zeida (2018) uses a life-cycle model with entrepreneurial human capital. They suggest an effect on the average GDP growth rate of 0.6% over the first ten years. Gale et al. (2017) review a range of assessments of the short- and medium-run effects of the TCJA on GDP. They conclude that estimates range from 0.3 to 0.9% of GDP in the short-run until 2020, and from 0.1 to 2.9% in the medium-run until 2027.

To our knowledge, this is the first paper that evaluates the impact of TCJA in a medium-scale dynamic stochastic general equilibrium open-economy model with many nominal and real rigidities. Nominal rigidities are important for evaluating short-run effects as well as the interaction of monetary and fiscal policy. The DSGE approach ensures that short- to medium-run dynamics due to nominal rigidities are consistent with the medium- to longer-run dynamics due to the real-business cycle framework with capital accumulation that is at the core of the model. Additionally, the two-country model makes it possible to gauge international transmission and spill-over effects from the U.S. economy.

3 Key elements of the Tax Cuts and Jobs Act

The TCJA was written in public law no. 115-97, signed by President Trump on December 22, 2017 and largely effective as of Januar 1, 2018.[1] It includes over 100 individual provisions. There are two key blocks that we will evaluate in our model: The reduction in corporate taxes and the individual income tax cut. We try to account for the numerous tax provisions by modelling changes in statutory and effective tax rates. Our analysis abstracts from the changes to the taxation of multinationals that are meant to encourage profit repatriation and limit possibilities for profit shifting.

3.1 Corporate Taxes

The TCJA altered the corporate tax system by decreasing the corporate tax rate and modifying associated depreciation and deduction allowances. The statutory corporate income tax rate was cut from 35% to 21%.[2] Thus, a given taxable profit is now subject to a lower rate under TCJA-law. Taxable profit is defined as the entire gross profit from all sources (i.e. sale of goods and services, rents, interest, dividends,...) minus depreciation allowances and permitted deductions. The latter encompass a wide variety of expenditures, e.g. wages, non-federal income tax and contributions to employee pension plans.

[1]The whole bill is available at `https://rules.house.gov/conference-report/hr-1`.

[2]A previously planned decrease to 20% was changed to 21% by the Congress shortly before the final agreement.

Other expenditures such as dividends are not allowed as deductions (Joint Committee on Taxation, 2018).

The TCJA expands some of these depreciation and deduction allowances. It also repeals the alternative minimum tax on corporations, which was applicable if the regular corporate tax liability fell below 20% of the taxable income.[3] With more generous depreciation and deduction allowances, the share of corporate income subject to taxation decreases. Thus, in the presence deduction and depreciation allowances the statutory top rate is not the actual rate paid by corporations on their gross profit. A more accurate measure is the effective corporate tax rate (ECTR), which is defined as corporate taxes paid divided by pre-tax book income (i.e. pre-tax financial income or gross profit). In simplified terms[4], the ECTR can be calculated as outlined by the US Department of the Treasury (2016):

$$ECTR = \frac{\text{Corporate taxes paid}}{\text{Book income + U.S./state/local/foreign tax expenses}} \tag{1}$$

The US Department of the Treasury (2016) reports that the average ECTR across all industries from 2007-2011 was 22%, and 20.5% in 2017 according to estimates of the Penn Wharton Budget Model (2017b). This is well below the statutory pre-TCJA rate of 35% and only slightly above the alternative minimum tax rate.[5] For the analysis at hand, focusing on the statutory rate alone would be misleading with regard to the actual level of corporate taxation and would not allow us to incorporate the extension of depreciation and deduction allowances due to the TCJA.

The cut in the statutory corporate tax rate is envisaged to be permanent as of 2018.[6] By contrast, the extension of the depreciation and deduction allowances are so-called "sunset" provisions, meaning that as of current law, these are temporary changes. Most of the sunset provisions are phased-out by 2027. This is likely to cause considerable time-variation in the average effectively paid corporate tax rate in the upcoming years. According to the Penn Wharton Budget Model (2017b) the average ECTR would have increased to about 24% in 2020 under pre-TCJA law, followed by a gradual return to 21.9% in 2040, as as shown in **Figure 1**. By contrast, calculations with this model imply that the TCJA leads to a strong decline of the ECTR in 2018 by about twelve percentage points down to 9.1%. This reduction mirrors almost fully the fourteen percentage point

[3]The alternative minimum tax was introduced in the Tax Reform Act of 1986, the second of the two "Reagan tax cuts", along with a reduction of depreciation allowances (Joint Committee on Taxation, 2007).

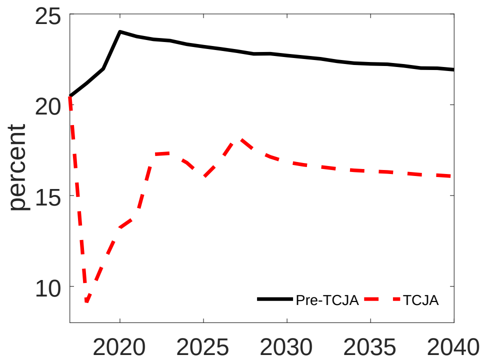
[4]The formula abstracts from the tax value of net operating loss deductions, which are losses carried over from previous years, and would appear in the numerator. In the denominator, it abstracts from foreign withholding taxes and taxes on repatriated income.

[5]According to the Penn Wharton Budget Model (2017b), there is a substantial degree of heterogeneity across industries, with the service industry featuring the maximum ECTR of 28%, compared to only 10% in the utilities industry.

[6]The House of Representatives' version contained a delay of the corporate tax cut to 2019.

cut in the statutory rate. From 2018 to 2021, the ECTR increases again, in line with the pre-TCJA ECTR, to a rate of 13.9%.

Figure 1: Estimated Effective Corporate Tax Rate



Note: Average effective corporate tax rates across all industries as estimated by the Penn Wharton Budget Model (2017b).

Starting in 2023, depreciation allowances are gradually phased-out, leading to a further rise in the average ECTR. According to this analysis, the long-run reduction in the ECTR due to the TCJA comes only to about six percentage points by 2030. It is possible, however, that the expiration of deductions and depreciation allowances may still be postponed in the future.

3.2 Individual Income Taxes

The TCJA also implies a reform of individual income taxation, in particular with respect to tax brackets, standard deductions and exemptions. In general, income subject to individual taxation in the U.S. corresponds to taxpayer's total gross income (from wages, dividends, capital gains, rents,...) less allowable exclusions, exemptions and deductions. Exclusions and deductions include, among others, pension contributions, employer-provided health insurance and capital losses incurred. Total gross income minus exclusions, exemptions and deductions yields the individual's adjusted gross income (AGI). The taxable income is then calculated by applying a standard deduction or itemized deductions to the AGI.[7] Taxable income is sorted into seven income brackets, which are subject to a progressively increasing marginal tax rate.

The TJCA implies a number of changes of income taxation. Income tax rates were

[7] According to Joint Committee on Taxation (2018), nowadays the vast majority of individuals chooses the standard deduction (135 million versus 20 million opting for itemized deductions).

cut and income bracket thresholds changed.[8,9] Table 1 shows the respective tax brackets and rates for single individuals before and after TCJA. Income bracket thresholds for household heads and married couples filing joint returns are generally higher, but the associated tax rates are the same.

Table 1: Individual Income Tax Brackets

	Pre-TCJA		TCJA	
Bracket	Taxable Income	Tax Rate	Taxable Income	Tax Rate
1	$\leq \$9,325$	10.0%	$\leq \$9,525$	10.0%
2	$\$9,326 - \$37,950$	15.0%	$\$9,526 - \$38,700$	12.0%
3	$\$37,951 - \$91,900$	25.0%	$\$38,701 - \$82,500$	22.0%
4	$\$91,901 - \$191,650$	28.0%	$\$82,501 - \$157,500$	24.0%
5	$\$191,651 - \$416,700$	33.0%	$\$157,501 - \$200,000$	32.0%
6	$\$416,701 - \$418,400$	35.0%	$\$200,001 - \$500,000$	35.0%
7	$> \$418,400$	39.6%	$> \$500,000$	37.0%

Note: Individual income tax schedule for single individuals pre-TCJA for 2017 and under TCJA as of 2018 under TCJA Joint Committee on Taxation (2017c, 2018). The tax rate is applicable to the excess taxable income over the respective bracket's lower bound.

As shown in the table, the tax rate decreases for most income brackets. In particular, it cuts the top individual income tax rate applicable to the highest bracket from 39.6% to 37.0% and the tax rates applicable to brackets 2 to 5 between 1 and 4 percentage points. The only brackets not receiving a tax cut are the lowest and the second-to-highest bracket. Moreover, tax bracket thresholds decrease substantially for the third, fourth and fifth bracket, but increase for the two top brackets. The threshold changes for the first and second bracket merely reflect the annual inflation indexation.[10]

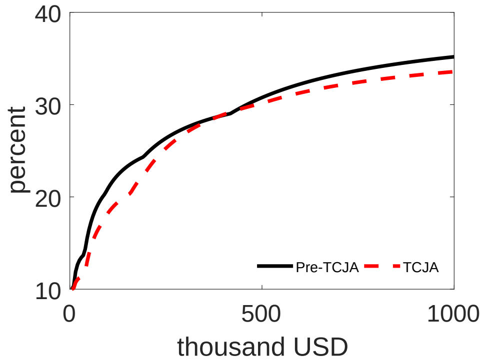
Figure 2 displays the corresponding average tax rates out of *taxable* income, using the tax brackets and rates from **Table 1**. Under pre-TCJA law, average individual income tax rates for single filers across the income distribution start at 10% and slowly approach the top rates. With the TCJA, average tax rates decrease in particular at the bottom and the top of the distribution. However, individual filers with a taxable income of around $350,000-450,000 face a higher average income tax rate under TCJA, because they are now subject to the tax rate associated with the sixth bracket at 35%, compared to 33% pre-TCJA.

[8]Previously, major changes were made during the Reagan administration, which passed two major tax bills: The Economic Recovery Tax Act of 1981 and the Tax Reform Act of 1986. The former included a phased-in cut of individual taxes, with the top marginal rate dropping from 70% to 50%. It decreased further to 38.5% under the 1986 bill, which also consolidated tax brackets from fifteen to four levels and expanded standard deductions.

[9]The House version contained a simplification of the tax schedule to just four tax brackets. The Senate amended the retention of the existing seven brackets.

[10]The TCJA changed the inflation rate used to index the income brackets and other tax thresholds from the Consumer Price Index for All Urban Consumers ("CPI-U") to the Chained Consumer Price Index for All Urban Consumers ("C-CPI-U").

Figure 2: Average Individual Income Tax Rates



Note: Average individual income tax rates as a function of taxable income. Own calculations based on Joint Committee on Taxation (2018).

Additionally, the TCJA doubles the standard deduction, repeals personal exemptions and increases exemptions for the individual alternative minimum tax and estate taxes.

To gauge the effect on the average household, it is helpful to consider a scenario, in which all taxpayers would be single filers. In 2014, the latest year for which detailed data from the Internal Revenue Service (IRS) is available, the average adjusted gross income (AGI) was \$69,565 per household. If all individuals were single filers and applied the standard deduction, this would correspond to an average taxable income of \$63,215 pre-TCJA and \$57,565 post-TCJA, the difference resulting from the increased standard deduction. In turn, applying the calculated average tax rates from **Figure 2**, this would translate into tax rates out of taxable income of approximately 18% pre-TCJA and 15% post-TCJA. This suggests that a taxpayer with an average income experiences a decrease of the average tax rate under the TCJA. It should be noted, however, that the actual average tax rate out of taxable income is lower, since not all individuals are single filers, and household heads and married couples benefit from higher income bracket thresholds.

With regard to the impact on effective tax rates, tax rates out of taxable income as described above need to be distinguished from tax rates out of total household income. Analogously to the ECTR outlined above, one may define the effective individual income tax rate (EIITR) as:

$$EIITR = \frac{\text{Individual income tax paid}}{\text{Taxable income + deductions/exemptions/exclusions}} \tag{2}$$

The EIITR can be interpreted as a measure of the tax rate out of gross income. Because of deductions, exemptions and exclusions, the average EIITR will generally be lower than the tax rates out of taxable income. In 2017, the taxpayer-average EIITR was about 10.3% according to the Joint Committee on Taxation (2017c).[11] The Joint Committee on Taxation (2018) estimates that the TCJA leads to a decline in the average individual income tax rate out of gross income by 1.1 percentage points to 9.2% in 2018. This implies approximately an increase of after-tax income of 1.2%.[12]

The changes to individual income taxation embodied in the TCJA are sunset provisions. The modification of income tax brackets, standard deductions and exemptions all expire at the end of 2025 except for some minor provisions (Joint Committee on Taxation, 2017a).[13] An extension of the individual tax changes is possible, but, of course, highly uncertain.

4 The Model

To evaluate the overall impact of the TCJA on economic activity and government debt, the model used should account for general equilibrium feedback and include a number of other key characteristics. First, to evaluate both short-run and long-run effects, the model must take into account essential economic dynamics such as capital accumulation as well as the optimizing decision-making of forward-looking households and firms. Such decision-making implies important reactions to current as well as announced future changes in tax rates. Second, to provide a meaningful characterization of short-term adjustments, the model should include nominal rigidities, monopolistic competition and various real economic frictions and adjustment costs. Third, the model should feature a sufficiently detailed fiscal sector, which includes distortionary taxation, government purchases and transfers as well as government debt.

The model used here fulfills all of these criteria. It extends the modeling framework of Coenen et al. (2008) and Cogan et al. (2013b). In particular, we allow the government to set the share of the capital stock that is eligible for depreciation allowances. This additional fiscal policy instrument allows us to differentiate between the statutory capital tax rate and the rate effectively paid. Following the terminology of Binder et al. (2019), our model is a New Keynesian Dynamic Stochastic General Equilibrium (DSGE) model of the second generation. Economic dynamics, adjustments costs and household and firm behavior are very similiar to medium-scale DSGE models such as Christiano et al.

[11] This masks a substantial degree of heterogeneity across the household distribution. Some taxpayers with low gross income actually face negative average tax rates because of refundable tax credits (Congressional Budget Office, 2013).

