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ABSTRACT
We develop a fiscal dynamic stochastic general equilibrium (DSGE) model for policy simulation and scenario analysis purposes tailored to Latvia, a small open economy in a monetary union. The fiscal sector elements comprise public investment, public consumption, government transfers that are asymmetrically directed to both optimizing and restricted (hand-to-mouth) households, cyclical unemployment benefits, foreign ownership of public debt, import content in public consumption and investment, and fiscal rules for each fiscal instrument. The model features a search-and-matching labour market friction with pro-cyclical labour costs, a financial accelerator mechanism, and import content in final goods. We estimate the model using Latvian data, study the new channels in the model, and provide a comprehensive analysis on the macroeconomic effects of the fiscal elements. Our results indicate that Latvian fiscal policy was pro-cyclical during the boom-bust period of 2004–2010 and that foreign ownership of public debt breaks Ricardian equivalence and raises fiscal multipliers.

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1. Introduction

Fiscal policy instruments are of critical importance for a small open economy within a monetary union, such as Latvia, to cushion asymmetric shocks in the presence of nominal rigidities (Galí & Monacelli, 2008). In addition, fiscal policy in a monetary union can play an important role even with symmetric shocks. A recent example in the euro area is the persistently low inflation period coupled with the effective lower bound on the monetary policy rate, a state in which prominent European policymakers called for fiscal cooperation (e.g. Draghi, 2019: *'Monetary policy can still achieve its objective, but it can do so faster and with fewer side effects if fiscal policies are aligned with it.'*). Another example is the subsequent COVID-19 pandemic, affecting specific service sectors especially hard, thus requiring targeted fiscal support measures (which has prompted a wave of recent studies with assessments of fiscal policy responses to this health crisis: among others, Faria-e-Castro, 2021; Garcia et al., 2021). The most recent European

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energy crisis is an example of a supply-side shock, for which monetary and fiscal policies are currently implemented in cooperation but in opposite directions–while the price stability mandate requires the central bank to tighten its monetary policy, fiscal policy is expected to support those that are affected the most (Sgaravatti et al., 2021). Therefore, it is of utmost importance for policy experts to be able to undertake fiscal policy simulations in order to evaluate the macroeconomic and fiscal consequences in each scenario. Hence, our goal in this paper is to develop and estimate a fiscal dynamic stochastic general equilibrium (henceforth, DSGE) model for Latvia and to use it for new assessments of Latvia's fiscal policy, especially in times of crises.

We are doing so by building on the existing large-scale New-Keynesian model for Latvia of Bušs (2017). The fiscal sector is developed along the following lines. The key government expenditure elements comprise utility-enhancing public consumption, public investment that increases private productivity, and transfers to two types of households (optimizing and restricted/hand-to-mouth households). We model unemployment benefits separately from the rest of transfers due to their cyclicality and their role as a worker outside option in the wage bargaining process. In the case of public investment and public consumption, a part of public goods is imported from abroad. The revenue side is composed of consumption taxes, labour income taxes, social security contributions by both employers and employees, capital income taxes, and lump-sum taxes (levied solely on optimizing households). We also allow for foreign holdings of domestic public debt–a feature that is not standard in the literature and that alters the model behaviour considerably. Fiscal rules describe the reaction of fiscal authorities to the output gap and to deviations of the debt-to-GDP ratio from its targeted level. Apart from the fiscal sector, we also describe our approach of modelling pro-cyclical wages, an attribute that is prominently featured in Latvian data.

We draw upon the following papers for choosing how to specify the fiscal sector in our model. First, we follow Coenen et al. (2013)'s extended New Area-Wide Model model in adding non-Ricardian households (restricted households), public consumption as a constant-elasticity-of-substitution (CES) aggregate with private consumption, public investment and capital (as a CES aggregate with private capital and subject to a time-to-build friction), as well as asymmetric government transfers to optimizing and restricted households. Differently from Coenen et al. (2013) and this paper, Clancy et al. (2016) and Schwarzmüller and Wolters (2014) model public capital as an additional input in the intermediate goods firms' production function and, thus, public capital is not bundled together with private capital and the production function exhibits increasing returns to scale.[1]

Second, we allow for fiscal instruments to react to (i) deviations in the debt-to-GDP ratio from its target and (ii) the output gap. We also allow for both unanticipated and anticipated shocks in the fiscal rules, but leave only the unanticipated shocks active in estimation. As such, our specification is similar to that of Coenen et al. (2013) and Attinasi et al. (2019). However, the latter study does not include the output gap term in fiscal rules. The fiscal rules for public consumption and investment in Ratto and Roeger (2009) do not feature a reaction term for the debt-to-GDP ratio deviations but instead a reaction term for the investment-to-GDP and consumption-to-GDP ratios. Third, we follow Clancy et al. (2016) by incorporating import content in public consumption and investment.

Third, there is a large literature on endogenous term structures in DSGE models (e.g. Falagiarda & Marzo, 2012; Horvath et al., 2017; Rudebusch & Swanson, 2012; van Binsbergen et al., 2012). However, these models are mostly used for closed economies and since Latvia is a small open economy in a monetary union whose shocks do not influence monetary policy decisions at the union level, we assume that the domestic government bond yield is endogenous in the following way. We assume it positively reacts to deviations of the public debt-to-GDP ratio to make it specific to the public debt dynamics in Latvia. As such, the higher the public debt, the more costly for the government to sustain it. In addition, we assume that it is driven by government bond-specific exogenous shocks in order to take movements in government bond yield data better into account in the estimation of our model.

Penultimately, our approach for modelling foreign ownership of public debt as well as pro-cyclical wages are our own. Both of these features enrich the model's behaviour notably. Foreign ownership of public debt is empirically relevant for Latvia, as the majority of Latvia's public debt is foreign-owned. The peak of the foreign ownership of the public debt occurred when Latvia received a rescue package of the International Monetary Fund and the European Union during the Global Financial Crisis of 2009–2010. Also, labour cost in Latvia has been strongly pro-cyclical over the observation period of 1995–2018. A standard Nash wage bargaining scheme has difficulty in fitting such data. Therefore, we alter the standard Nash wage bargaining by endogenizing the worker outside option. Thus, the model is better able to capture the dynamics of unemployment and wages, hence also of unemployment benefit expenditures and labour tax revenues. Wage pro-cyclicality dampens the reaction of the real economy to fiscal shocks, since this channel works as a pro-cyclical labour cost to firms.

Finally, the model is rich beyond the fiscal block, featuring a number of nominal frictions. In particular, the model contains the financial frictions block whose importance in the Latvian economy is documented by Bušs (2016). The financial frictions channel, for example, amplifies the effects of a capital income tax shock.

From a practical perspective, this paper fills a void in that, before our model, there was no fiscal DSGE model for Latvia that would be used for policy simulation and scenario analysis exercises. Since its inception, the model has been used regularly in scenario analyses at Latvijas Banka (2019), Latvijas Banka (2020), Latvijas Banka (2021), Latvijas Banka (2022a) and Latvijas Banka (2022b). In this paper, we develop and estimate a fiscal model using Latvian quarterly data for the period 1995:Q2–2018:Q3 with 28 observables, nine of which are fiscal time series. Given the model is made for policy simulations, which may require drawing alternative paths using conditional forecasts, we make sure the model fits the data dynamics well. Furthermore, we use the new fiscal model to assess the role of fiscal policy in the boom-bust episode of 2004–2010 and contrast its findings to the model in Bušs (2017). Moreover, we assess the effect of fiscal policy in response to exemplary 'COVID-19' pandemic shocks.

Our main findings are as follows. First, comparing the historical shock decomposition of Latvian GDP growth in our model with the one in the model without the fiscal block (Bušs, 2017), we find that the new fiscal model is providing a more complete story of Latvia's fiscal policy over the business cycle. Specifically, the estimated fiscal rule parameters in front of the output gap, though weakly identified, and the historical shock decomposition give some evidence on the pro-cyclical behaviour of Latvian fiscal policy, especially during the boom-bust episode of 2004–2010. Despite the support from abroad, the Latvian government contributed to the crisis of 2009 by cutting about 3 percentage points (pp) from Latvian GDP growth in the middle of the recession.

Second, having foreign-held public debt amplifies the effects of a government sector risk premium shock to the economy, as a share of government interest payments leaves the country. Also, it breaks the Ricardian equivalence in the case of government transfers being exclusively directed to optimizing households with only the lump-sum tax rule being active, as borrowing money from abroad increases the total amount of money in the economy in the short run. The optimizing households use this money to buy foreign bonds, thus lowering the domestic risk premium and raising consumption and investment. Furthermore, the foreign ownership of government debt amplifies the fiscal multipliers by about 0.2pp on the expenditure side and 0.4pp on the revenue side for a 10-year horizon.

Third, modelling productive public capital is key to induce persistent effects on GDP and private consumption in response to a shock to public investment expenditure. Private investment is crowded in only in the short term. In contrast, modelling household utility-enhancing government consumption induces a minor boost of GDP, while crowding out private consumption.

Fourth, we compute present-value fiscal multipliers in our model for horizons of up to 40 quarters. The largest discounted present-value multiplier in the long run is the public investment multiplier, reaching almost 1.5 in the long run. In comparison, the government consumption multiplier is between 0.1 and 0.3 and the transfers multiplier is between 0 and 0.2 in the long run, where the larger values are seen in the benchmark model, while the smaller values prevail in the model without foreign-held debt. On the revenue side, the labour tax multiplier reaches 0.4 in the model without foreign-held debt and 1.1 in the benchmark model, while the consumption tax multiplier is between −0.1 and 0.4. On impact, the largest multiplier is associated with public consumption (0.6), followed by public investment (0.5) due to the larger home bias in public consumption and the time-to-build friction in building public capital. Tax and transfers multipliers reach on impact up to 0.4. Our results on fiscal multipliers are broadly comparable to what the previous literature has found. On the one hand, the share of foreign-held government debt raises fiscal multipliers, on the other hand import content reduces fiscal multipliers, especially that of public investment. The majority of the literature agrees that the public investment multiplier is among the highest in the long run. More on fiscal multipliers in related studies can be found after the next paragraph.

Fifth, we assess the effectiveness of different fiscal policy responses to the recent COVID-19 pandemic in deterministic simulations. We consider three fiscal policy responses–increases in public consumption expenditure, public investment expenditure, or government transfers expenditure–against large exemplary domestic and foreign negative demand and supply shocks, i.e. consumption preference, foreign demand, total factor productivity, and foreign technology shocks. Consistently across all shocks, public consumption increases prove to be the most costly in terms of the increase in the debt to GDP ratio, followed by transfers increases, while public investment increases put the lowest strain on public finances. While increases in transfers and public investment expenditure prove more helpful in assisting the economy in the medium to long run, the most effective policy to stabilize economic performance in the short run is an increase in public consumption expenditure.

How does our model compare to other fiscal DSGE models in the literature in terms of both policy implications and modelling choices? Beyond the aforementioned studies, our model is similar to the following fiscal models, among others. The model of Boscá et al. (2010) embeds a fiscal sector into a New-Keynesian economy with money providing utility to households, a labour search-and-matching friction, and a financial friction. The fiscal sector provides public capital to the production sector and unemployment benefits and social transfers to households. Government consumption is fully wasteful in contrast to our assumption of utility-enhancing government consumption and only a lump-sum tax rule is active. The fiscal sector in Boscá et al. (2020) is similar to the one of Boscá et al. (2010), but it does not feature unemployment benefits or social transfers. However, the sources of government revenue are more diverse since the model also features banks and a housing supply sector, which are also taxed (taxes on housing services, loans, and deposits are present). Boscá et al. (2010) find a short-run public investment multiplier similar in magnitude to us (0.68), while its long-run multiplier is larger (3.28), as expected for a larger, less open economy and without import content in public expenditure. The historical shock decomposition in Boscá et al. (2020) demonstrates that fiscal shocks contributed positively to per capita GDP growth of Spain before the Global Financial Crisis and at the beginning of it until the middle of 2010 and also during the recovery period from 2014 onward.

Stähler and Thomas (2012) develop a two-country model with a detailed fiscal sector in each country and labour search-and-matching frictions. Above and beyond considering two big open economies, important differences to our model are the inclusion of public wages (also in the bargaining process) and the absence of financial frictions. They find that fiscal devaluation in their model should be ideally achieved by reducing the public sector wage bill, as output and employment losses are the lowest among all considered alternatives. The most damaging way to consolidate public finances in their model is achieved by cutting public investment.[2] A similar structure of the fiscal sector is employed in the small open economy model of Papageorgiou (2014). He also considers public wages in his model for the Greek economy. The short-run multipliers in his model are similar to ours. His computed impact multipliers are about 0.92 for both public consumption and investment and about 0.3 for the labour income tax and the consumption tax.

The model for the Irish economy of Varthalitis (2019) explicitly distinguishes between non-tradable and tradable goods. The tradable goods sector is export-oriented to account for the high openness of the Irish economy. He computes fiscal multipliers for three years after the shock. Due to the high openness of the Irish economy these multipliers are relatively small. Similar to our results, he finds that the public consumption (0.59) and the public investment (0.62) multipliers are on impact larger than the transfers (0.24), the labour income tax (0.09), and the consumption tax (0.51) multipliers. A similar fiscal sector as in our model can also be found in the model of Múčka and Horváth (2015) for the Slovak economy. A key difference is that public consumption goods are produced using public labour via a production function. A comparison of 15 different DSGE models for individual euro area member countries or the whole euro area with respect to fiscal multipliers is undertaken by Kilponen et al. (2019). They–similar to us–find that public consumption multipliers are usually larger than tax multipliers in the short run, while the long-run tax multipliers can be larger than the long-run public consumption multiplier, especially in the case of the labour income tax and the capital income tax. They do not report public investment multipliers though.

Sharing similarities with Christiano et al. (2011), this paper also relates to other estimated small open economy policy models of central banks (e.g. Kilponen et al., 2016), and, to a lesser extent, to studies on the data fit of small open economy DSGE models (e.g. Marcellino & Rychalovska, 2014).

Due to the recent COVID-19 pandemic which has caused many governments to provide unprecedented fiscal support to households and firms in order to cushion the adverse economic effects of the applied health measures,[3] there has been a surge of new studies that explicitly evaluate the effects of these fiscal support measures.

Multi-country models are used by Garcia et al. (2021) and Bartocci et al. (2020). Both studies emphasize the role of fiscal spillovers and fiscal policy coordination. The 4-country EAGLE model is used by Garcia et al. (2021). Fiscal policy (mainly public consumption and transfers increases) becomes active in response to a synthetic pandemic shock, composed of both demand and supply shocks. Four small open economies within the euro area–Ireland, Luxembourg, the Netherlands, and Slovenia–are studied. The fiscal policy spillovers depend in particular on the economy's openness characteristics. A symmetric two-country New-Keynesian model for the euro area is developed by Bartocci et al. (2020) with financial frictions, trade linkages, and unconventional monetary policy. The fiscal response to their synthetic, symmetric pandemic shocks takes the form of lump-sum transfers and public consumption. They find coordinated fiscal policy actions to have larger fiscal multipliers than isolated fiscal policy responses. In case of sovereign bond yields moving asymmetrically ('fragmentation risk'), efficiency can be restored by a supranational fiscal authority issuing public bonds (as implemented in reality by the European Commission for the 'Next Generation EU' fund).

Two-sector models for one country are developed by Faria-e-Castro (2021) and Guerrieri et al. (2022). While Faria-e-Castro (2021) evaluates the effects of the US fiscal pandemic package (CARES act) to cushion the negative supply shock in the services sector to find that the best fiscal policies are unemployment benefits for income stabilization and liquidity assistance for employment stabilization, Guerrieri et al. (2022) more generally and theoretically study conditions when supply shocks in one sector become Keynesian (by also causing demand deterioration in other sectors). Bayer et al. (2022) finds conditional transfers (unemployment benefits when a worker lost her job due to the pandemic) more effective than unconditional transfers in a medium-scale HANK model for the US. Besides also focusing on the US, Gomme (2021) concentrates more on the period after the pandemic and the fiscal sustainability paths from applying different fiscal austerity measures. He finds that capital income tax adjustments lead to the fastest convergence of the debt-to-GDP ratio back to the steady state in the aftermath of the pandemic.