[12] $\frac{1-\tau^{\text{new}}}{1-\tau^{\text{old}}} - 1 = \frac{1-0.092}{1-0.103} - 1 = 0.012$. This is broadly in line with findings by the Tax Policy Center (2017), which calculates that the full TCJA, including corporate taxation, would raise average after-tax income by 2.2% in 2018. They estimate a corresponding increase of 1.7% in 2025 and of 0.2% in 2027. Also, Tax Policy Center (2017) notes the heterogeneity of changes in after-tax income across households.

[13] Under the House plan, the individual tax cuts would have been permanent. The main reason for making the individual tax provisions temporary in the Senate version was to reduce the predicted increase in the federal deficit over the next 10 years. In turn, this allowed the Senate to pass the bill with a simple majority vote and to circumvent a filibuster that would have been possible under the Byrd Rule.

(2005) and Smets and Wouters (2003, 2007) but the fiscal sector is modeled in much greater detail. The model has two country blocks. Its parameters are set consistent with estimated DSGE models for the U.S. and the euro area. Accordingly, the model provides an assessment of the spill-overs from the U.S. tax reform to the euro area.

In the following, we provide a short description of key relationships. The full set of equations is shown in Appendix A.

4.1 Fiscal Authority

The period-by-period government budget constraint in real terms is given by

$$\begin{aligned} G_t + TR_t + B_{t-1}\,{\Pi_t}^{-1} + M_{t-1}\,{\Pi_t}^{-1} - M_t \quad &= \\ \tau_t^C\,C_t + \left(\tau_t^N + \tau_t^{W_h} + \tau_t^{W_f}\right) W_t\,N_t + \tau_t^K\,\left(R_t^K\,u_t - \left(\Gamma_t^u + \delta\,\tau_t^A\right)\,P_t^I\right)\,K_t \quad &+ \quad \tau_t^D\,D_t + T_t + {R_t}^{-1}\,B_t \end{aligned}$$

Expenditures are on the left-hand-side of the equation. They consist of government consumption G_t, government transfers TR_t and the repayment of issued bonds B_t. The right hand side captures the revenues. They stem from taxes on consumption (C_t at rate τ_t^C), labor (N_t, with associated wage W_t taxed at τ_t^N) and social security contributions by employees and employers ($\tau_t^{W_h}$ and $\tau_t^{W_f}$). Further revenues result from the taxation of the net rate of return on capital ($R_t^K u_t$). Thus, the costs of capital utilization Γ^u and a share τ_t^A of depreciation costs are exempt from taxation. We introduce the variable τ_t^A to account for the numerous provisions of the TCJA that alter the effective rate of capital taxation (to be discussed further below). The government is also able to raise a tax on dividends (D_t at τ_t^D), raise lump-sum taxes T_t, issue new bonds B_{t+1} at the nominal interest rate R_t and increase the money supply (M_t).

Government consumption, transfers, the consumption tax rate, the labor tax rate, employee and employers' social security contributions, the capital tax rate, the share of the capital stock eligible for depreciation allowances and the dividend tax rate are all exogenous and set by the government. The demand for government bonds and money balances is determined by households' optimizing behavior, which is described further below. Lump-sum taxes are endogenous. They are set according to a fiscal reaction function. This reaction function ensures that fiscal policy remains sustainable and government debt is stabilized. It implies that lump-sum taxes are adjusted according to the gap between the actual debt relative to nominal output and a target (steady-state) level B^*:

$$\frac{T_t}{P_t Y_t} = \phi_{B_Y}\left(\frac{B_t}{P_t Y_t} - B^*\right)$$

The fiscal response to debt is governed by the parameter ϕ_{B_Y}. It determines to what extent a given budget deficit is paid for by issuing new debt or raising lump-sum taxes.

The reaction parameter is set to rule out explosive government debt dynamics.[14] The long-run level of the government debt-to-GDP ratio is jointly determined by B^* and endogenous household demand for government bonds.

Thus, the fiscal authority in the model sets six different distortionary tax rates as well as the share of the capital stock eligible for depreciation allowances. On the expenditure-side, it sets government purchases and transfers. While there are tax policy models that aim to account for much greater detail and heterogeneity of the tax system, this model has a fairly detailed fiscal sector compared to macroeconomic models that captures empirical short- and medium-run macroeconomic dynamics sufficiently well.

4.2 Households

The behavior of households is key to understand the impact of government purchases and taxes on the whole economy. In particular, it determines whether incentives set by the tax system have an influence on overall economic activity and whether there exists a crowding-in effect of fiscal stimulus. To account for these effects, it is essential to have at least two types of households (Galí et al., 2007; Cogan et al., 2010). One type of household behaves in an optimizing and forward-looking manner, thus responding strongly to incentives set by the tax system. The other type of household is constrained in its decision-making such that consumption choices are primarily driven by current disposable income.

Specifically, the model here assumes that the two economies are both populated by two types of households that differ in their access to financial markets. A share $1-\omega$ of households belongs to the first type and can save by investing in bonds, money and capital. The only means of saving for the second type (with fraction ω) is holding money balances.

4.2.1 Type 1 Households

The per-period utility function of type 1 households is a standard CRRA utility function with habit formation in consumption and disutility from labor. Omitting household indices for the sake of simplifying notation, lifetime utility for each type 1 household is given by:

$$E_t \sum_{i=0}^{\infty} \beta^i \left(\frac{(C_{t+i} - \kappa C_{t+i-1})^{1-\sigma}}{1-\sigma} - \frac{N_{t+i}^{1+\zeta}}{1+\zeta} \right) \tag{3}$$

[14] In the small model of Galí et al. (2007), the necessary and sufficient condition is $\phi_{B_Y} > 1-\beta$.

Type 1 households optimize subject to the following budget constraint:

$$
\begin{aligned}
& (1+\tau_t^C+\Gamma^v(v_t))C_t + P_t^I I_t + R_t^{-1}B_t + ((1-\Gamma_{B^F}(B_t^F))R_t^F)^{-1}S_t B_t^F + M_t \\
= \quad & (1-\tau_t^N-\tau_t^{W_h})W_t N_t + (1-\tau_t^K)(R_t^K u_t - \Gamma^u(u_t)P_t^I)K_t + \tau_t^A \tau_t^K \delta P_t^I K_t \\
& +(1-\tau_t^D)D_t + TR_t - T_t + B_{t-1}\Pi_t^{-1} + S_t B_{t-1}^F + M_{t-1}\Pi_t^{-1}
\end{aligned} \tag{4}
$$

Household expenditures comprise consumption goods, investment in the capital stock, purchases of domestic and foreign bonds and money holdings. Household revenues consists of after-tax labor income, after-tax income from capital holdings (accounting for depreciation allowances), after-tax income from firm dividends, lump-sum transfers and lump-sum taxes. Further sources of income are the returns on bond and money holdings.

Importantly for our analysis, the after-tax return to capital $\widetilde{R}_{k,t}$ is given by:

$$
\begin{aligned}
\widetilde{R}_t^K &= (1-\tau_t^K)(R_t^K u_t - \Gamma^u(u_t)P_t^I)K_t + \tau_t^K \delta P_t^I K_t \\
&= \underbrace{(R_t^K u_t - \Gamma^u(u_t)P_t^I)K_t}_{\text{gross income}} \underbrace{- \tau_t^K (R_t^K u_t - \underbrace{\Gamma^u(u_t)P_t^I - \tau_t^A \delta P_t^I}_{\text{Utilization and depreciation allowances}})K_t}_{\text{taxes}}
\end{aligned} \tag{5}
$$

The effective tax rate on the return on capital holdings $\widetilde{\tau}_t^K$ thus corresponds to:

$$
\widetilde{\tau}_t^K = \frac{\text{Taxes paid}}{\text{Book income}} = \frac{\tau_t^K (R_t^K u_t - \Gamma^u(u_t)P_t^I - \tau_t^A \delta P_t^I)}{R_t^K u_t - \Gamma^u(u_t)P_t^I} \tag{6}
$$

In other words, the effective capital tax $\widetilde{\tau}_t^K$ differs from the statutory capital tax rate τ_t^K due to the exemption of capital utilization costs and depreciation allowances. Both, the statutory rate and the share of the capital stock eligible for depreciation allowances distort the decision of type 1 households to invest in the capital stock by altering the associated net return. With taxation of the return to capital and time-varying depreciation allowances, the Euler equation for type 1 households that pins down the price of capital Q_t is given by:

$$
Q_t = \beta\, E_t\left[\frac{\Lambda_{t+1}}{\Lambda_t}\ \left((1-\tau_{t+1}^K)\ \left(R_{t+1}^K\, u_{t+1} - P_{t+1}^I\, \Gamma_{t+1}^u\right) + \delta\, \tau_{t+1}^K\, \tau_{t+1}^A\, P_{t+1}^I + (1-\delta)\ Q_{t+1}\right)\right] \tag{7}
$$

Investment is subject to adjustment costs Γ^I, such that the capital stock (K_t) evolves according to:

$$
K_{t+1} = (1-\delta)K_t + (1-\Gamma^I(I_t/I_{t-1}))I_t \tag{8}
$$

The existing capital stock may be used at a variable utilization rate u_t. Changing the degree of capital utilization involves real costs that are determined by $\Gamma^u(u_t)$. Capital services K_t^s available for production are given by:

$$
K_t^s = u_t K_t \tag{9}
$$

Greenwood et al. (1988) first introduced variable capital utilization within a real-business cycle framework. Christiano et al. (2005) demonstrate that variable capital utilization is a crucial ingredient to dampen sharp movements of the rental rate of capital following shocks. This reduces the investment response. In turn, this helps to explain empirically observed inertia in investment, output and inflation following monetary policy shocks. By now, variable capital utilization is a feature of many DSGE models, but its implications for the impact of tax policy effects has not yet been investigated.

All households are required to pay a tax on consumption (τ_t^C). For the type 1 households who are optimizing intertemporally, this tax distorts their optimal intertemporal allocation of consumption. In particular, consumption taxes alter the marginal utility with respect to consumption and thus enter the intertemporal Euler equation, which is given by

$$\beta R_t E_t \left[\frac{\Lambda_{t+1}}{\Lambda_t \, \Pi_{t+1}} \right] = 1 \tag{10}$$

where marginal utility Λ corresponds to:

$$\Lambda_t = (C_t - \kappa \, C_{t-1})^{-\sigma} \left(1 + \tau_t^C + \Gamma_t^{\nu} + \Gamma_t^{\prime\nu} \, v_t \right)^{-1} \tag{11}$$

Labor is supplied under conditions that give all households some monopolistic power in the labor market. Additionally, nominal wage-setting is subject to a rigidity such that only a certain fraction of households can optimally choose a new wage each period. The remaining households adjust their wage by indexing it to an average of last period's inflation and the steady-state inflation rate. Both types of households pay taxes on labor income (τ_t^N) as well as social security contributions ($\tau_t^{W_h}$). Labor income taxes and social security contributions alter the marginal rate of substitution between consumption and labor, such that lower labor taxes improve incentives to work. This can also be seen by inspecting the intra-temporal optimality condition for the allocation between labor and consumption (abstracting from wage rigidity for the sake of exposition), which is given by:

$$(1 - \tau_t^N - \tau_t^{W_h}) W_t = \frac{\eta^W}{\eta^W - 1} \frac{N_t^{\zeta}}{\Lambda_t} \tag{12}$$

Finally, type 1 households also receive dividend payments from the firms they own. Dividends are distributed lump-sum and are subject to dividend taxation (τ_t^D). Because type 1 households have unconstrained access to financial markets, their optimality conditions are not affected by lump-sum dividends nor by lump-sum transfers and taxes received and levied by the government. Thus, Ricardian equivalence applies to this part of the household sector.

4.2.2 Type 2 Households

Type 2 households have the same utility function as type 1 households, but are constrained in their access to financial markets. In particular, they can only save by holding money balances. Hence, they cannot hold bonds nor invest in capital. Their budget constraint is given by:

$$\begin{aligned}(1+\tau_t^C+\Gamma^v(v_t))C_t+M_t = \\ (1-\tau_t^N-\tau_t^{W_h})W_tN_t+TR_t-T_t+M_{t-1}\Pi_t^{-1}\end{aligned} \tag{13}$$

Expenditures concern consumption goods and money holdings. Income of type 2 households consists of labor income, lump-sum transfers minus taxes and existing money holdings. On the labor market, type 2 agents behave exactly as type 1 households. Their demand for money as a savings vehicle is determined by the following Euler equation:

$$\beta E_t\left[\frac{\Lambda_{t+1}}{\Lambda_t\,\Pi_{t+1}}\right]=1-\Gamma'^{\nu}_t\,{v_t}^2 \tag{14}$$

Due to their limited access to financial markets, type 2 households adjust their consumption decisions directly in reaction to changes in lump-sum taxes and transfers. Their behavior is characterized by a higher propensity to consume compared to type 1 households. However, type 2 households are not pure hand-to-mouth (or "Keynesian") consumers as in Galí et al. (2007) because they can save by holding money balances.

4.3 Firms

A continuum of intermediate goods firms indexed by f produces differentiated outputs. These firms are using an increasing-returns-to-scale Cobb-Douglas production function with capital services and labor as inputs. It is given by

$$Y_t^f=\max\left[z_t(K_t^{f,D})^{\alpha}(N_t^{f,D})^{1-\alpha}-\psi,0\right] \tag{15}$$

where z is total factor productivity and ψ denotes the fixed cost of production.

Intermediate goods firms hire workers on the labor market and rent capital from households. They take the aggregate wage rate and the aggregate return to capital as given. They also pay the employer's contribution to social security, Thus, it enters the marginal cost (MC) of firms and drives a wedge between effective cost and marginal revenue of labor:

$$MC_t^f=\frac{1}{z_t^{1-\alpha}\alpha^{\alpha}(1-\alpha)^{1-\alpha}}(R_t^K)^{\alpha}((1+\tau_t^{W_f})W_t)^{1-\alpha} \tag{16}$$

As they operate in a monopolistically competitive market, intermediate goods firms have some price-setting power. They are able to sell their goods both in the domestic and in the foreign market. Price setting in each of the markets is staggered due to a nominal rigidity. Each firm can only reset prices in any of the markets with certain independent probabilities. Firms unable to adjust their price set it equal to an average of last period's market-specific inflation and the respective steady-state inflation rate.