Additionally, although much less related to our study, the pandemic has also prompted research on developing new models that combine an epidemiological module (SIR models) in the spirit of Kermack and McKendrick (1927) with an economic module. Some examples for this strand of literature are, inter alia, Eichenbaum et al. (2021) for the US, or Marenčák (2022) for Slovakia.

While in this paper we are focusing on the development and estimation of a fiscal DSGE model, we address its application regarding the effects of the European Union fiscal rules in a companion paper (Bušs et al., 2021), which is related to several studies concentrating on the effects of different fiscal rules (e.g. Torój, 2017; Vogel et al., 2013).

The remainder of this study is structured as follows. Section 2 gives a brief outline of the base model and a detailed description of the new fiscal elements of the DSGE model for Latvia. Section 3 provides the details on the calibration and estimation of the model. It also analyses the data fitting performance of the model and the historic shock decomposition of Latvian GDP growth. Section 4 inspects the model behaviour and various channels in terms of standardized shock simulations and provides an analysis of fiscal multipliers and the effectiveness of certain fiscal policy adjustments in response to exemplary 'COVID-19 pandemic' shocks. Section 5 concludes.

2. Model

In this paper, we take the model of Bušs (2017), which builds on Bušs (2015) and Bušs (2016), as a benchmark and extend it to include a detailed fiscal block. In the following section, we briefly describe the benchmark model and our approach to modelling pro-cyclical wages. This is followed by the detailed description of the fiscal sector model elements in Section 2.2. Appendices B and C contain the full description of the whole model, while Appendix D contains the measurement equations.

2.1. The non-fiscal part of the model

2.1.1. The previous version of the model

The model of Bušs (2017) consists of three main blocks: the core block, the financial frictions block, and the labour market block. *The core block* is similar to Christiano et al. (2005) and Adolfson et al. (2008). There are three final goods–consumption, investment, and exports–which are produced by combining the domestic homogeneous good with specialized imports for each type of final good. The homogeneous domestic good is produced by a competitive, representative firm. A part of the domestic good is lost due to real frictions in the model economy arising from investment adjustment and capital utilization costs. Households maximize expected lifetime utility from a discounted stream of consumption, subject to habit formation. In the core block, households own the economy's stock of physical capital. They determine the rate at which the capital stock is accumulated and the rate at which it is utilized. Households also own the stock of net foreign assets and determine the rate of stock accumulation.

Monetary policy is conducted exogenously due to Latvia being a member of the euro area (henceforth, EA) with a small share of GDP in overall EA GDP. The foreign economy is modelled as a structural vector auto-regressive (henceforth, SVAR) model in EA output, inflation, nominal interest rate, and unit-root technology growth, as well as foreign demand, competitors' export price, and nominal effective exchange rate. The latter three variables were added in recent years due to the necessity to use the model in regular forecasting exercises (see Appendix B.7 for the foreign block equations). The model economy has one source of exogenous growth, i.e. neutral technology growth, and it is identified using EA data in the foreign economy block. Several fixed share parameters are subject to technology diffusion as in Schmitt-Grohé and Uribe (2012) and Christiano et al. (2021).

The financial frictions block adds the Bernanke et al. (1999) financial accelerator mechanism to the model. Financial frictions allow for borrowers and lenders being different people that have different sets of information. Thus, this block introduces 'entrepreneurs' who are agents with special skills in the operation and management of capital. Their skill in operating the capital is such that it is optimal for them to operate more capital than their own resources can support by borrowing additional funds. There is a financial friction because managing capital is risky, i.e. entrepreneurs can go bankrupt and only entrepreneurs observe their own idiosyncratic productivity without costs. In this setup, households are assumed to deposit their money in banks (only implicitly present). The interest rate on household deposits is nominally non-state-contingent. The banks then lend funds to entrepreneurs using a standard nominal debt contract, which is optimal given the asymmetric information. The amount that banks are willing to lend to an entrepreneur under this debt contract is a function of the entrepreneurial net worth.

The labour market block adds the labour market search and matching framework similar to Mortensen and Pissarides (1994), Hall (2005a), Hall (2005b), Shimer (2005), Shimer (2012) and Christiano et al. (2016). There is no exogenously imposed wage rigidity, and all changes in the total hours worked are attributed to the extensive margin of labour supply. The model allows for both a vacancy posting cost and a hiring fixed cost, but only the latter is assumed to be present in our benchmark calibration. The addition of the labour market block splits the production of intermediate goods into wholesaler and retailer blocks as in Christiano et al. (2016) and Bušs (2017). The wage bargaining process takes place between wholesaler firms and workers. Wholesalers produce the intermediate good using labour which has a fixed marginal productivity of unity. This product of wholesalers is then purchased by retailers to produce specialized inputs for the production of the homogeneous domestic good. The previous version of the model (Bušs, 2017) uses the alternating-offer wage bargaining setup, while our current model deviates from that as outlined in the next section.

2.1.2. Modelling wage pro-cyclicality

Some amendments have been made to the model since its published version in Bušs (2017), among which one is related to the wage bargaining process. Bušs (2017) uses the alternating-offer bargaining mechanism of Christiano et al. (2016). Although the model is able to replicate the unemployment dynamics fairly well, the labour cost in Latvia is pro-cyclical (Figure 1, left panel), thus being at odds with the relatively sticky wages of the alternating-offer bargaining scheme.

Therefore, the current wage bargaining setup in the model is Nash wage bargaining without exogenously imposed wage rigidity but with a procyclical worker outside option, generating pro-cyclical wages. In particular, we use a standard Nash sharing rule:

$$J_t = \frac{1-\eta}{\eta}(V_t - U_t), \tag{1}$$

where J_t is the present value of a worker to a firm, V_t is the present value of a worker being matched with a firm, U_t is the present value of a worker being unemployed, and the parameter η is the bargaining power of the worker. The present value of a worker being

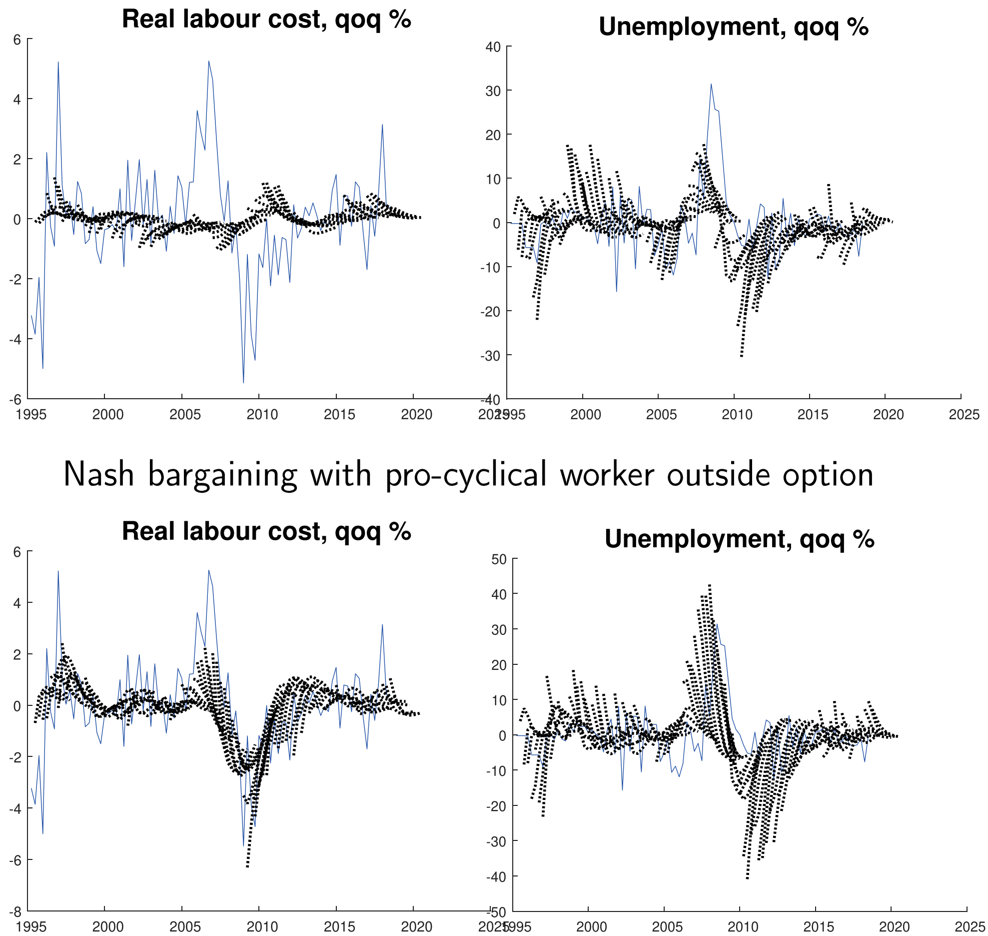

Figure 1. Data fit for constant versus pro-cyclical worker outside option.