Final goods firms operate under perfect competition in the final goods market. They purchase domestically produced intermediate goods and imported foreign intermediate goods. The associated exports and imports generate trade links between the two countries/economies. Final goods producers use domestic and foreign intermediate goods to produce the final consumption and investment goods. They employ constant-returns-to-scale CES technology. The public consumption good is produced by using domestically produced intermediate goods only.

4.4 Monetary Policy

The central bank follows a Taylor-type policy rule for the nominal interest rate. The rule includes responses to inflation and output growth as well as the lagged interest rate:

$$ {r_t}^A = \phi_R \, {r_{t-1}}^A + (1-\phi_R)\, \left(\Pi^{*A}\, r^A + \phi_\pi\, \left(\Pi_t^A - \Pi^{*A}\right)\right) + \phi_{gy} \left(\frac{Y_t}{Y_{t-1}} - 1\right) + \epsilon_R \quad (17) $$

Thus, the net nominal annualized interest rate r reacts to annualized gross consumer price inflation Π^A relative to the inflation target Π^{*A} and to gross output growth relative to steady-state output growth (normalized to zero). Importantly, the nominal interest rate set by the central bank influences the cost of issuing new government debt. We abstract from strategic interactions between monetary and fiscal policymakers. Furthermore, we abstract from the zero lower bound because the effective federal funds rate stood at 1.30% at the end of 2017 by the time the TCJA was enacted. Nevertheless, an extension to analyse the effect of tax cuts in a situation when the zero lower bound on nominal interest rates is binding would be possible.

4.5 Calibration

Coenen et al. (2008) calibrate the two countries symmetrically with parameters based on estimation results of Smets and Wouters (2003) for the euro area, except for the population size of the two economies. Instead, we calibrate the parameters of the equations describing the U.S. economy to the estimates obtained by Cogan et al. (2010).The estimation is based on U.S. data from 1966:1-2004:4 and carried out with Bayesian methods as in Smets and Wouters (2007). These estimates include a share of "Keynesian" rule-of-thumb consumers, which we apply to financially constrained households. In line with that, the share of constrained households is set to $\omega = 0.27$ and the elasticity of lump-sum

Table 2: Calibration

Parameter	Notation	U.S.	EA
Inverse intertemporal elasticity of substitution	σ	1.00	1.00
Degree of consumption habit formation	κ	0.67	0.60
Inverse Labor supply elasticity	ζ	0.54	0.50
Share of non-Ricardian households	ω	0.27	0.25
Calvo price stickiness domestic market	ξ^H	0.65	0.90
Calvo price stickiness export market	ξ^X	0.30	0.30
Price indexation parameter	χ^H	0.22	0.50
Calvo wage stickiness	ξ^L	0.73	0.75
Wage indexation parameter	χ^L	0.62	0.75
Consumption tax rate	τ^C	0.08	0.18
Labor tax rate	τ^N	0.10	0.12
Employee's social security contributions	τ^{W_h}	0.07	0.12
Employer's social security contributions	τ^{W_f}	0.07	0.22
Capital tax rate	τ^K	0.35	0.18
Share of capital stock eligible for allowances	τ^A	0.68	0.00
Government consumption to GDP	G/Y	0.16	0.18
Elasticity of lump-sum taxes w.r.t. debt	ϕ_{B_Y}	0.05	0.10

taxes with respect to government debt in the fiscal reaction function is set to $\phi_{B_Y} = 0.05$. Utility in consumption is assumed to be logarithmic by setting $\sigma = 1$, consistent with a balanced-growth path. The two economies are assumed to be of the same size consistent with 2017 population estimates. In the baseline version of the model we abstract from distributional considerations. Therefore, similar to Cogan et al. (2013b), we assume that both households pay the same share of lump-sum taxes T and receive equally distributed government transfers TR.

We calibrate the steady-state share of the capital stock eligible for depreciation allowances to $\tau^A = 0.676$. As a result, the effective steady-state capital tax rate corresponds to $\widetilde{\tau}^K = 0.205$ at a statutory rate of $\tau^K = 0.35$ as estimated by Penn Wharton Budget Model (2017b). The steady-state labor tax rate is calibrated to $\tau^N = 0.103$ to reflect the empirical average labor income tax rates for 2017 (Joint Committee on Taxation, 2017c). The target B^* in the U.S. is calibrated to yield a steady-state debt-to-GDP ratio of 104%. This corresponds to the total public debt level in the U.S. as of Q42017. **Table 2** provides an overview of key parameter values.

4.6 Solution and Simulation

We employ the Fair and Taylor, 1983) Newton-type algorithm in the form of the stacked-time version implemented by Juillard (1996) to approximate the solution to the nonlinear system of simultaneous equations. Since the TCJA involves permanent changes of tax rates, the system converges to a new long-run equilibrium. This long-run equilibrium features a substantially higher capital stock. Capital utilization costs are assumed to capture costs associated with short-run variations in capital utilization. Thus, they are calibrated to be zero at steady state. As the economy converges to a new steady state, the function governing these costs is adjusted accordingly. A detailed overview of the parameters governing the steady-state calibration assumptions is available in Appendix B.

The model exhibits a balanced-growth path with all real variables growing at the same rate. Thus, the simulation can be interpreted as providing the complete intertemporal transition path from the balanced-growth path under pre-TCJA law to a new balanced-growth path following the temporary and permanent tax rate changes induced by the TCJA. This makes it possible to investigate short-, medium- and long-run macroeconomic and fiscal effects associated with the TCJA.

5 Macroeconomic Effects of the TCJA

This section investigates the quantitative implications of the TCJA tax reform for key macroeconomic aggregates based on the dynamic general equilibrium model. First, we outline how the changes to the tax system are introduced into the model. In the following, we present and explain the impact on economic activity and the evolution of government debt.

5.1 Simulating the TCJA

As reviewed in Section 2, the TCJA resulted in major changes to corporate taxes and personal income taxes. Translating these changes into the macroeconomic model is subject to a number of limitations. First, the mapping from actual tax rates to modeled tax rates is inherently imperfect and subject to simplifying assumptions. Second, as described in Section 3, estimates of the impact on effective average tax rates are imprecise. Third, there is uncertainty to what extent the resulting behavioral incentives being modelled correspond to actual incentives of households and firms in the U.S. economy. These qualifications need to be kept in mind. In the following, we explain how key features of the TCJA tax reform are captured by changes in model parameters and variables.

5.1.1 Corporate Taxes

In the model, the fiscal authority controls the statutory capital tax rate τ_t^K, the share of the capital stock eligible for depreciation allowances τ_t^A and the labor income tax τ_t^N. Furthermore, it determines consumption and dividend taxes, social security contributions, government spending, transfers and lump-sum taxes. We translate the corporate tax change to a reduction in the tax on capital income in the model and the personal income tax change to a reduction in the tax on labor income in the model.

The Type 1 households are the owners of firms and of the capital stock. These are often referred to as "Ricardian" households, because they can take full advantage of financial instruments to pass savings from one period to the next. Accordingly, they receive the return to capital as well as any remaining firm profits. As firm profits are distributed lump-sum to these households, they do not distort any of their optimizing decisions. As a result, the intertemporal profile of these profits has no impact on real economic activity. The same applies to the tax on dividends levied by the government. By contrast, changes in taxes on the return to capital affect household incentives for investing in the capital stock.

Thus, in order to capture the impact of the corporate tax cut on investment, we consider a cut in the tax on the return to capital in the model. The modeling assumption that the tax is paid at the household level is relatively innocuous and standard in the literature. Accordingly, we can abstract from firm heterogeneity and focus on average corporate tax rates. The appropriate empirical counterpart for the effective corporate tax rate is the effective capital tax rate in the model $\widetilde{\tau}_t^K$. It depends on the statutory capital tax rate τ_t^K and the share of the capital stock eligible for depreciation allowances τ_t^A.

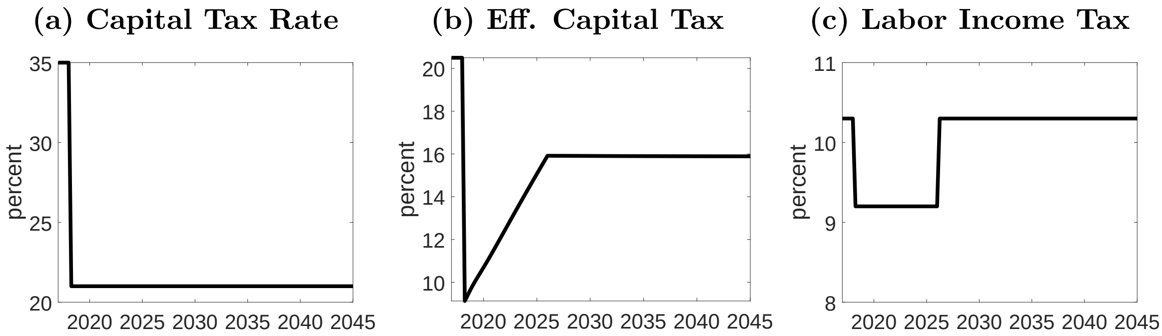
In line with the TCJA, we consider a *permanent* reduction of the capital tax rate from 35% to 21%, effective as of 2018Q1. We account for the numerous provisions that influence the effective corporate tax rate – without changing the statutory top rate – by using the additional fiscal policy instrument that we introduced. According to the Penn Wharton Budget Model (2017b) the TCJA implies an immediate drop of the average effective corporate tax rate in 2018, followed by a gradual partial reversal due to expiring deduction and depreciation allowances.

Thus, we set the share of the capital stock eligible for depreciation allowances such that the resulting effective capital tax rate remains broadly in line with the path estimated by the Penn Wharton Budget Model (2017b). In our simulation, the effective capital tax rate decreases from 20.5% to 9.5% in 2018. Due to the expiration of provisions, the effective capital tax rate then increases gradually and reaches 15.9% in 2025. We assume that the effective capital tax rate stays constant thereafter. **Figure 3** shows the simulated path of statutory and effective capital tax rates in Panels (a) and (b).

5.1.2 Income Taxes

In our framework, both types of households obtain wage income from labor and receive fiscal transfers. While transfers are paid lump-sum, income taxes have distortionary effects with regard to labor supply. We consider all households to be affected by the

Figure 3: Simulated Tax Reform



Note: Simulated TCJA baseline scenario. The effective capital tax rate is an endogenous outcome in general equilibrium (see Equation 6).

labor income tax in the same way. Hence, we abstract from distributional effects of the tax reform. In the absence of heterogeneous tax rates in the model, we can focus on average tax rates.

To calibrate the change in the labor income tax, we rely on the findings of the Joint Committee on Taxation (2017c, 2018). Accordingly, we model an initial drop of the average effective labor income tax rate τ_t^N from 10.3% in 2017 to 9.2% in 2018. To account for the sunset clauses, the tax cut is assumed to be phased out after 2025. The baseline implies a constant labor income tax of 10.3%. Panel (c) of Figure 3 displays the evolution of labor income tax rates in the model simulation of the TCJA.

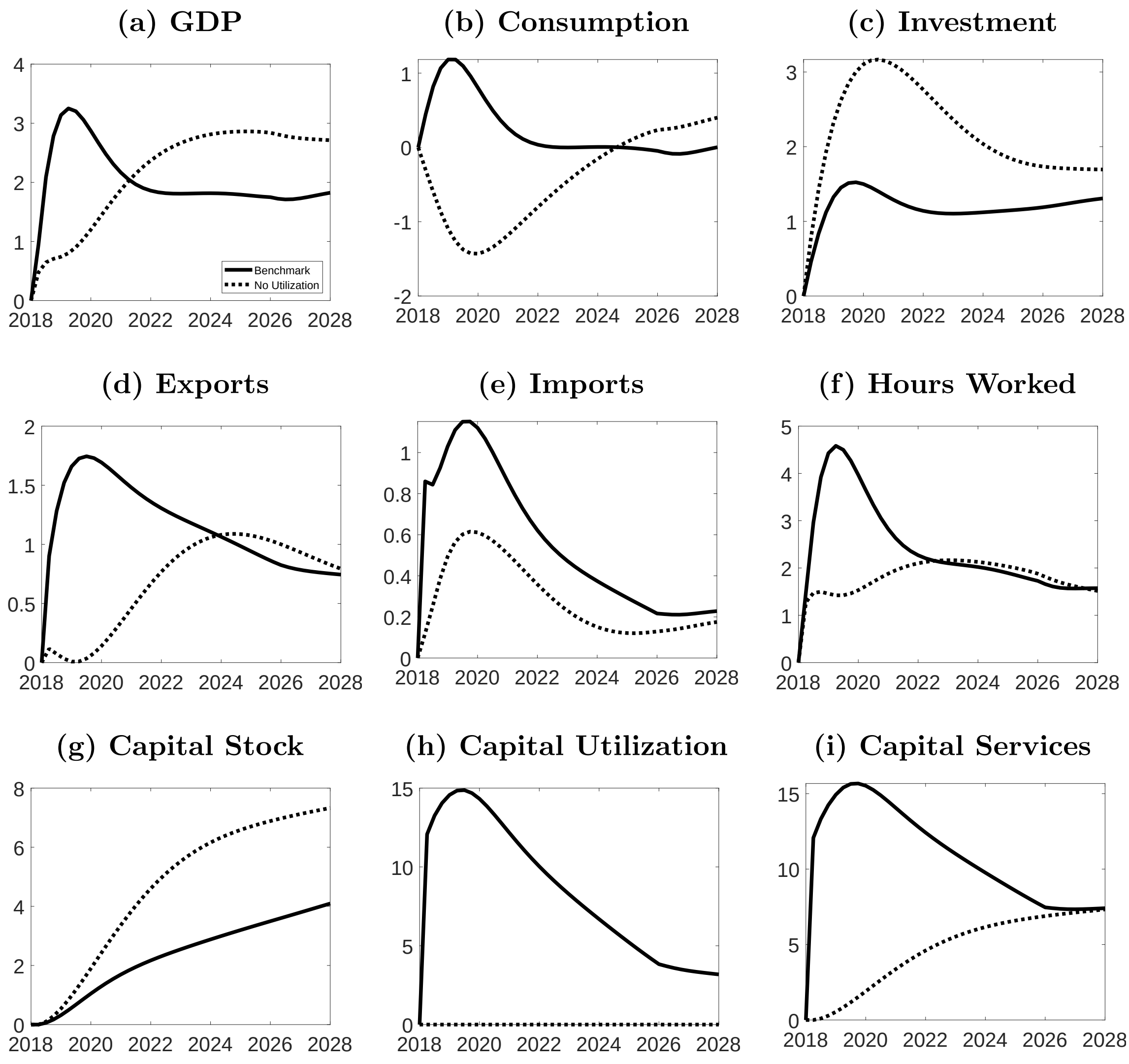
In our simulation, the tax changes become effective in the first quarter of 2018. Households and firms incorporate the announced path of statutory and effective tax rates in their expectations formation. In other words, they are behaving in a forward-looking manner and form rational expectations about the implications of the TCJA for the tax rates they face from the first quarter of 2018 onwards. As tax rates change, the long-run steady state of the model changes. The dynamic nature of the model allows us to calculate the transition path to this new steady state taking into account the behavioral responses of households, firms and the government as well as a variety of economic frictions.

5.2 Assessing the Quantitative Impact on U.S. Economic Activity

The model allows us to quantify the impact of the tax changes on U.S. economic activity in the short-, medium- and long-run. Its structure also makes it possible to disentangle behavioral responses of households and firms and channels of fiscal policy transmission. It shows how different margins are important in this process, such as how effectively the capital stock is utilized and how quickly new investment leads to an increase in the capital stock. We find, in particular, that the extent to which the utilization of the existing capital stock can be intensified has a crucial effect on the short- to medium-run consequences of tax reform.

Figure 4 reports the effects of the tax changes on U.S. real GDP, its components and the factors of production, that is labor supplied and the capital stock, in the first ten years. It shows simulation results for two different scenarios. The solid line refers to the benchmark scenario with the degree of variable capital utilization that has become standard in medium-size New Keynesian macroeconomic models estimated to fit U.S. data. The dotted line considers an alternative scenario with a constant degree of capital utilization.

Figure 4: Real Economic Activity



Note: Values shown in percentage deviations from steady-state. GDP components are shown as a fraction of the initial steady-state output. GDP is defined as output minus adjustment costs.

In the benchmark scenario, the tax changes stimulate a substantial short-run increase in GDP, consumption, investment and net exports. GDP increases about 3% by 2019 and then returns to a level of about 2% above baseline. The contribution of household consumption to the initial increase of GDP is about 1% of GDP. The contribution of investment is about 1.4% and the contribution of next exports another 0.4% of GDP. The increase in production is made possible partly by a surge in hours-worked and partly by a substantial boost to capital utilization (and hence in capital services used in production). The capital stock itself, however, takes some time to be built up. It only increases substantially from 2020 onwards.

Due to the reduction of the tax rate on the return to capital services, household face much more favorable conditions for investment in the capital stock. In other words, the effect of the depreciation allowances is comparable to investment tax credits Judd (1985, 1987). As a result, the tax cut induces an increase in investment. This increase, however, only contributes a little more than a third of the increase in GDP. In order to reap the increased returns from capital holding early on, households strongly increase capital utilization and thereby capital services. The increase in capital utilization comes at the expense of higher capital utilization costs. Additionally, the labor tax cut increases the incentives to supply labor and boosts hours worked.

Regarding consumption, the initial peak captures a strong income effect. The source of this strong positive income effect is precisely the possibility to quickly extend capital utilization. This follows from a comparison with the alternative scenario with a constant degree of capital utilization (dotted lines). In this case, the tax cuts induce a much stronger investment boom, contributing about 3% to GDP growth by 2020. GDP increases much more slowly because capital services can only be increased by building up the stock of capital. Households have to save in order to boost investment. Thus, consumption declines and contributes negatively to GDP, at -1.4% by 2020. Similarly, net exports decline initially.

The constant capital utilization scenario is somewhat extreme as it indicates sharply diverging consumption and investment. This is typically not borne out by observed consumption and investment dynamics. Yet, this alternative scenario helps to isolate the crucial role of variable capital utilization in the benchmark simulation. Furthermore, it suggests that the benchmark simulation might overestimate the short-run boost to GDP.

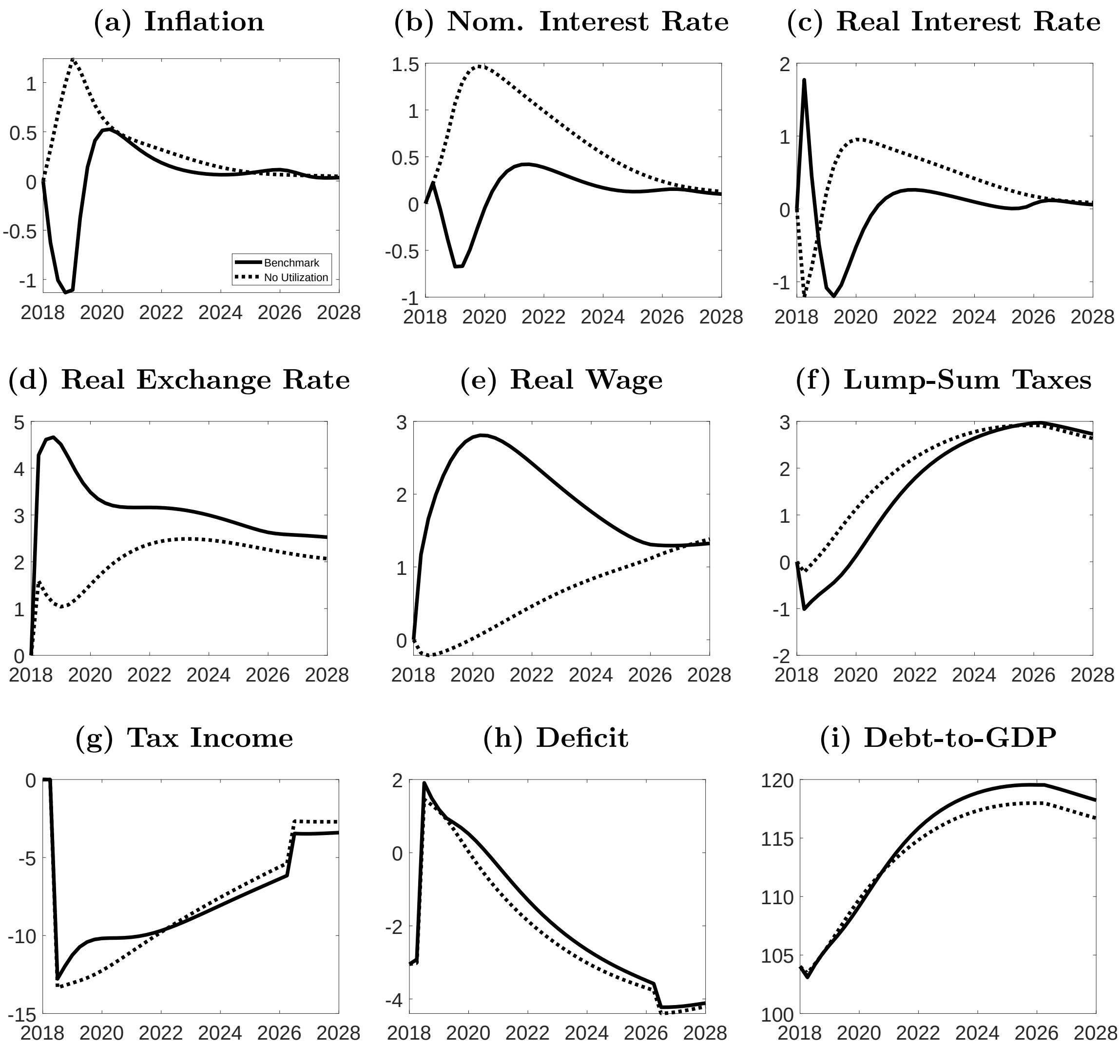
In the benchmark scenario, the increase in investment is relatively persistent in the medium run, despite the gradual reversal in effective capital taxation. Capital utilization declines along with an increasing capital stock. The high level of capital utilization is mainly profitable before depreciation allowances partially expire by 2025. The sustained investment flow comes at the expense of only moderately increased consumption over the medium-run. Consumption is also negatively affected by the expiration of the labor income tax cuts in 2025.

The long-run effect on GDP beyond the first ten years is about 2.6% and is the same for both scenarios, i.e. with variable and constant capital utilization. The main driver is investment (1.5%), followed by consumption (0.75%) and net-exports (0.35%).

5.3 Adjustment in Prices, Wages, Interest Rates and Debt

The impact of the tax changes on economic activity comes along with changes in prices and wages that set the incentives for behavioral responses. In particular, increased labor demand drives up the real wage, thus motivating higher hours worked. This channel is particularly strong in the benchmark scenario with variable capital utilization as shown by **Figure 5** (Panel e). The marginal product of labor increases substantially due to higher capital services and firms expand their labor demand. Labor supply also increases as the cut in income taxes raises work incentives for households. Furthermore, the after-tax rental rate of capital rises because the tax cut renders capital services particularly profitable, and the higher demand from firms makes the available capital services relatively scarce.

Figure 5: Prices, Wages, Interest and Debt



Note: Values shown in percentage deviations from steady-state. Transfers, tax income and deficit are shown as a fraction of the output. The deficit and debt-to-GDP are in levels.

The tax cuts reduce marginal costs for firms and change the terms of trade, that is domestic import versus export prices, such that foreign demand shifts towards exports of the United States. Accordingly, the real exchange rate depreciates (Panel d).[15] This effect is largely driven by variable capital utilization, which allows for a substantial rise of production alongside a falling effective return to capital (see Equation 6). The real depreciation and the rise in U.S. net exports is thus much more pronounced for the benchmark scenario with variable capital utilization.

The real interest rate follows a whipsaw pattern. In the bechmark scenario it increases on impact, then declines sharply, then increases again. This is consistent with the temporary increase in consumption as the Euler equation would tend to link a higher (lower) real interest rate to an expected increase (decrease) of consumption. In the scenario with constant capital utilization, consumption declines initially and also the real interest rate first declines, then increases.

As the model takes into account nominal wage and price rigidities, it allows to investigate the interaction of monetary and fiscal policy and the consequences of the tax cut for inflation and nominal interest rates. In the benchmark scenario, inflation first declines as marginal costs decrease. The central bank reacts by lowering the nominal interest rate, but to a limited degree because it also reacts to the increase in the growth rate of GDP. In the scenario with constant capital utilization, inflation increases initially as the downward pressures on marginal costs are not as pronounced. In both cases, inflation stabilizes within a few years.

Turning to the implications of the tax reform for the government budget and debt, Panels (f)-(i) of Figure 5 display the debt-to-GDP ratio, the primary deficit and tax revenue from distortionary taxes (consumption, labor and capital taxes and social security contributions) as well as lump-sum taxes. The latter are determined by the fiscal reaction function that ensures fiscal sustainability.

The tax cuts cause a substantial drop in fiscal revenue from labor and capital taxes. On impact, total tax income drops by more than 10%. Thus, the increase in the respective tax base due to higher consumption, hours worked and the capital stock does not make up for the reduction in the tax rate. According to this result, the U.S. economy is on the left-hand side of the so-called Laffer curve where tax revenues decline along with a reduction of the tax rates. As a consequence, the primary deficit and the government debt-to-GDP ratio increase. Lower tax revenues and the deficit persist over the medium-term until temporary provisions expire and the effective tax rate rises again by 2027. The debt-to-GDP ratio increases by 15.5 percentage points from 104 to 119.5 percent of GDP until 2025.

[15] This appears to be in contrast to the standard Mundell-Fleming model, where fiscal expansion leads to exchange rate appreciation. However, in the model used here, a government spending or transfer stimulus also leads to an apprecation. However, the supply-side oriented tax reduction that we consider has a different effect.

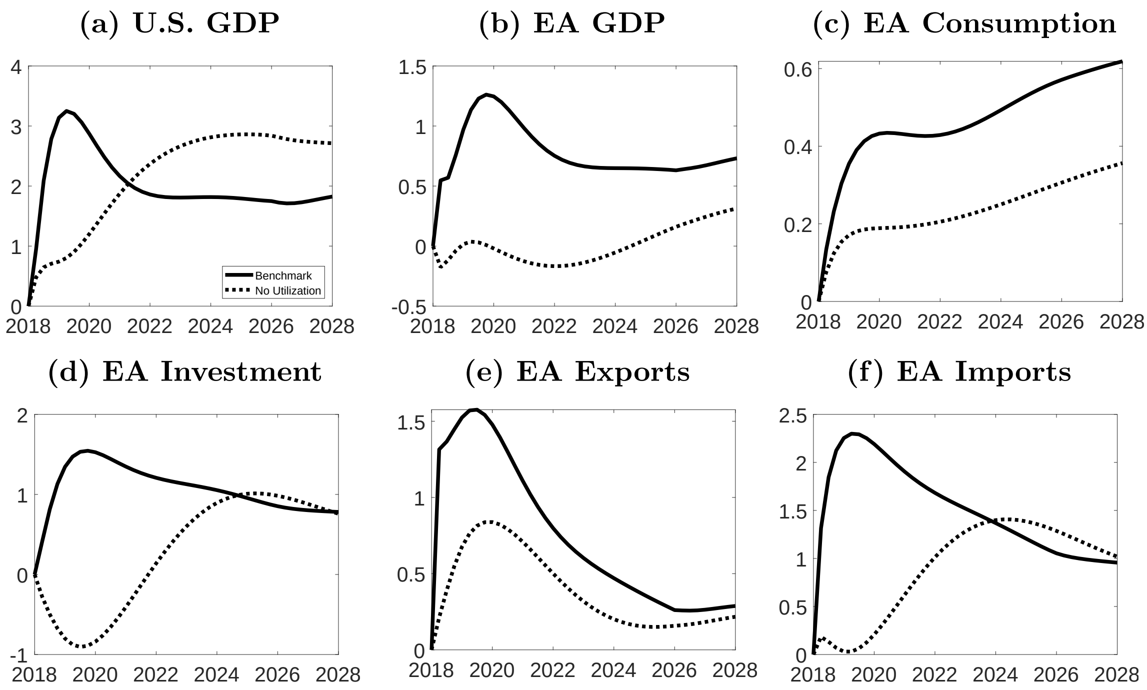
As the tax basis continues to increase and the effective tax rate recovers, the primary deficit declines and turns into a moderate primary surplus. The debt-to-GDP ratio eventually stabilizes, partially due to the expiration of some elements of the TJCA that result in higher effective taxes and partially due to higher lump-sum taxes. The increase in lump-sum taxes can alternatively be understood as a reduction of lump-sum transfers on the expenditure side of the government. Certainly, a possible consequence of the TCJA could be that down the road mandatory government spending programs are being cut in order to reign in the increase in government debt. This effect is built-in by the fiscal reaction that ensures fiscal sustainability in the model.