Notes: The data series are depicted in solid, iterated forecasts are depicted in dotted lines. They are produced with a linearized model.

unemployed is defined as follows:

$$U_t = B_t^u + \mathbb{E}_t[((1-\lambda_r)\mathbb{M}_{t+1}^o + \lambda_r \mathbb{M}_{t+1}^r)[f_{t+1}V_{t+1} + (1-f_{t+1})U_{t+1}]], \tag{2}$$

where $1-\lambda_r$ (λ_r) is the share of optimizing (restricted) households in the economy and $\mathbb{M}_{t+1}^o$ ($\mathbb{M}_{t+1}^r$) is the nominal stochastic discount factor of optimizing (restricted) households. The presence of the weighted discount factor, $(1-\lambda_r)\mathbb{M}_{t+1}^o + \lambda_r \mathbb{M}_{t+1}^r$, in the above equation takes into account that both types of households bargain over wages in our economy, as in, for example, Boscá et al. (2011). The variable f_t is the job finding rate. The search-and-matching literature typically assumes that the present value of unemployment is constant (Christiano et al., 2021) or a constant share of wages at time t (but as wages are typically modelled relatively acyclical, so is the worker outside option, see Jacquinot et al., 2018).

Here, we deviate from the literature by assuming that the normalized worker outside option $b_t^u = B_t^u/(P_t z_t^+)$ is endogenous and pro-cyclical, in particular, linked to the labour market conditions. The practical reason of doing so is that the pro-cyclical worker outside option is a simple mechanism generating pro-cyclical worker bargaining power, thus the much needed pro-cyclical wages. Although we fully acknowledge that this mechanism is not built from micro-foundations and that the true reasons for wage pro-cyclicality may be different (thus more work on this mechanism is justified), it can be reasoned that labour market conditions affect the outside option of a worker. When the labour market is slack–as in a downturn–a worker faces less options of finding a job elsewhere, thus her bargaining power is lower compared to normal or boom times, hence she might accept a lower wage at the current employer. And, vice versa, as the labour market tightens, firms compete for workers more, which is reflected in a higher bargaining power of a worker via her higher outside option; as a result, there is a pressure on labour costs. This mechanism assumes relatively frequent and de-centralized wage re-negotiation, which may suit the case of Latvia since labour unions in Latvia are relatively scarce.

This mechanism is formalized via linking the worker outside option to the labour market tightness:

$$b_t^u = (b_{t-1}^u)^{\rho_{b^u}} (b^u)^{1-\rho_{b^u}} \left(\frac{1-L}{1-L_{t-1}} \right)^{(1-\rho_{b^u})\alpha^u} \exp(\epsilon_{b^u,t}), \tag{3}$$

where the term in the large parentheses is the measure of labour market tightness, that is, the unemployment rate relative to the non-accelerating inflation rate of unemployment (henceforth, NAIRU), the latter being for simplicity assumed constant and equal to the steady state of the unemployment rate. The parameter α^u controls for the sensitivity of the worker bargaining power to the labour market conditions, the persistence parameter ρ_{b^u} allows for persistence in the worker outside option.

This expression adds a new shock $\epsilon_{b^u,t}$ to the model, which we interpret as a wage cost-push shock. Note that in the resulting wage setting mechanism, there is no additional imposed wage friction or indexation. Also note that it is straightforward to switch back to the standard Nash bargaining setup by setting $\alpha^u = 0$.

From the above expression, it is evident that the worker bargaining power and thus the pressure on wages exhibits a non-linear pattern–the higher is the deviation of the unemployment rate from NAIRU, the increasingly larger is its effect on worker bargaining power and wages. Thus, the mechanism is well suited for simulating the effects of various policies on labour costs at different business cycle stages. Using the aforementioned modelling mechanism, Latvijas Banka (2017) warns about economic overheating, its negative effects on competitiveness, and the subsequent deeper economic downturn. Besides using this modelling approach in simulations, it results in a better data fit (see Figure 1).

2.2. The fiscal block of the model

In the following sections, the new fiscal sector elements are described in detail. First, we introduce public investment into the model. Then, public consumption is added. Third, we describe the government transfers and the budget constraint of restricted households. Fourth, the government budget constraint is given alongside with the debt accumulation process. Next to last, the fiscal rules that determine fiscal policy in the model are specified. Finally, we conclude the description of the fiscal model elements by stating the aggregate resource constraint and the current account.

2.2.1. Public investment

To incorporate public investment and capital, the capital used in the production function of intermediate goods is given by a CES aggregate of private and public capital.[4] Building public capital is subject to a time-to-build fraction and needs to be fuelled by public investment expenditure which is determined as an exogenous fraction of total government expenditure in the steady state and via a fiscal rule dynamically.

The production function of the jth intermediate goods producer becomes:

$$Y_{j,t} = (z_t H_{j,t})^{1-\alpha} \epsilon_t \widetilde{K}_{j,t}^{\alpha} - z_t^{+} \phi, \tag{4}$$

where $H_{j,t}$ denotes the labour input, ϕ is fixed cost of production, ϵ_t, z_t, and z_t^{+} are technology shocks, and the capital bundle $\widetilde{K}_{j,t}$ is a CES aggregate of private capital $K_{j,t}$ and public capital $K_{g,t}$:

$$\widetilde{K}_{j,t} = \left(\alpha_k^{\frac{1}{\nu_k}} (K_{j,t})^{\frac{\nu_k - 1}{\nu_k}} + (1-\alpha_k)^{\frac{1}{\nu_k}} (K_{g,t})^{\frac{\nu_k - 1}{\nu_k}} \right)^{\frac{\nu_k}{\nu_k - 1}}, \tag{5}$$

with the elasticity of substitution denoted by ν_k and the weight on private capital denoted by α_k. Private capital is subject to an endogenous utilization rate, i.e. $K_t = u_t \bar{K}_t$, where $\bar{K}_t$ is the total amount of capital in the economy. The amount of public capital accumulates according to the following equations, where public investment $G_{i,t}$ obeys a condition that incorporates a two-period lag in building public capital from public investment (instead of a one-period lag in building private capital):[5]

$$K_{g,t+1} = (1-\delta_g) K_{g,t} + A_{g,i,t-1}, \quad G_{i,t} = b_0 A_{g,i,t} + b_1 A_{g,i,t-1}, \tag{6}$$

where b_0 and b_1 are parameters controlling the amount to be spent over the two periods it takes to build public capital and $A_{g,i,t-1}$ is the amount of public capital being built at time t which becomes available at time $t+1$ in the production of intermediate goods. Public investment expenditure in the deterministic steady state is an exogenously specified fraction τ_i^g of total public expenditure, and public investment expenditure is split into expenditure directed towards the domestic good and the imported public investment good (with price $p_t^{m,g,i}$) as follows:

$$G_i^{exp} = \tau_i^g G, \quad G_{i,t}^{exp} = G_{i,t}^d + p_t^{m,g,i} G_{i,t}^m. \tag{7}$$