In the long run, the government debt-to-GDP ratio settles at 112.6 percent, that 8.6 percentage points above the starting point. Lump-sum transfers are cut by 1.7% of GDP. The long-run increase in GDP due to the TCJA is 2.6 % above baseline.

5.4 Spillovers to the Euro Area

The two-country model makes it possible to gauge the effects of the tax reform in the United States on the euro area. As shown in **Figure 6**, the economic expansion in the United States has positive effects for economic activity in the euro area.[16]

Figure 6: Spillover Effects to the Euro Area



Note: Values shown in percentage deviations from steady-state. GDP components are shown as a fraction of the initial steady-state output. GDP is defined as output minus adjustment costs.

The positive impact on the euro area is most pronounced in the benchmark scenario, in

[16]In Appendix C, we consider an alternative scenario with additional tax cuts in the euro area.

which the TCJA generates a rapid boost in U.S. GDP due to variable capital utilization. The expansionary effect on euro area GDP is driven by an increase of consumption and investment, adding up to an increase in euro area GDP by about 1% initially and about 0.5% in the longer run. The higher demand from the U.S. generates a positive income effect for households and firms in the euro area. As the income effect spills over to the euro area, consumption and investment rise there as well.

Interestingly, the positive spillover is realized even though the U.S. dollar depreciates and U.S. net exports to the euro area increase. While euro area exports to the United States increase, euro area imports increase by more and therefore euro area net exports decline. In the model, the trade balance is affected by two forces. On the one hand, the TCJA results in a substantial positive income effect for U.S. households and firms. Consequently, they expand consumption and investment as well as demand for euro area goods, raising euro area exports. On the other hand, the real depreciation of the dollar renders euro area goods relatively more expensive, equivalent to a substitution effect away from euro area goods and towards U.S. goods. In the benchmark scenario, the substitution effect dominates the income effect such that euro area imports increase more than euro area exports.

The alternative scenario with constant capital utilization has quite different effects in the short and medium run (due to the different time profile of income and substitution effects), but similar effects in long run. In the short run, euro area GDP remains unchanged and investment declines. The U.S. dollar depreciates much less in real terms than in the benchmark scenario such that euro area net exports improve a bit initially.

6 Sunset Provisions and Sensitivity Studies

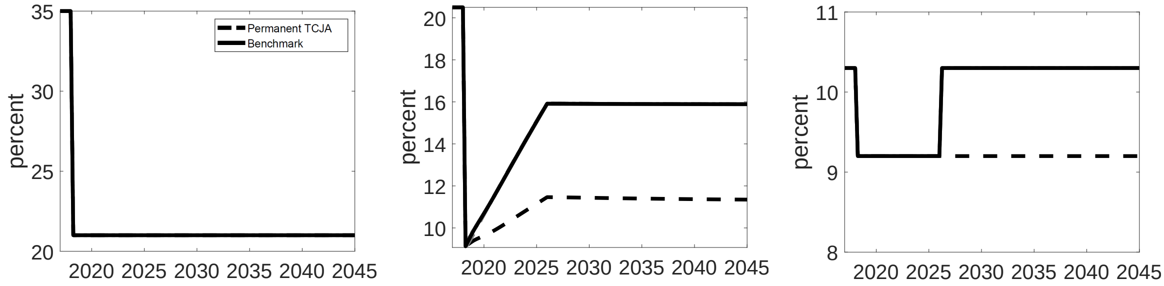
For comparison, we consider an alternative specification of the tax reform. In particular, we explore the case if all sunset provisions were abolished and thus all temporary elements of the TCJA became permanent. This scenario is labeled "permanent TCJA". It is assumed that the extension of TCJA is anticipated in 2018Q1.[17]

Figure 7 compares the path of statutory and effective tax rates under the benchmark scenario with the "permanent TCJA" scenario. For the permanent TCJA scenario, we set the share of the allowance-eligible capital stock such that the effective capital tax rate drops to 11.5% until 2025, equivalent to a 9 percentage points decrease. Thereafter, the statutory rate and the capital stock share stay constant. In the long-run, the effective capital tax declines by about 4.4 percentage points more than in the benchmark scenario. Furthermore, the labor income tax cut does not expire by 2025. Rather, the labor income tax is lowered permanently by 1.1%.

[17] Alternatively, it would be possible to simulate the consequences of announcing such an extension at a later point in time.

Figure 7: Benchmark scenario versus "Permanent TCJA"

(a) Capital Tax Rate **(b) Eff. Capital Tax** **(c) Labor Income Tax**



Note: Simulated TCJA scenario for the sensitivity analysis. The effective capital tax rate is an endogenous outcome of the general equilibrium (see Equation 6).

Furthermore, we have conducted a number of additional sensitivity studies in order to assess the robustness of our key findings. These additional scenarios explore the consequences of particular parameter choices for the benchmark scenario. These parameter choices influence the transmission channels for tax policy in our model. In particular, we assess the role of nominal rigidities, uncovered interest rate parity and monetary policy.

In the scenario "nominal rigidities", the parameters governing the likelihood of price and wage changes in the Calvo (1983) staggered contracts setup (ξ^L, ξ^H, ξ^X) as well as the parameters determining the degree of indexation to past price or wage inflation (χ^L, χ^H, χ^X) are all set equal 0.1. As a result, the model exhibits a much lower degree of price and wage persistence and is closer to a real-business-cycle framework.

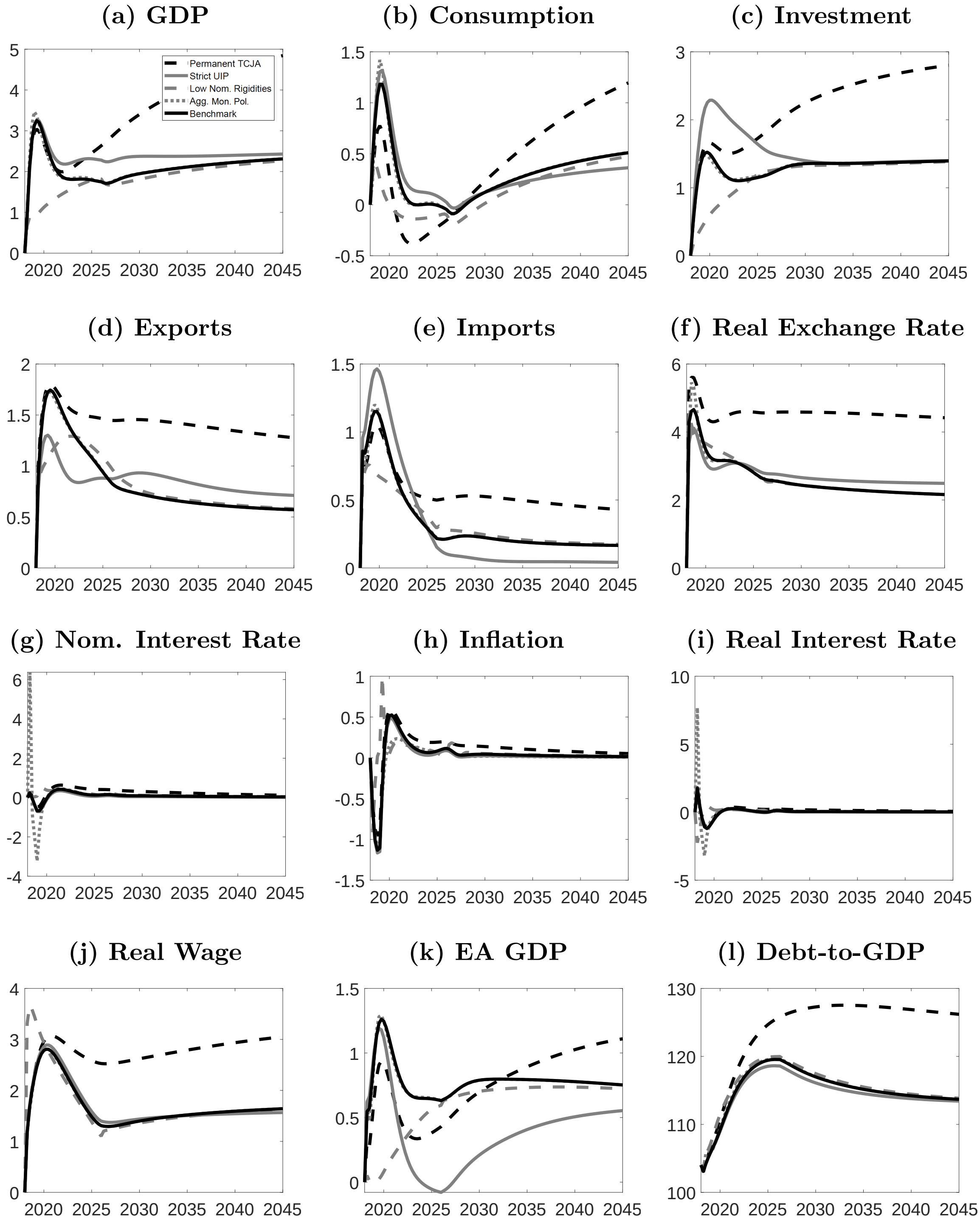
The scenario "strict UIP" eliminates the financial intermediation premium that type 1 households incur when investing in foreign bonds. This premium is governed by $\Gamma_{B^F}(B_t^F)$. As a consequence, the model features a strict uncovered interest rate parity condition.

The scenario "aggressive monetary policy" explores the interaction of monetary policy with the tax cuts. To this end, we consider a monetary policy rule that implies more aggressive or activist reactions to output and inflation. Compared to the rule estimated by Cogan et al. (2010), we set the interest-rate smoothing coefficient $\phi_R = 0$ instead of 0.82, and we raise the reaction coefficient on inflation, $\phi_\pi = 4$ instead of 2.05, as well as the reaction coefficient on output $\phi_{gy} = 2$ instead of 0.1.

Figure 8 reports on macroeconomic outcomes under the "permanent TCJA" scenario as well as the three additional sensitivity studies. Whether the tax cuts and provisions are extended does not change the short-run impact very much, but certainly the longer-run consequences. Eventually, U.S. GDP increases by 5.7% (black dashed line). The lasting reduction of effective capital taxes and labor income taxes induces a longer-lasting investment boom. This comes at the expense of much higher government debt. The debt-to-GDP ratio increases by more than 20 percentage points, reaching 125.6% in 2025.

The three sensitivity studies overall confirm the findings regarding the impact of the

Figure 8: "Permanent TJCA" and Additional Sensitivity Studies



Note: Values shown in percentage deviations from steady-state. GDP components are shown as a fraction of the initial steady-state output. GDP is defined as output minus adjustment costs. Debt-to-GDP is in levels.

TCJA on U.S. economic activity. The long-run consequences are almost identical, as shown in **Table 3**. The short-run impact, however, is quite different when nominal rigidities are reduced substantially (grey dashed line). In this case, the initial expansion of U.S. GDP is quite a bit smaller, reaching a bit more than 1% of GDP by 2020. GDP only catches up with the expansion under the benchmark scenario by 2025. This shows that not only the variability of capital utilization but also the extent of nominal rigidities play a role in inducing the particularly strong short-run impact under the benchmark scenario, which is larger than the long-run impact in this scenario. With smaller nominal rigidities, prices and wages adjust more quickly to the changes in the tax system. In particular, the price of capital increases rapidly as firms face higher demand for capital from households who want to benefit from temporarily higher returns. This dampens the short-run investment boom. Both consumption and investment rise more gradually, thereby delaying the expansionary effect of the TCJA.

Table 3: Long-Run Effects

	Benchmark	Permanent TCJA	Strict UIP	No Utilization	Low Nom. Rigidities	Aggressive Mon. Pol.
GDP	2.58	5.73	2.56	2.58	2.58	2.58
C	0.74	1.88	0.64	0.74	0.74	0.74
I	1.49	3.10	1.47	1.49	1.49	1.49
EX	0.53	1.13	0.57	0.53	0.53	0.53
IM	0.18	0.38	0.13	0.18	0.18	0.18
Hours Worked	0.99	2.55	1.03	0.99	0.99	0.99
Capital Stock	8.13	16.86	7.98	8.13	8.13	8.13
Real Wage	1.79	3.42	1.73	1.79	1.79	1.79
Debt-to-GDP	112.60	123.65	112.71	112.60	112.60	112.60
Tax Income	-2.74	-8.11	-2.80	-2.74	-2.74	-2.74
Transfers	-1.74	-4.16	-1.76	-1.74	-1.74	-1.74
EA GDP	0.51	1.07	0.55	0.51	0.51	0.51
EA C	0.49	1.06	0.62	0.49	0.49	0.49
EA I	0.46	0.98	0.51	0.46	0.46	0.46
EA EX	0.23	0.49	0.17	0.23	0.23	0.21
EA IM	0.68	1.45	0.74	0.68	0.68	0.68

Note: Values shown in percentage deviations from steady-state. GDP components are shown as a fraction of the initial steady-state output. Tax income and transfers are displayed as a fraction of output. GDP is defined as output minus adjustment costs. Debt-to-GDP is in levels.

Under the other two scenarios – "strict uncovered interest rate parity" and "more aggressive monetary policy" – the effects of real economic activity remain very similar to the benchmark scenario. In the absence of the financial intermediation premium, there are greater incentives to accumulate foreign bonds. Euro area households invest more in U.S. bonds, inducing more demand for U.S. currency. As a result, the initial real depreciation of the U.S. dollar is slightly dampened. The initial impact on U.S. net exports turns out to be negative. However, domestic investment is a bit higher and compensates for that. The initial impact on U.S. GDP remains unchanged relative to the benchmark scenario.

The changes to the monetary policy rule that render the response to current GDP and inflation more aggressive have little impact. According to this scenario, the macroeconomic effects of the TCJA remain largely unchanged. The reason is that the tax reform produces a reduction in distortionary taxation that leads to an increase in potential GDP.

U.S. monetary policy is neither a key driver of U.S. GDP nor a major counteracting force in this case.