Public investment is a CES aggregate of the domestic good $G_{i,t}^d$ and the imported good $G_{i,t}^m$:

$$G_{i,t} = \left((1-\omega_{g,i})^{\frac{1}{\eta_{g,i}}} (G_{i,t}^d)^{\frac{\eta_{g,i}-1}{\eta_{g,i}}} + (\omega_{g,i})^{\frac{1}{\eta_{g,i}}} (G_{i,t}^m)^{\frac{\eta_{g,i}-1}{\eta_{g,i}}} \right)^{\frac{\eta_{g,i}}{\eta_{g,i}-1}}, \tag{8}$$

where the fraction of imports is given by the constant $\omega_{g,i}$ and the elasticity of substitution between the domestic good and the imported good is denoted by $\eta_{g,i}$. These imported public investment goods are produced by a specialized imports firm using a similar technology and yielding a similar demand condition as for private investment good imports:

$$G_{i,t}^m = \left[\int_0^1 (G_{i,j,t}^m)^{\frac{1}{\lambda_{m,g,i}}} \mathrm{d}j \right]^{\lambda_{m,g,i}}, \quad G_{i,j,t}^m = G_{i,t}^m \left(P_t^{m,g,i} / P_{j,t}^{m,g,i} \right)^{\frac{\lambda_{m,g,i}}{1-\lambda_{m,g,i}}}, \tag{9}$$

where $\lambda_{m,g,i}$ is the elasticity of substitution between any two inputs to specialized imports production, and $P_t^{m,g,i}$ ($P_{j,t}^{m,g,i}$) is the average price (price set by the jth producer) of the specialized import for public investment. The total amount of imported goods is (for the trade balance):

$$S_t P_t^* R_t^{\nu,*} G_{i,t}^m (p_t^{m,g,i})^{\frac{\lambda_{m,g,i}}{1-\lambda_{m,g,i}}}, \tag{10}$$

where S_t is the nominal effective exchange rate, P_t^* is the foreign price level, $p_t^{m,g,i}$ is a measure of price distortion in the differentiated good $G_{i,t}^m$, and $R_t^{\nu,*} = \nu^* R_t^* + 1 - \nu^*$ with R_t^* being the foreign nominal rate of interest.[6]

2.2.2. Public consumption

Public consumption expenditure adds to the utility of households by assuming that the utility bundle is a CES aggregate of private and public consumption.

Specifically, the optimizing household's preferences are given by the following lifetime utility function, subject to internal consumption habits controlled by the parameter b:

$$\mathbb{E}_0\left[\sum_{t=0}^{\infty} \beta^t \left(\zeta_t^c \ln(\widetilde{C}_{o,t} - b\widetilde{C}_{o,t-1})\right)\right], \tag{11}$$

where β is the time discount factor and the utility bundle is defined by the following CES aggregate of private consumption $C_{o,t}$ and public consumption $G_{c,t}$ (with elasticity of substitution ν_c and weight on private consumption α_c):

$$\widetilde{C}_{o,t} = \left(\alpha_c^{\frac{1}{\nu_c}} (C_{o,t})^{\frac{\nu_c - 1}{\nu_c}} + (1-\alpha_c)^{\frac{1}{\nu_c}} (G_{c,t})^{\frac{\nu_c - 1}{\nu_c}}\right)^{\frac{\nu_c}{\nu_c - 1}}. \tag{12}$$

Public consumption expenditure $G_{c,t}^{exp}$ in the deterministic steady state is calibrated to be a fraction τ_c^g of total public expenditure. This expenditure is split into domestic goods purchase of public goods $G_{c,t}^d$ and imported goods purchase of public goods $p_t^{m,g,c} G_{c,t}^m$ as follows:

$$G_c^{exp} = \tau_c^g G, \quad G_{c,t}^{exp} = G_{c,t}^d + p_t^{m,g,c} G_{c,t}^m. \tag{13}$$

Public consumption is a CES aggregate of the domestic good and the imported good:

$$G_{c,t} = \left((1-\omega_{g,c})^{\frac{1}{\eta_{g,c}}} (G_{c,t}^d)^{\frac{\eta_{g,c}-1}{\eta_{g,c}}} + (\omega_{g,c})^{\frac{1}{\eta_{g,c}}} (G_{c,t}^m)^{\frac{\eta_{g,c}-1}{\eta_{g,c}}}\right)^{\frac{\eta_{g,c}}{\eta_{g,c}-1}}, \tag{14}$$

where $\omega_{g,c}$ is the fraction of imports in public consumption and the elasticity of substitution is denoted by $\eta_{g,c}$. Imported public consumption goods are produced by a specialized import firm using the same technology as the private consumption good import firm and yielding a similar demand condition:

$$G_{c,t}^m = \left[\int_0^1 (G_{c,j,t}^m)^{\frac{1}{\lambda_{m,g,c}}} \mathrm{d}j\right]^{\lambda_{m,g,c}}, \quad G_{c,j,t}^m = G_{c,t}^m \left(P_t^{m,g,c} / P_{j,t}^{m,g,c}\right)^{\frac{\lambda_{m,g,c}}{1-\lambda_{m,g,c}}}, \tag{15}$$

where $\lambda_{m,g,c}$ is the elasticity of substitution between any two inputs to specialized imports production, and $P_t^{m,g,c}$ ($P_{j,t}^{m,g,c}$) is the average price (price set by the jth producer) of the specialized import for public consumption. The total amount of this imported good is (for the trade balance):

$$S_t P_t^* R_t^{\nu,*} G_{c,t}^m (p_t^{m,g,c})^{\frac{\lambda_{m,g,c}}{1-\lambda_{m,g,c}}}, \tag{16}$$

where $p_t^{m,g,c}$ is a measure of price distortion in the differentiated good $G_{c,t}^m$.

2.2.3. Government transfers and restricted households

Government transfers (less unemployment benefits) TR_t to both optimizing and restricted households are added to the model as the next new fiscal expenditure item. These transfers are such that in the steady state they are an exogenously given percentage τ_{tr}^g of total public expenditure:

$$\mathrm{TR} = \tau_{tr}^g G. \tag{17}$$

Dynamically, transfers follow a fiscal rule, as will be specified in Section 2.2.5. These transfers are split into transfers to optimizing and restricted households according to the following distribution rule:

$$\mathrm{TR}_t = \lambda_r \cdot \mathrm{TR}_{r,t} + (1-\lambda_r)\mathrm{TR}_{o,t}, \quad \tau_r^{tr} \cdot \mathrm{TR}_{o,t} = (1-\tau_r^{tr})\mathrm{TR}_{r,t}, \tag{18}$$

where $\mathrm{TR}_{r,t}$ denotes the transfers to restricted households (with mass λ_r) and $\mathrm{TR}_{o,t}$ the transfers to optimizing households (with mass $1-\lambda_r$). The constant τ_r^{tr} determines the relative size of transfers to restricted households. In the benchmark model, we assume that government transfers are asymmetric, i.e. $\tau_r^{tr} > 0.5$, so that restricted households receive larger transfers than optimizing households.[7]

The restricted households do not optimize over their consumption and just consume their disposable income each period. Their period-by-period real budget constraint is therefore given by:

$$(1+\tau_t^c)p_t^c C_{r,t} = (1-\tau_t^y-\tau_{w,t}^w)W_t L_t/P_t + D_{b,t}(1-L_t) + \mathrm{TR}_{r,t}, \tag{19}$$

where p_t^c is the real price of consumption goods, τ_t^c is the consumption tax rate, τ_t^y is the labour income tax rate, $\tau_{w,t}^w$ is the worker social security contribution rate, W_t is the nominal wage, L_t is the labour supply, and P_t is the domestic price level. The steady state level of unemployment benefits per unemployed $D_{b,t}$ is calibrated to be a share of steady-state gross wage: $D_b = \mathrm{bshare} \cdot W$. Dynamically, real unemployment benefits per unemployed are endogenous and form a constant share of the worker outside option, i.e. $D_{b,t} = \mathrm{bshare}/\mathrm{woo} \cdot B_t^u/P_t$, where woo is the steady-state share of the worker outside option in the gross wage. The lifetime utility function of restricted households is analogous to the preferences for optimizing households, which becomes relevant for the form of the restricted households' stochastic discount factor in the model's wage bargaining process.

2.2.4. Government budget and debt

Total public expenditure is a constant fraction η_g of GDP in the steady state. It consists of public consumption expenditure, public investment expenditure, total government transfers to households, unemployment benefits, and interest payments on public debt. The residual part is wasteful public expenditure Z_t. Wasteful public expenditure is given by the sum of a constant and an exogenous wasteful spending shock times the technology level z_t^+ to ensure stationarity, i.e. $Z_t = z_t^+(\bar{Z} + \varepsilon_{g,t})$. This implies the following breakdown of total public expenditure:

$$G_t = G_{c,t}^{exp} + G_{i,t}^{exp} + TR_t + D_{b,t}(1 - L_t) + \ln(R_{g,t-1})/\pi_t \cdot D_{g,t-1} + Z_t. \quad (20)$$

The debt interest rate $R_{g,t}$ between time t and $t+1$ equals the foreign interest rate (i.e. Euribor) plus a government-specific risk premium:

$$R_{g,t} = \Phi_{g,t} R_t^*, \quad (21)$$

$$\Phi_{g,t} = \ln(R) - \ln(R^*) + \tilde{\phi}_{g,r}\left(\frac{D_{g,t}}{Y_t + Y_{t-1} + Y_{t-2} + Y_{t-3}} - \overline{dgy}\right) + \varepsilon_{g,t}^{rp}. \quad (22)$$

Above, R_t^* is the gross foreign nominal (risk-free) interest rate, R_t is the gross domestic nominal (risk-free) interest rate, $\varepsilon_{g,t}^{rp}$ is a public debt risk premium shock, and $\tilde{\phi}_{g,r}$ is the parameter controlling the sensitivity of the risk premium to deviations of the public debt-to-GDP ratio from target. Specifically, $\tilde{\phi}_{g,r} > 0$ allows to model a risk premium on public debt that depends on the annual public debt-to-GDP ratio–the higher the public debt-to-GDP ratio, the higher the risk premium the government has to pay on its debt. The intuition is that a higher public debt-to-GDP ratio raises concerns about debt sustainability. Financial markets in turn require a compensation for the higher risk.

On the revenue side, the government levies distortionary taxes on consumption τ_t^c, capital income τ_t^k, labour income τ_t^y, as well as social security contributions on employers $\tau_{e,t}^w$ and employees $\tau_{w,t}^w$. The total real tax revenue T_t from distortionary and lump-sum taxes $T_{ls,t}$ is given by:[8]

$$T_t = \tau_t^c p_t^c(\lambda_r C_{r,t} + (1 - \lambda_r)C_{o,t}) + (\tau_t^y + \tau_{e,t}^w + \tau_{w,t}^w)\frac{W_t L_t}{P_t} + \frac{\tau_t^k \bar{K}_t}{P_t}[u_t r_t^k - P_t^i a(u_t) - \delta P_t^i]$$
$$+ T_{ls,t}, \quad (23)$$

where δ determines the capital depreciation rate and u_t is the private capital utilization rate. The government budget constraint is given by:

$$G_t = \text{Deficit}_{g,t} + T_t, \quad (24)$$

where $\text{Deficit}_{g,t}$ is the fiscal deficit at time t. Real public debt $D_{g,t}$ is governed by the following law of motion (where π_t denotes inflation):

$$D_{g,t} = D_{g,t-1}/\pi_t + \text{Deficit}_{g,t}. \quad (25)$$

The steady-state or target level of public debt is denoted by $\overline{dgy}$. Only a fraction ω_h of public debt is held by domestic (optimizing) households in the steady state, the rest is held abroad. The variable $B_{g,t}$ denotes domestic public debt holdings, and the variable $B_{g,t}^*$ denotes foreign public debt holdings between time t−1 and t. In particular, domestic households can hold a constant share of the total public debt $\overline{B}_{g,t+1} = \omega_h D_{g,t}$ freely and need to pay quadratic adjustment costs $\Gamma_{g,t} = 0.5\gamma_g(B_{g,t+1} - \overline{B}_{g,t+1})^2/\overline{B}_{g,t+1}$ at time t for deviating from this level. Therefore, public debt holdings evolve as follows:

$$D_{g,t} = B_{g,t+1} + B_{g,t+1}^*, \quad B_g = \omega_h D_g. \quad (26)$$

The optimizing household's first-order condition with respect to public debt holdings is equal to:

$$B_{g,t+1} = \left(1 + \gamma_g^{-1}\left(\mathbb{E}_t\left[\mathbb{M}^o_{t,t+1}R_{g,t} - 1\right]\right)\right)\overline{B}_{g,t+1}, \tag{27}$$

where $\mathbb{M}^o_{t,t+1}$ is the stochastic discount factor of optimizing households. In the steady state, total public expenditure is a constant fraction of output:

$$G = \eta_g Y. \tag{28}$$

Dynamically, total public expenditure changes due to adjustments in the revenue or expenditure elements of the government budget, as stipulated in the next section.

2.2.5. Fiscal rules

The dynamic adjustments in the revenue and expenditure elements are controlled for by the following eight fiscal rules:[9]

$$\begin{aligned}\ln(x_t) = {} & (1-\rho_x)\ln(x) + \rho_x \ln(x_{t-1}) + (1-\rho_x)\phi_{x,d}\left(\frac{D_{g,t}}{Y_t + Y_{t-1} + Y_{t-2} + Y_{t-3}} - \overline{dgy}\right) \\ & + (1-\rho_x)\phi_{x,y}(\ln(y_t) - \ln(y)) + \varepsilon_{x,t},\end{aligned} \tag{29}$$

where x_t is an element of the set $\mathbb{X} = \{g^{exp}_{i,t};\, g^{exp}_{c,t};\, \mathrm{tr}_t;\, \tau^c_t;\, \tau^y_t;\, \tau^w_{e,t};\, \tau^w_{w,t};\, t_{ls,t}\}$.[10] Therefore, the government adjusts the taxes or expenditures by reacting to deviations of the debt-to-GDP ratio from the steady state (parameter $\phi_{x,d}$) and to the output gap (parameter $\phi_{x,y}$).[11] Moreover, the government allows for the smoothing of tax rates and expenditures (parameter ρ_x). Finally, unanticipated fiscal shocks via non-zero values of $\varepsilon_{x,t}$ may occur. The capital income tax follows a simple AR(1) process:

$$\ln(\tau^k_t) = (1-\rho_{\tau,k})\ln(\tau^k) + \rho_{\tau,k}\ln(\tau^k_{t-1}) + \varepsilon_{\tau^k,t}. \tag{30}$$

2.2.6. Aggregate resource constraint and current account

The domestic homogeneous final good is used for wasteful public expenditure, domestic part of public consumption expenditure, domestic part of private consumption, domestic part of public investment expenditure, domestic part of private investment, exports, and several frictional costs. The resource constraint is thus given by:

$$\begin{aligned}Y_t - D_t = {} & Z_t + G^d_{c,t} + C^d_t + G^d_{i,t} + I^d_t + \left[\omega_x\left(P^{m,x}_t\right)^{1-\eta_x} + (1-\omega_x)(P_t)^{1-\eta_x}\right]^{\frac{\eta_x}{1-\eta_x}}(1 \\ & - \omega_x)(p^x_t)^{\frac{-\lambda_x}{\lambda_x - 1}}(P^x_t)^{-\eta_f}Y^f_t,\end{aligned} \tag{31}$$

where

$$D_t = \mu G(\bar{\omega}_t;\, \sigma_{t-1})R^k_t P_{k',t-1}\bar{K}_t + \left(\frac{K^v_t}{Q_t} + K^h_t\right)\chi_t L_{t-1} + \frac{\gamma_g(B_{g,t+1} - \overline{B}_{g,t+1})^2}{2\overline{B}_{g,t+1}} \tag{32}$$

is a sum of monitoring costs of entrepreneurs, vacancy posting and recruitment costs, and bond adjustment costs. In this equation, μ controls the amount of monitoring costs of entrepreneurs, $G(\bar{\omega}_t;\, \sigma_{t-1})$ is the fraction of entrepreneurs who are bankrupt in period t, K^v_t and K^h_t are the firms' vacancy posting and hiring costs per new hire, Q_t is the vacancy filling rate, and $\chi_t L_{t-1}$ is the number of new hires.