7 Alternative Tax Reform Scenarios

The findings based on our model indicate that the TCJA has a substantial stimulative effect on U.S. GDP that comes with an increase in investment, labor supply and real wages. However, it certainly does not pay for itself. Rather, the debt-to-GDP ratio increases by 15.5 percentage points until 2025. Counteracting effects are due to the sunset provisions on some elements of the TCJA and an endogenous response of lump-sum taxes/transfers. The latter fiscal reaction function is key to stabilize government debt at a new, higher steady-state level. Under these conditions, the long-run increase in the debt-to-GDP ratio comes in a bit lower at 8.6 percentage points.

An important question is whether the tax reform could be modified in order to better contain the increase in government debt, while maintaining the positive effect on economic activity. The model we use can serve as a testing ground for such alternative tax reforms. To this end, we consider two other tax reduction and fiscal consolidation packages. The magnitude of both packages is designed to achieve the same long-run increase in U.S. GDP as in our benchmark scenario for the impact of the TCJA.

Our first alternative package extends the TCJA reform by making the labor tax cut permanent and by committing to a reduction of both, government purchases and transfers, by 1% of GDP respectively. Thus, the package comes closer to the consolidation strategy of Cogan et al. (2013a,b) that roughly captures the spirit of the 2013 House Budget Resolution and the House Budget Committee Plan of 2013. The magnitude of the labor income tax cut is set to a value such that the overall fiscal package achieves the same long-run increase in U.S. GDP as the benchmark TCJA. The second alternative package lets the labor income tax cut expire as in the TCJA, but extends the reduction of the effective capital tax permanently. It also adds an element of fiscal consolidation on the spending side by reducing government purchases and transfers, each by 1% of GDP. For both scenarios, the required tax cuts are only a bit larger than in the TCJA benchmark scenario. The required effective capital tax cut in the second alternative scenario remains smaller than for the "permanent TCJA" case.

Table 4 compares the long-run effects of the two alternative scenarios with the TCJA benchmark. Of course, by design the impact on GDP is the same. However, the debt-to-GDP ratio compares very favorably. Under the first alternative package it rises by 1.6 percentage points and under the second one only by 0.6 percentage points. Furthermore, due to lower tax burdens, household disposable income and hence household consumption increase permanently relative to the benchmark TCJA scenario.

In sum, lowering labor and capital taxes reduces distortions in the economy and makes

Table 4: Long-Run Effects of Alternative Tax Reforms

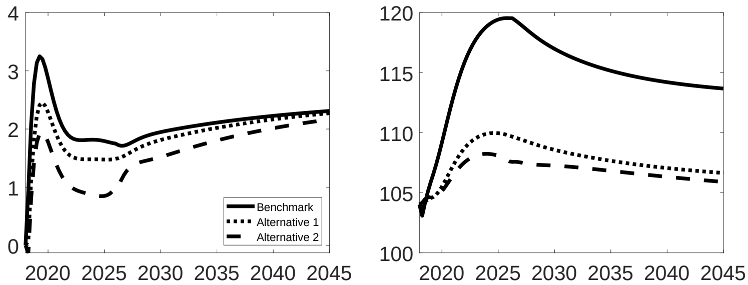
	Scenario		
Variable	TCJA Benchmark	Labor Tax + Spending Cut	Capital Tax + Spending Cut
Labor tax rate τ^N	-	-1.47	-
Effective capital tax rate $\widetilde{\tau}^K$	-4.60	-4.60	-5.96
Government purchases G	-	-1.00	-1.00
Transfers TR	-	-1.00	-1.00
GDP	2.58	2.58	2.58
Consumption	0.74	1.73	1.35
Investment	1.49	1.44	1.79
Net-exports	0.35	0.40	0.44
Hours worked	0.99	0.90	0.51
Capital Stock	8.13	7.84	9.70
Real Wage	1.79	1.70	2.31
Debt-to-GDP	8.60	1.57	0.59

Note: Tax rate changes and debt-to-GDP are in percentage point deviations from steady-state. All other variables are in percentage deviations from steady-state. GDP components are shown as a fraction of the initial steady-state output. GDP is defined as output minus adjustment costs.

it possible to converge to a more efficient, new steady-state. A reduction of government spending helps to keep government debt fairly stable relative to economic activity. **Figure 9** shows that the associated short- and medium-run contractionary effects are outweighed by the stimulative effect of the lower distortionary taxation. As a result, the full tax and spending reform package remains expansionary in the short and medium run despite the spending cuts. Our model suggests that it is possible to design reforms that yield the same expansionary effect as the TCJA while being close to debt-neutral in the long run.

Figure 9: Alternative Tax-Reforms: GDP and Debt

(a) GDP **(b) Debt-to-GDP**



Note: GDP is shown as percentage deviation from steady-state, and is defined as output minus adjustment costs. Debt-to-GDP is in levels.

8 Conclusion

The macroeconomic and fiscal effects of the Tax Cuts and Jobs Act (TCJA) of 2017 remain the subject of heated debates. The TCJA constitutes a major reform of the U.S. tax system, including a substantial and permanent reduction of the statutory tax rate on corporate profits as well as a temporary reduction of the personal income tax. Numerous other provisions, many of them of a temporary nature, change the effective corporate tax rate. Investigating the overall effects of this tax reform on economic activity and government indebtedness requires a structural macroeconomic model.

In this paper, we assess the quantitative effects of the TCJA based on a large-scale two-country dynamic general equilibrium model featuring a rich fiscal sector as well as nominal rigidities. We map the changes in tax rates on corporate profits and personal income into the model. Specifically, we simulate a change in the model's tax rates on returns to capital services and labor income as well as the share of the capital stock that is eligible for depreciation allowances. Thus, our setup can accommodate TCJA provisions that affect the effective capital tax rate for a given statutory rate.

Our baseline simulation suggests that the TCJA increases U.S. GDP by about 2.5% in the long-run. This expansionary effect stems mainly from higher investment stimulated by cutting the effective taxation of capital returns. This triggers a substantial increase in the capital stock, and an increase in real wages to motivate larger labor supply. Yet, the TJCA does not pay for itself. The debt-to-GDP ratio increases by about 9 percentage points in the long-run. Debt is stabilized partially because of expiring provisions and partially by an endogenous fiscal reaction leading to expenditure cuts. The U.S. tax reform has small but positive spillover effects for the euro area.

Nominal rigidities, real adjustment costs and behavioral assumptions such as habit persistence enable us to go beyond the long-run effects of the TCJA and study business cycle dynamics resulting from the tax reform. We find that the degree and costs of variable capital utilization play a key role in the quantitative assessment of short- to medium-run consequences. Variable capital utilization has become a standard feature of medium-size DSGE models that is essential to match empirical investment dynamics. We find that it also turns out to play a crucial role regarding the impact of tax changes. In particular, using a standard specification of variable capital utilization implies that capital services can be increased more rapidly, such that the TCJA induces a substantial short-run increase in consumption, investment and real GDP.

A variant of the TCJA with permanent tax cuts and extended provisions generates a GDP boost of 5.7% in the long-run, but increases the government debt-to-GDP ratio by more than 20 percentage points until 2025. We demonstrate that a fiscal consolidation package combining tax and spending cuts would have been able to achieve the same effect on overall GDP as the TCJA alongside a much smaller increase in government debt.

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Appendix

A Equilibrium Conditions

This section details equilibrium equations of the model. As both country blocks are modelled identically, we outline the equilibrium conditions for one country only. Foreign variables are denoted with superscript F. Variables referring to specific household types are labeled with subscript 1 or 2.

A.1 Households

A.1.1 Type 1 Households

FOC w.r.t. consumption:

$$\Lambda_{1,t} = \left(C_{1,t} - \kappa\, C_{1,t-1}\right)^{-\sigma} \left(1 + \tau_t^C + \Gamma_{1,t}^{\nu} + {\Gamma'}_{1,t}^{\nu}\, v_{1,t}\right)^{-1} \tag{A1}$$

FOC w.r.t. bonds:

$$\Lambda_{1,t} = \beta E_t \left[\frac{R_t}{\Pi_{t+1}^C} \Lambda_{1,t+1}\right] \tag{A2}$$

FOC w.r.t. money:

$$\beta E_t \left[\frac{\Lambda_{1,t+1}}{\Lambda_{1,t}\, \Pi_{t+1}^C}\right] = 1 - {\Gamma'}_{1,t}^{\nu}\, {v_{1,t}}^2 \tag{A3}$$

Consumption-based velocity:

$$v_{1,t} = \left(1 + \tau_t^C\right) \frac{C_{1,t}}{M_{1,t}} \tag{A4}$$

Consumption transaction costs:

$$\Gamma_{1,t}^{\nu} = \gamma^{\nu,1}\, v_{1,t} + \frac{\gamma^{\nu,2}}{v_{1,t}} - 2\, \left(\gamma^{\nu,1}\, \gamma^{\nu,2}\right)^{1/2} \tag{A5}$$

First derivative of consumption transaction costs:

$${\Gamma'}_{1,t}^{\nu} = \gamma^{\nu,1} - \gamma^{\nu,2}\, {v_{1,t}}^{-2} \tag{A6}$$

Capital accumulation:

$$K_{1,t+1} = (1-\delta)\; K_{1,t} + \left(1 - \Gamma_{t-1}^I\right)\; I_{1,t} \tag{A7}$$

Investment adjustment costs:

$$\Gamma_t^I = \frac{\gamma^I}{2} \left(\frac{I_{1,t}}{I_{1,t-1}} - 1\right)^2 \tag{A8}$$

First derivative of investment adjustment costs:

$${\Gamma'}_t^I = \gamma^I\, \frac{\left(\frac{I_{1,t}}{I_{1,t-1}} - 1\right)}{I_{1,t-1}} \tag{A9}$$

Capital utilization costs:

$$\Gamma_t^u = \frac{\left(\delta + \beta^{-1} - 1\right)\, Q_t - \beta\, \tau_t^A\, \tau_t^K\, P_t^I}{\left(1 - \tau_t^K\right) P_t^I}\; (u_t - 1) + \frac{\gamma^{u,2}}{2}\; (u_t - 1)^2 \tag{A10}$$

First derivative of capital utilization costs:

$$\Gamma'^{u}_t = \frac{\left(\delta + \beta^{(-1)} - 1\right)\, Q_t - \delta\, \tau^A_t\, \tau^K_t\, P^I_t}{\left(1 - \tau^K_t\right) P^I_t} + \gamma^{u,2}\,(u_t - 1) \tag{A11}$$

FOC w.r.t. utilization rate:

$$R^K_t = P^I_t\, \Gamma'^{u}_t \tag{A12}$$

FOC w.r.t. investment:

$$P^I_t = Q_t\,\left(1 - \Gamma^I_t - \Gamma'^I_t\, I_{1,t}\right) + \beta E_t\left[\frac{Q_{t+1}\, \Gamma'^I_{t+1}\, {I_{1,t+1}}^2}{I_{1,t}}\, \frac{\Lambda_{1,t+1}}{\Lambda_{1,t}}\right] \tag{A13}$$

FOC w.r.t. capital:

$$Q_t = \beta\, E_t\left[\frac{\Lambda_{1,t+1}}{\Lambda_{1,t}}\,\left(\left(1 - \tau^K_{t+1}\right)\,\left(R^K_{t+1}\, u_{t+1} - P^I_{t+1}\, \Gamma^u_{t+1}\right) + \delta\, \tau^K_{t+1}\, \tau^A_{t+1}\, P^I_{t+1} \right.\right.$$
$$\left.\left. + \left(1 - \delta\right)\, Q_{t+1}\right)\right] \tag{A14}$$

Optimal reset wage:

$$\widetilde{W}^{1+\zeta\,\eta_1}_{1,t} = \frac{\eta_1}{\eta_1 - 1}\, \frac{F_{1,t}}{G_{1,t}} \tag{A15}$$

Auxiliary variable optimal reset wage:

$$F_{1,t} = {N^D_{1,t}}^{1+\zeta}\, {W_{1,t}}^{1+\zeta\,\eta_1} + \beta\, \xi^L\, E_t\left[\left(\frac{\Pi^C_{t+1}}{{\Pi^C_t}^{\chi^L}\, {\Pi^*}^{1-\chi^L}}\right)^{(1+\zeta)\,\eta^L} F_{1,t+1}\right] \tag{A16}$$

Auxiliary variable optimal reset wage:

$$G_{1,t} = N^D_{1,t}\, \Lambda_{1,t}\,\left(1 - \tau^N_t - \tau^{W_f}_t\right)\, {W_{1,t}}^{\eta_1} + \beta\, \xi^L\, E_t\left[\left(\frac{\Pi^C_{t+1}}{{\Pi^C_t}^{\chi^L}\, {\Pi^*}^{1-\chi^L}}\right)^{\eta_1 - 1} G_{1,t+1}\right] \tag{A17}$$

Wages:

$${W_{1,t}}^{1-\eta_1} = \left(1 - \xi^L\right)\, \widetilde{W}^{1-\eta_1}_{1,t} + \xi^L\, {W_{1,t-1}}^{1-\eta_1}\,\left(\frac{{\Pi^*}^{1-\chi^L}\, {\Pi^C_{t-1}}^{\chi^L}}{\Pi^C_t}\right)^{1-\eta_1} \tag{A18}$$

A.1.2 Type 2 Households

Budget constraint:

$$C_{2,t}\,\left(1 + \tau^C_t + \Gamma^\nu_{2,t}\right) + M_{2,t} = \left(1 - \tau^N_t - \tau^{W_f}_t\right)\, W_{2,t}\, N_{2,t} + TR_{2,t} - T_{2,t} + M_{2,t-1}\, {\Pi^C_t}^{-1} \tag{A19}$$

Marginal utility:

$$\Lambda_{2,t} = \left(C_{2,t} - \kappa\, C_{2,t-1}\right)^{-\sigma}\,\left(1 + \tau^C_t + \Gamma^\nu_{2,t} + \Gamma'^\nu_{2,t}\, v_{2,t}\right)^{-1} \tag{A20}$$

FOC w.r.t. money:

$$\beta E_t\left[\frac{\Lambda_{2,t+1}}{\Lambda_{2,t}\, \Pi^C_{t+1}}\right] = 1 - \Gamma'^\nu_{2,t}\, {v_{2,t}}^2 \tag{A21}$$