In the current account, we need to take into account that a part of public debt is held abroad and thus some funds, especially the interest payments on foreign-held debt, are flowing out of the country and are therefore lost to the domestic economy. At the same time, we require that net exports are zero in the steady state. In order to retain this property with the aforementioned new outflow of funds, we allow for a non-zero steady-state level of net foreign bond holdings, i.e. $A^* > 0$. The current account is balanced dynamically by adjustments in the optimizing household's holdings of foreign short-term risk-free bonds A^*_t and by adjustments in the net exports balance NX_t:

$$\mathrm{NX}_t = \mathrm{Exports}_t - \mathrm{Imports}_t \tag{33}$$

$$\begin{aligned}&= S_t P^c_t P^x_t X_t - S_t P^*_t R^{\nu,*}_t \Bigg(C^m_t (p^{m,c}_t)^{\frac{\lambda_{m,c}}{1-\lambda_{m,c}}} + G^m_{c,t} (p^{m,g,c}_t)^{\frac{\lambda_{m,g,c}}{1-\lambda_{m,g,c}}} + I^m_t (p^{m,i}_t)^{\frac{\lambda_{m,i}}{1-\lambda_{m,i}}} \\ &\quad + G^m_{i,t} (p^{m,g,i}_t)^{\frac{\lambda_{m,g,i}}{1-\lambda_{m,g,i}}} + X^m_t (p^{m,x}_t)^{\frac{\lambda_{m,x}}{1-\lambda_{m,x}}} \Bigg).\end{aligned} \tag{34}$$

The definition of the current account is therefore:

$$S_t A^*_{t+1} + B^*_{g,t} R_{g,t-1} = \mathrm{NX}_t + R^*_{t-1} \Phi_{t-1} S_t A^*_t + B^*_{g,t+1}. \tag{35}$$

3. Calibration, estimation, and data fit

This section lays out our choices for the parameter calibration (Section 3.1), our estimation approach and its results (Section 3.2), and the data fit of our estimated model (Section 3.3).

3.1. Model calibration

One period in the model corresponds to a quarter. A subset of the model's parameters are calibrated and the rest are estimated using data for Latvia (domestic part) and the foreign economy for the period 1995:Q2–2018:Q3.

We calibrate a subset of the parameters to ensure matching key ratios in the model and estimate the remaining parameters, as it is standard practice in estimating DSGE models. We relegate the information about the calibration and estimation of the non-fiscal part of the model to Appendix A, since that part largely follows Bušs (2017). A few parameters from there are worth mentioning though. First, we estimate the share of restricted households with a prior mean of 50% in line with other DSGE models (e.g. Attinasi et al., 2019). Its posterior mode is 32%, matching well with the evidence from Latvian micro-level data.[12] Second, the unemployment benefit share of gross wage is set to 0.1 in order to match the unemployment benefit expenditure share in total public expenditures, which is roughly 1% in recent years (before the COVID-19 pandemic). As a result, we differentiate between the steady-state level of the unemployment benefit share and the worker outside option in the wage bargaining mechanism, since we estimate the steady state of the latter (with the posterior mode typically fluctuating around 0.5).

Moving to the fiscal block, its calibrated parameters are reported in Table 1. Consistent with Latvian data, the steady-state government spending share in GDP is 38%; therefore, we set $\eta_g = 0.38$. The steady-state target for the ratio of public debt to annual GDP is set to 30%, a value consistent with the historical average for the period 1995:Q2–2018:Q3.

Furthermore, this calibration implies that the steady-state deficit-to-GDP ratio is equal to about 0.9% which aligns well with the aforementioned historical data sample and with the medium term objective for Latvia (structural balance-to-GDP share of up to −1%) set by the European Commission. A minor part of this debt is held domestically, as most of Latvian public debt during the Global Financial Crisis of the late 2000s was bought by the European Commission and the International Monetary Fund. After the crisis, there is a slow upward trend of the domestically owned public debt share. Therefore, we assume that only 10% of public debt is held by optimizing households, i.e. $\omega_h = 0.1$.

We use data on effective tax rates from Eurostat, that is, tax revenues divided by the corresponding tax base. As such, the effective tax rates are typically smaller than the nominal standard tax rates due to both imperfect tax compliance and the existence of alternative tax regimes. While we include the data on the effective tax rates as observables, we calibrate their steady states to the end of the observable sample, in particular to the year of 2017. Therefore, the effective tax rates are 15.5% (SSC employer), 6.1% (SSC employee), 21% (consumption: value added tax effective rate 13.5% plus excise tax rate), and 16.4% (labour income tax rate). We do not have data on the effective capital tax rate, and calibrate it to 10% (formal tax rate on income from renting a property is 10%, while the rate on capital gains and dividends is 20%). We set price markups for imported public consumption and investment in line with their counterparts in the core block, that is, to 1.05. The calibrated import shares for public consumption and public investment are $\omega_{g,c} = 0.13$ and $\omega_{g,i} = 0.45$, respectively. To compute those, we use input-output tables and adjust the numbers upwards in line with the calibrated imports shares for the private sector, which are also calibrated higher than what input-output tables would suggest. We assume that 70% of government transfers are directed to restricted households, i.e. $\tau_r^{tr} = 0.7$. We motivate this calibration by the fact that the

Table 1. Calibrated parameters, fiscal block.

Parameter	Value	Description
Fiscal block		
$\underline{\eta_g}$	0.3800	Steady-state government spending share per GDP
dgy	0.3000	Target of public debt per annual GDP
ω_h	0.1000	Share of public debt held domestically
τ^k	0.1000	Steady-state capital income tax rate
τ_e^w	0.1550	Steady-state social security contribution rate, employer
τ_w^w	0.0610	Steady-state social security contribution rate, employee
τ^c	0.2100	Steady-state consumption tax rate
τ^y	0.1640	Steady-state labour income tax rate
$\lambda_{m,g,c}$	1.0500	Price mark-up for imported public consumption good
$\lambda_{m,g,i}$	1.0500	Price mark-up for imported public investment good
$\omega_{g,c}$	0.1300	Import share in public consumption goods
$\omega_{g,i}$	0.4500	Import share in public investment goods
τ_r^{tr}	0.7000	Transfer share going to restricted households
τ_c^g	0.4630	Steady-state share of public consumption expenditure in government spending
τ_i^g	0.1170	Steady-state share of public investment expenditure in government spending
τ_{tr}^g	0.3000	Steady-state share of transfers in government spending
α_k	0.8500	Share of private capital in aggregate capital bundle
b_0	1.0000	Parameter in time-to-build technology of public capital
b_1	0.0000	Parameter in time-to-build technology of public capital
$10 \cdot \tilde{\phi}_{g,r}$	0.0500	Sensitivity of public sector risk premium to deviations of public debt-to-GDP ratio
$\theta_{ls,d}$	0.0000	Fiscal rule, lump-sum tax, public debt gap reaction
$\theta_{ls,y}$	0.0000	Fiscal rule, lump-sum tax, output gap reaction

Notes: The table reports the calibrated parameters of the fiscal block of the model.

largest part of public transfers is pensions and most pensioners in Latvia would likely fall into the restricted household type.

The total public spending in the steady state is composed of public consumption expenditure of 46.3% ($\tau_c^g = 0.463$), public investment expenditure of 11.7% ($\tau_i^g = 0.117$), and transfers expenditure of 30% ($\tau_{tr}^g = 0.300$) of the total budget. The remaining smaller expenditure items comprise debt service payments, expenses related to unemployment benefits (modelled separately from other transfers, as they are cyclical), and wasteful public expenditure (a residual). The quasi-share of private capital in the aggregate capital bundle is set to $\alpha_k = 0.85$, close to Latvijas Banka's internal estimates of private capital share in total capital in Latvia. As in Coenen et al. (2013), we postulate that building public capital lasts two quarters instead of the usual one quarter, i.e. subject to an additional one-period lag, and that all expenditure is accounted for two periods before public capital becomes available to the economy. This implies that we set $b_0 = 1$ and $b_1 = 0$. Finally, the sensitivity of the risk premium process for the public debt interest rate with respect to deviations of the debt-to-GDP ratio from its target is set to a small positive number, i.e. $\tilde{\phi}_{g,r} = 0.005$. We suspend the anticipated fiscal shocks for the ease of interpretation.