Consumption-based velocity:

$$v_{2,t} = \left(1 + \tau^C_t\right)\, \frac{C_{2,t}}{M_{2,t}} \tag{A22}$$

Consumption transaction costs:

$$\Gamma^\nu_{2,t} = \gamma^{\nu,1}\, v_{2,t} + \frac{\gamma^{\nu,2}}{v_{2,t}} - 2\,\left(\gamma^{\nu,1}\, \gamma^{\nu,2}\right)^{0.5} \tag{A23}$$

First derivative of consumption transaction costs:

$$\Gamma'^{\nu}_{2,t} = \gamma^{\nu,1} - \gamma^{\nu,2}\, v_{2,t}{}^{-2} \tag{A24}$$

Optimal reset wage:

$$\widetilde{W}_{2,t}^{1+\zeta\,\eta_2} = \frac{\eta_2}{\eta_2 - 1}\,\frac{F_{2,t}}{G_{2,t}} \tag{A25}$$

Auxiliary variable optimal reset wage:

$$F_{2,t} = N_{2,t}^{D\;1+\zeta}\, W_{2,t}{}^{1+\zeta\,\eta_2} + \beta\,\xi^L\, E_t\left[\left(\frac{\Pi_{t+1}^C}{\Pi_t^{C\,\chi^L}\,\Pi^{*\,1-\chi^L}}\right)^{(1+\zeta)\,\eta_2} F_{2,t+1}\right] \tag{A26}$$

Auxiliary variable optimal reset wage:

$$G_{2,t} = N_{2,t}^D\,\Lambda_{2,t}\,\left(1 - \tau_t^N - \tau_t^{W_f}\right)\, W_{2,t}{}^{\eta_2} + \beta\,\xi^L\, E_t\left[\left(\frac{\Pi_{t+1}^C}{\Pi_t^{C\,\chi^L}\,\Pi^{*\,1-\chi^L}}\right)^{\eta_2-1} G_{2,t+1}\right] \tag{A27}$$

Wages:

$$W_{2,t}{}^{1-\eta_2} = \left(1-\xi^L\right)\,\widetilde{W}_{2,t}^{1-\eta_2} + \xi^L\, W_{2,t-1}{}^{1-\eta_2}\,\left(\frac{\Pi^{*\,1-\chi^L}\,\Pi_{t-1}^{C\;\;\chi^L}}{\Pi_t^C}\right)^{1-\eta_2} \tag{A28}$$

A.2 Firms

A.2.1 Intermediate-Good Firms

Production function:

$$Y_t^S = z_t\, K_t^{D\,\alpha}\, N_t^{D\,1-\alpha} - \psi \tag{A29}$$

FOC w.r.t. capital:

$$R_t^K = \alpha\,\frac{\left(Y_t^S + \psi_t\right)}{K_t^D}\, MC_t \tag{A30}$$

Marginal costs:

$$MC_t = z_t{}^{-1}\,\alpha^{-\alpha}\,\left(1-\alpha\right)^{-(1-\alpha)}\, R_t^{K\,\alpha}\,\left(\left(1+\tau_t^{W_h}\right)\, W_t\right)^{1-\alpha} \tag{A31}$$

Demand for labor of type 1:

$$N_{1,t}^D = \left(1-\omega\right)\,\left(\frac{W_{1,t}}{W_t}\right)^{-\eta} N_t^D \tag{A32}$$

Demand for labor of type 2:

$$N_{2,t}^D = \omega\,\left(\frac{W_{2,t}}{W_t}\right)^{-\eta} N_t^D \tag{A33}$$

Total labor demand:

$$N_t^{D\,1-\frac{1}{\eta}} = \left(1-\omega\right)^{\frac{1}{\eta}}\, N_{1,t}^{D\;1-\frac{1}{\eta}} + \omega^{\frac{1}{\eta}}\, N_{2,t}^{D\;1-\frac{1}{\eta}} \tag{A34}$$

Firm dividends:

$$D_t = P_t\, Y_t - R_t^K\, K_t^D - N_t^D\,\left(1+\tau_t^{W_h}\right)\, W_t \tag{A35}$$

Optimal reset price of domestic intermediate goods:

$$\frac{\widetilde{P}_t^H}{P_t^H} = \frac{\theta}{\theta-1}\,\frac{F_t^H}{G_t^H} \tag{A36}$$

Auxiliary variable optimal reset price of domestic intermediate goods:

$$F_t^H = MC_t\, H_t + \beta\,\xi^H\, E_t\left[\frac{\Lambda_{1,t+1}}{\Lambda_{1,t}}\,\left(\frac{\Pi_{t+1}^H}{\Pi_t^{H\,\chi^H}\,\Pi^{*\,1-\chi^H}}\right)^{\theta} F_{t+1}^H\right] \tag{A37}$$

Auxiliary variable optimal reset price of domestic intermediate goods:

$$G_t^H = P_t^H\, H_t + \beta\, \xi^H\, E_t \left[\frac{\Lambda_{1,t+1}}{\Lambda_{1,t}} \left(\frac{\Pi_{t+1}^H}{{\Pi_t^H}^{\chi^H}\, {\Pi^*}^{1-\chi^H}} \right)^{\theta-1} G_{t+1}^H \right] \tag{A38}$$

Price of domestic intermediate goods:

$${P_t^H}^{1-\theta} = \left(1-\xi^H\right) \left(\widetilde{P}_t^H\right)^{1-\theta} + \xi^H \left(\frac{P_{t-1}^H}{\Pi_t^C} \right)^{1-\theta} \left({\Pi^*}^{1-\chi^H}\, {\Pi_{t-1}^H}^{\chi^H} \right)^{1-\theta} \tag{A39}$$

Domestic intermediate goods inflation:

$$\Pi_t^H = \Pi_t^C\, \frac{P_t^H}{P_{t-1}^H} \tag{A40}$$

Optimal intermediate export goods reset price:

$$\frac{\widetilde{P}_t^X}{P_t^X} = \frac{\theta}{\theta-1}\, \frac{F_t^X}{G_t^X} \tag{A41}$$

Auxiliary variable optimal reset price of intermediate export goods:

$$F_t^X = MC_t\, EX_t\, + \beta\, \xi^X\, E_t \left[\frac{\Lambda_{1,t+1}}{\Lambda_{1,t}} \left(\frac{\Pi_{t+1}^X}{{\Pi_t^X}^{\chi^X}\, {\Pi^*}^{1-\chi^X}} \right)^{\theta} F_{t+1}^X \right] \tag{A42}$$

Auxiliary variable optimal reset price of intermediate export goods:

$$G_t^X = EX_t\, P_t^X\, \widetilde{RER}_t + \beta\, \xi^X\, E_t \left[\frac{\Lambda_{1,t+1}}{\Lambda_{1,t}} \left(\frac{\Pi_{t+1}^X}{{\Pi_t^X}^{\chi^X}\, {\Pi^*}^{1-\chi^X}} \right)^{\theta-1} G_{t+1}^X \right] \tag{A43}$$

Price of intermediate export goods:

$${P_t^X}^{1-\theta} = \left(1-\xi^X\right) \left(\widetilde{P}_t^X\right)^{1-\theta} + \xi^X \left(\frac{P_{t-1}^X}{P_t^{F,C}} \right)^{1-\theta} \left({\Pi_{t-1}^X}^{\chi^X}\, {P^{*,F}}^{1-\chi^H} \right)^{1-\theta} \tag{A44}$$

Intermediate export goods inflation:

$$\Pi_t^X = \Pi_t^{C,F}\, \frac{P_t^X}{P_{t-1}^X} \tag{A45}$$

Real exchange rate:

$$\widetilde{RER}_t = \frac{RER_t}{RER_t^F}; \tag{A46}$$

A.2.2 Final-Good Firms

Final private consumption good:

$${Q_t^C}^{\frac{\mu^C-1}{\mu^C}} = {\nu^C}^{\frac{1}{\mu^C}}\, {H_t^C}^{1-\frac{1}{\mu^C}} + \left(1-\nu^C\right)^{\frac{1}{\mu^C}} \left(\left(1-\Gamma_t^{IM^C}\right) IM_t^C \right)^{1-\frac{1}{\mu^C}} \tag{A47}$$

Demand for consumption intermediate-good bundle:

$$H_t^C = \nu^C\, {P_t^H}^{-\mu^C}\, Q_t^C \tag{A48}$$

Price of private consumption good:

$$1 = \nu^C\, {P_t^H}^{1-\mu^C} + \left(1-\nu^C\right) \left(\frac{P_t^{IM}}{{\Gamma'}_t^{IM^C}} \right)^{1-\mu^C} \tag{A49}$$

Final consumption-good-firm adjustment cost:

$$\Gamma_t^{IM^C} = \frac{\gamma^{IM^C}}{2} \left(\frac{IM_t^C / Q_t^C}{IM_{t-1}^C / Q_{t-1}^C} - 1 \right)^2 \tag{A50}$$

First derivative of final consumption-good-firm adjustment cost:

$$\Gamma'^{IM^C}_t = 1 - \Gamma_t^{IM^C} - \gamma^{IM^C} \frac{IM_t^C / Q_t^C}{IM_{t-1}^C / Q_{t-1}^C} \left(\frac{IM_t^C / Q_t^C}{IM_{t-1}^C / Q_{t-1}^C} - 1 \right) \tag{A51}$$

Final private investment good:

$$Q_t^{I \frac{\mu^I - 1}{\mu^I}} = \nu^{I \frac{1}{\mu^I}} H_t^{I 1 - \frac{1}{\mu^I}} + \left(1 - \nu^I\right)^{\frac{1}{\mu^I}} \left(\left(1 - \Gamma_t^{IM^I}\right) IM_t^I \right)^{1 - \frac{1}{\mu^I}} \tag{A52}$$

Demand for investment intermediate-good bundle:

$$H_t^I = \nu^I \left(\frac{P_t^H}{P_t^I} \right)^{-\mu^I} Q_t^I \tag{A53}$$

Price of private investment good:

$$P_t^{I 1 - \mu^I} = \nu^I P_t^{H 1 - \mu^I} + \left(1 - \nu^I\right) \left(\frac{P_t^{IM}}{\Gamma'^{IM^I}_t} \right)^{1 - \mu^I} \tag{A54}$$

Final investment-good-firm adjustment cost:

$$\Gamma_t^{IM^I} = \frac{\gamma^{IM^I}}{2} \left(\frac{IM_t^I / Q_t^I}{IM_{t-1}^I / Q_{t-1}^I} - 1 \right)^2 \tag{A55}$$

First derivative of final investment-good-firm adjustment cost:

$$\Gamma'^{IM^I}_t = 1 - \Gamma_t^{IM^I} - \gamma^{IM^I} \frac{IM_t^I / Q_t^I}{IM_{t-1}^I / Q_{t-1}^I} \left(\frac{IM_t^I / Q_t^I}{IM_{t-1}^I / Q_{t-1}^I} - 1 \right) \tag{A56}$$

A.3 Fiscal Authority

Government budget constraint:

$$\begin{aligned} G_t + TR_t + B_{t-1} \Pi_t^{C^{-1}} + M_{t-1} \Pi_t^{C^{-1}} = \tau_t^C C_t + \Big(\tau_t^N & \\ + \tau_t^{W_f}\Big) \left(W_{1,t} N_{1,t}^D + W_{2,t} N_{2,t}^D\right) + \tau_t^{W_h} W_t N_t^D + \tau_t^K \Big(R_t^K & \\ u_t - \left(\Gamma_t^u + \delta \tau_t^A\right) P_t^I\Big) K_t + \tau_t^D D_t + T_t + R_t^{-1} B_t + M_t & \end{aligned} \tag{A57}$$

Lump-sum taxes:

$$\frac{T_t}{P_t Y_t} = \phi_{BY} \left(\frac{B_t}{P_t Y_t} - B^* \right) \tag{A58}$$

Taxes to type 1:

$$T_{1,t} = \upsilon_T T_t \tag{A59}$$

Transfers to type 1:

$$TR_{1,t} = \upsilon_{TR} TR_t \tag{A60}$$

Taxes to type 2:

$$T_t = (1 - \omega) T_{1,t} + \omega T_{2,t} \tag{A61}$$

Transfers to type 2:

$$TR_t = (1 - \omega) TR_{1,t} + \omega TR_{2,t} \tag{A62}$$

A.4 Monetary Authority

Taylor rule:

$$ {r_t}^A = \phi_R \, {r_{t-1}}^A + (1-\phi_R) \left({\Pi^*}^A \, r^A + \phi_\pi \left(\Pi_t^{C,A} - {\Pi^*}^A \right) \right) + \phi_{gy} \left(\frac{Y_t}{Y_{t-1}} - 1 \right) + \epsilon_R \tag{A63} $$

Annualized net interest rate:

$$ r_t^A = R_t^4 - 1 \tag{A64} $$

Annual inflation:

$$ \Pi_t^{C,A} = \Pi_t^C \Pi_{t-1}^C \Pi_{t-2}^C \Pi_{t-3}^C \tag{A65} $$

A.5 Aggregation and Market Clearing

Aggregate consumption:

$$ C_t = (1-\omega) \; C_{1,t} + \omega \, C_{2,t} \tag{A66} $$

Aggregate money:

$$ M_t = (1-\omega) \; M_{1,t} + \omega \, M_{2,t} \tag{A67} $$

Aggregate capital:

$$ K_t = (1-\omega) \; K_{1,t} \tag{A68} $$

Aggregate investment:

$$ I_t = (1-\omega) \; I_{1,t} \tag{A69} $$

Aggregate transaction costs:

$$ \Gamma_t^\nu = (1-\omega) \; \Gamma_{1,t}^\nu + \omega \, \Gamma_{2,t}^\nu \tag{A70} $$

Labor market clearing type 1:

$$ N_{1,t} = s_{1,t} \, N_{1,t}^D \tag{A71} $$

Wage dispersion type 1:

$$ s_{1,t} = (1-\xi_1) \left(\frac{\widetilde{W}_{1,t}}{W_{1,t}} \right)^{-\eta_1} + \xi_1 \left(\frac{W_{1,t-1}}{W_{1,t}} \right)^{-\eta_1} \left(\frac{\Pi_t^C}{{\Pi^*}^{1-\chi_1} \, {\Pi_{t-1}^C}^{\chi_1}} \right)^{\eta_1} s_{1,t-1} \tag{A72} $$

Labor market clearing type 2:

$$ N_{2,t} = s_{2,t} \, N_{2,t}^D \tag{A73} $$

Wage dispersion type 2:

$$ s_{2,t} = (1-\xi_2) \left(\frac{\widetilde{W}_{2,t}}{W_{2,t}} \right)^{-\eta_2} + \xi_2 \left(\frac{W_{2,t-1}}{W_{2,t}} \right)^{-\eta_2} \left(\frac{\Pi_t^C}{{\Pi^*}^{1-\chi_2} \, {\Pi_{t-1}^C}^{\chi_2}} \right)^{\eta_2} s_{2,t-1} \tag{A74} $$

Capital market clearing:

$$ u_t \, K_t = K_t^D \tag{A75} $$

Final goods market clearing:

$$ Y_t^S = s_t^H \, H_t + s_t^X \, EX_t \tag{A76} $$

Domestic demand price dispersion:

$$ s_t^H = (1-\xi_H) \left(\frac{\widetilde{P}_t^H}{P_t^H} \right)^{-\theta} + \xi^H \left(\frac{\Pi_t^H}{{\Pi^*}^{1-\chi^H} \, {\Pi_{t-1}^H}^{\chi^H}} \right)^{\theta} s_{t-1}^H \tag{A77} $$

Export price dispersion:

$$ s_t^X = (1-\xi_X) \left(\frac{\widetilde{P}_t^X}{P_t^X} \right)^{-\theta} + \xi^X \left(\frac{\Pi_t^X}{{\Pi^*}^{1-\chi^X} \, {\Pi_{t-1}^X}^{\chi^X}} \right)^{\theta} s_{t-1}^X \tag{A78} $$

Domestic demand:

$$H_t = G_t + H_t^C + H_t^I \tag{A79}$$

Imports goods market clearing:

$$IM_t = IM_t^C + IM_t^I \tag{A80}$$

Market clearing final private consumption:

$$Q_t^C = C_t + \Gamma_t^\nu \tag{A81}$$

Market clearing final investment:

$$Q_t^I = I_t + \Gamma_t^u K_t \tag{A82}$$

Aggregate ressource constraint:

$$P_t Y_t = Q_t^C + \Pi_t Q_t^I + P_t^H G_t + P_t^{F,IM} \widetilde{RER}_t EX_t - P_t^{IM} \left(\frac{1 - \Gamma_t^{IM^C}}{\Gamma'^{IM^C}_t} IM_t^C + \frac{1 - \Gamma_t^{IM^I}}{\Gamma'^{IM^I}_t} IM_t^I \right) \tag{A83}$$

Final good market clearing:

$$Y_t = Y_t^S \tag{A84}$$

Euler equation of foreign households w.r.t. domestic bonds:

$$1 = \beta^F E_t \left[\frac{R_t}{\Pi_{t+1}^C} \left(1 - \Gamma_{B,t}^F\right) \frac{RER_{t+1}^F}{RER_t^F} \frac{\Lambda_{1,t+1}^F}{\Lambda_{1,t}^F} \right] \tag{A85}$$

Foreign financial intermediation premium:

$$\Gamma_{B,t}^F = \gamma_B^F \, exp \left(\frac{RER_t^F B_t^{F,D}}{\Pi_t^C P_t^F Y_t^F} - 1 \right) - RP_t \tag{A86}$$

Foreign trade balance:

$$TB_t^F = P_t^{IM} IM_t RER_t^F - P_t^{F,IM} IM_t^F \tag{A87}$$

Foreign holdings of domestic bonds:

$$\frac{B_t^{F,D}}{R_{t-1}} = B_{t-1}^{F,D} + \frac{TB_{t-1}^F}{RER_{t-1}^F} \tag{A88}$$

Market clearing internationally traded bonds:

$$B_t^{F,D} = B_t^{H,S} \tag{A89}$$

A.6 Exogenous processes

Technology:

$$log\,(z_t) = (1 - \rho_z)\; log\,(z) + \rho_z \, log\,(z_{t-1}) + \epsilon_z \tag{A90}$$

Government expenditure:

$$\frac{G_t}{Y_t} = (1 - \rho_G) \, \frac{G}{Y} + \rho_G \, \frac{G_t}{Y_{t-1}} + \epsilon_G \tag{A91}$$

Transfers:

$$\frac{TR_t}{Y_t} = (1 - \rho_{TR}) \, \frac{TR}{Y} + \rho_{TR} \, \frac{TR_t}{Y_{t-1}} + \epsilon_{TR} \tag{A92}$$

Consumption taxes:

$$\tau_t^C = (1 - \rho_{\tau^C}) \, \tau^C + \rho_{\tau^C} \, \tau_{t-1}^C + \epsilon_{\tau^C} \tag{A93}$$

Labor taxes:

$$\tau_t^N = (1 - \rho_{\tau^N}) \, \tau^N + \rho_{\tau^N} \, \tau_{t-1}^N + \epsilon_{\tau^N} \tag{A94}$$

Firm contribution to social security:

$$\tau_t^{W_f} = (1 - \rho_{\tau^{W,f}})\, \tau^{W_f} + \rho_{\tau^{W,f}}\, \tau_{t-1}^{W_f} + \epsilon_{\tau^{W_f}} \tag{A95}$$

Worker contribution to social security:

$$\tau_t^{W_h} = (1 - \rho_{\tau^{W,h}})\, \tau^{W_h} + \rho_{\tau^{W,h}}\, \tau_{t-1}^{W_h} + \epsilon_{\tau^{W_h}} \tag{A96}$$

Capital taxes:

$$\tau_t^{K} = (1 - \rho_{\tau^{K}})\, \tau^{K} + \rho_{\tau^{K}}\, \tau_{t-1}^{K} + \epsilon_{\tau^{K}} \tag{A97}$$

Share of capital stock eligible for depreciation allowances:

$$\tau_t^{A} = (1 - \rho_{\tau^{A}})\, \tau^{A} + \rho_{\tau^{A}}\, \tau_{t-1}^{A} + \epsilon_{\tau^{A}} \tag{A98}$$

Dividend taxes:

$$\tau_t^{D} = (1 - \rho_{\tau^{D}})\, \tau^{D} + \rho_{\tau^{D}}\, \tau_{t-1}^{D} + \epsilon_{\tau^{D}} \tag{A99}$$

Financial intermediation premium shock:

$$RP_t = \rho_{RP}\, RP_{t-1} + \epsilon_{RP} \tag{A100}$$

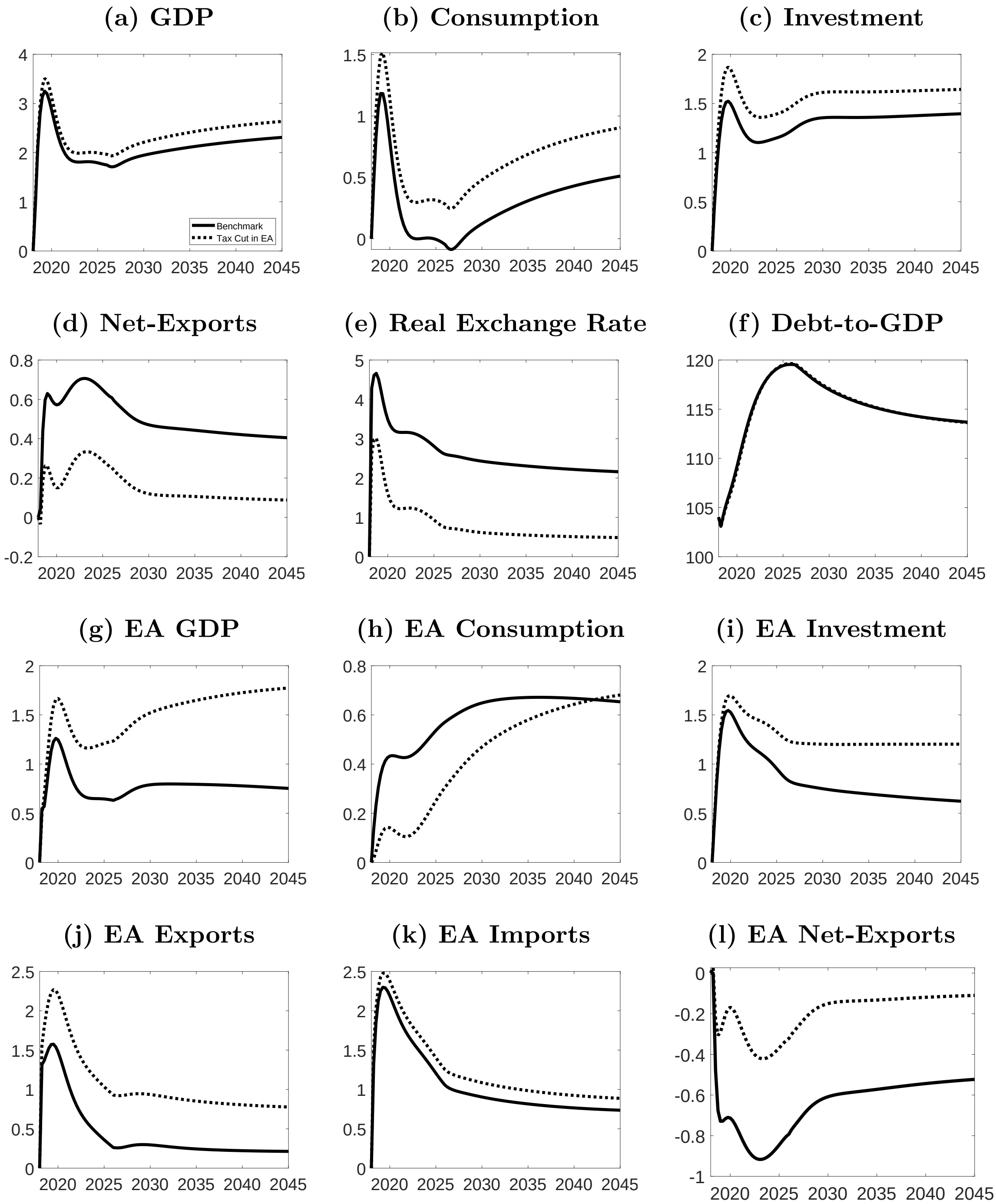
B Calibration

Parameter	Symbol	U.S.	EA
Household			
Share of financially-constrained households	ω	0.27	0.25
Discount factor	β	0.99	0.99
Inverse intertemporal elasticity of substitution	σ	1.00	1.00
Habit parameter	κ	0.67	0.60
Inverse labor supply elasticity	ζ	1.87	2.00
Depreciation rate	δ	0.025	0.025
Elasticity of substitution labor bundling	η	6.00	6.00
Elasticity of substitution labor type1 bundling	η_1	6.00	6.00
Elasticity of substitution labor type 2 bundling	η_2	6.00	6.00
Calvo wage parameter	ξ^L	0.73	0.75
Calvo wage indexation	χ^L	0.62	0.75
Intermediate-Good Firms			
Cobb-Douglas production function parameter	α	0.30	0.30
Fixed cost of production	ψ	0.20	0.20
Elasticity of substitution intermediate goods	θ	6.00	6.00
Calvo price parameter domestic goods	ξ^H	0.65	0.90
Calvo price parameter export goods	ξ^X	0.30	0.30
Calvo price indexation domestic goods	χ^H	0.22	0.50
Calvo price indexation export goods	χ^X	0.50	0.50
Final-Good Firms			
Home bias final consumption good bundling	ν^C	0.90	0.92
Elasticity of substitution final consumption good bundling	μ^C	1.50	1.50
Home bias final investment good bundling	ν^I	0.67	0.42
Elasticity of substitution final investment good bundling	μ^I	1.50	1.50
Adjustment and Transaction Costs			
Consumption transaction cost parameter	$\gamma^{\nu,1}$	0.03	0.29
Consumption transaction cost parameter	$\gamma^{\nu,2}$	0.15	0.15
Investment adjustment cost parameter	γ^I	3.00	3.00
Variable capital utilization cost parameter	$\gamma^{u,1}$	0.03	0.03
Variable capital utilization cost parameter	$\gamma^{u,2}$	0.01	0.01
Import consumption bundling cost parameter	γ^{IM^C}	2.50	2.50
Import investment bundling cost parameter	γ^{IM^I}	0.00	0.00
Foreign bond holding cost parameter	γ_B^F	0.01	0.01
Fiscal Policy			
Debt-to-GDP target	B^*	4.22	2.40
Lump-sum taxes parameter	ϕ_{BY}	0.05	0.10
Steady-state government expenditure to output	$\frac{G}{Y}$	0.16	0.18
Steady-state transfers to output	$\frac{TR}{Y}$	0.08	0.20
Steady-state consumption tax	τ^C	0.08	0.18
Steady-state capital tax	τ^K	0.35	0.18
Steady-state labor tax	τ^N	0.10	0.12
Steady-state household social security contribution	$\tau^{W,h}$	0.07	0.12
Steady-state firm social security contribution	$\tau^{W,f}$	0.07	0.22
Steady-state share of capital stock eligible for depreciation allowances	τ^A	0.68	1.00
Steady-state dividend tax	τ^D	0.24	0.00
Transfer distribution parameter	υ_T	1.00	1.00
Transfer distribution parameter	υ_{TR}	1.00	1.00
Monetary Policy			
Annualized inflation target	Π^{*A}	1.02	1.02
Quarterly inflation target	Π^*	1.005	1.005
Interest rate smoothing	ϕ_R	0.82	0.95
Reaction to inflation	ϕ_π	2.05	2.00
Reaction to output growth	ϕ_{gy}	0.10	0.10

C Scenario with Additional Euro Area Tax Cuts

In this simulation, we consider a scenario with additional tax cuts in the euro area. Specifically, the euro area statutory capital tax rate decreases permanently by 3 percentage points in 2018Q1. As shown in **Figure A1**, such accompanying tax cuts substantially increase the expansionary effect in the euro area. The driving force behind this effect is the positive impact of the euro area tax cut on its trade balance. The tax cut reduces the price of euro area goods, thus inducing a substitution effect to euro area exports.

Figure A1: Additional Euro Area Tax Cuts



Note: Values shown in percentage deviations from steady-state. GDP components are shown as a fraction of the initial steady-state output. GDP is defined as output minus adjustment costs. Debt-to-GDP is in levels.