3.2. Model estimation

The log-linearized model is estimated with Bayesian techniques in `dynare` 4.6.4 (Adjemian et al., 2011). In particular, to find a positive definite Hessian matrix, we first run the Metropolis-Hastings algorithm with a diagonal covariance matrix. The number of simulations used in the estimation of the covariance matrix is equal to 20'000; the number of simulations used when tuning the scale parameter is 200'000; the number of simulations used when climbing the hill is chosen to be 200'000.[13] Then, we approximate the posterior and the marginal data density using the Laplace method. We are using 28 observables, nine of which are fiscal variables. The real variables are in terms of demeaned per capita quarterly growth rates. The data covers the period 1995:Q2–2018:Q3.

The foreign (SVAR) block is estimated separately in line with the assumption used in forecasting rounds that shocks in Latvia do not affect the foreign economy. SVAR shocks are identified via zero restrictions, and by assuming that EA output and EA inflation are predetermined relative to the ECB interest rate shock. The foreign block equations are outlined in Appendix B.7, Equation (B.91) in particular indicates the applied zero restrictions. After the estimation of the foreign block, its estimated parameters are then loaded into the main DSGE model and treated as fixed during the estimation of the domestic block.

3.2.1. Observables

The fiscal observables are: public consumption expenditure, public investment expenditure, public debt-to-GDP ratio, government transfers, effective consumption tax rate, effective labour income tax rate, effective social security contributions by employees, effective social security contributions by employers, and nominal government bond yield.

The non-fiscal observables are: nominal short-term deposit rate, real private consumption, real total investment, real imports, real exports, real GDP, real labour cost, unemployment rate, consumer price index (CPI) inflation, total investment deflator inflation, GDP deflator inflation, spread between the bank short-term lending rate to non-financial corporations and the short-term deposit rate, as well as real house price.

The following variables enter the estimation of the foreign (SVAR) block: EA nominal short-term interest rate, EA CPI inflation, EA GDP, Latvia's foreign demand, Latvia's competitors price on the export side, and the nominal effective exchange rate. The latter is modelled as an AR(1) process.

3.2.2. Estimated shock processes

In total, there are 30 estimated shocks in our model. In the core block, there are three technology shocks: the stationary neutral technology shock ϵ_t, the stationary marginal efficiency of investment shock Υ_t, and the unit-root neutral technology shock $\mu_{z,t}$. Furthermore, there are a shock to consumption preferences ζ_t^c, a domestic risk premium shock affecting the relative riskiness of foreign assets compared to domestic assets $\tilde{\phi}_t$, a stationary exports technology shock ϵ^x, and a shock to nominal effective exchange rate growth s_t.

Moreover, there are five markup shocks in the core block of the model, one for each type of intermediate good: domestic (τ_t^d), exports (τ_t^x), imports for consumption ($\tau_t^{m,c}$), imports for investment ($\tau_t^{m,i}$), and imports for exports ($\tau_t^{m,x}$). The financial frictions block allows for one more shock: a shock to entrepreneurial survival probability γ_t, which serves as a wealth shock. The labour market block adds another shock: a shock to the worker outside option $D_{b,t}$. There are also shocks to each of the five foreign observed variables: euro area GDP Y_t^{ea}, EA inflation π_t^{ea}, EA nominal interest rate R_t^{ea}, foreign demand Y_t^f, competitors' price on the exports side π_t^{compx}.

The fiscal block adds 11 estimated shocks: two markup shocks (imports of public consumption and imports for public investment), shocks to public consumption expenditure $G_{c,t}^{exp}$, public investment expenditure $G_{i,t}^{exp}$, government transfers TR_t, consumption tax rate τ_t^c, labour income tax rate τ_t^y, SSC employer rate $\tau_{e,t}^w$, SSC employee rate $\tau_{w,t}^w$, lump-sum tax $T_{ls,t}$ (to close the government budget balance), and public sector risk premium $\Phi_{g,t}$.

In addition to the above stochastic processes, there are measurement errors except for the domestic deposit rate and the foreign variables. The variance of the measurement errors is calibrated to correspond to 10% of the variance of each data series. Measurement errors are also applied to the fiscal observables, except for the debt-to-GDP ratio, for which we assume there are no measurement errors, and the two social security contribution series, for which the size of measurement errors is halved.

Due to the estimation of the non-fiscal part of the model being already described in previous papers (Bušs, 2015, 2016, 2017), we do not repeat the description of the similar results here and refer the interested reader to these papers or to Appendix A for the prior-posterior tables.

3.2.3. Estimated fiscal parameters

Here we briefly discuss the estimated parameters of the fiscal block, reported in Table 2. First, with the prior mean for the elasticity of substitution between private and public consumption ν_c set to 0.9 and the posterior mode being 0.88, the data provides evidence for moderate complementarity between private and public consumption. Second, when the prior mean for the elasticity of substitution between private and public capital is set to a value below unity, the posterior goes to close to unity. Therefore, in our benchmark version the prior mean is set to a value above unity (1.5), with the posterior mode being 1.57. Thus, the estimation results show evidence of moderate substitution between private and public capital.[14] In comparison, the estimation results of Coenen et al. (2013) suggest strong complementarity between private and public consumption as well as moderate complementarity between private and public capital in the euro area as a whole. Third, the posterior of the quasi-share of private consumption in the aggregate consumption bundle α_c is 0.93 that is above its prior of 0.85, the latter roughly corresponding to the share of private consumption in total consumption in the data.

Fourth, proceeding to the discussion of the fiscal rules, the priors for the parameters relating fiscal instruments to public debt are set so that the model is dynamically stable; that is, fiscal instruments should at least weakly react to public debt deviations from target in a manner to reduce debt deviations. The estimated posterior modes, in several cases, are not far from their priors, suggesting some of these parameters are weakly identified.

Lastly, the estimated parameters relating fiscal instruments to the output gap suggest fiscal instruments have been weakly pro-cyclical; that is, setting prior means to zero, posterior modes suggest that both public consumption and public investment are positively reacting to the output gap. Also, three out of four of according parameters for effective tax rates (incl. consumption tax) are negative, thereby also suggesting pro-cyclical fiscal policy. Yet, on the revenue side, one cannot exclude that the pro-cyclical nature of effective tax rates are driven by a pro-cyclical tax base, a countercyclical shadow economy, or endogenous private sector expenditure switching (Bems & di Giovanni, 2016). In addition, the parameter identification analysis (see Figure F.1 in Appendix F) suggests the fiscal rule parameters in front of the output gap are only weakly identified, therefore one should not draw strong conclusions from their estimated values.

3.3. Data fit and historical shock decomposition

As this model is created for scenario analysis purposes, which may involve building alternative scenarios around the baseline using conditional forecasts, we pay particular attention to our model's data fit and its dynamic behaviour in terms of projections.

Figure 2 depicts the results from our pseudo real-time forecasting exercise that allows us to evaluate the data fit of the model. The figure depicts the data series in solid lines and the iterated forecasts in dotted lines for the whole estimation sample. The forecasts are produced with the Kalman filter using our final estimated parameters and shock standard deviations. Despite there being considerable short-term volatility, trends, and level shifts in the data, the model fits the data decently overall. Particularly, there is no substantial bias in forecasts for any observable, as well as the amplitude and the timing of the cyclical fluctuations are captured relatively accurately.

Figure 3 depicts the historical shock decomposition of the annual GDP growth rate. It demonstrates that Latvia's open economy is strongly affected by foreign shocks and that the Global Financial Crisis episode in 2009–2010 is marked by a lineup of negative shocks–

Table 2. Estimated parameters and shocks, fiscal block.

Parameter	Description	Prior $\mathcal{D}$, **Mean**,St.d.	Posterior **Mode**,St.d.
Fiscal block			
$\xi_{m,g,c}$	Calvo parameter, imports for public consumption	β,**0.75**,0.075	**0.794,**0.046
$\xi_{m,g,i}$	Calvo parameter, imports for public investment	β,**0.75**,0.075	**0.638,**0.020
$\kappa_{m,g,c}$	Inflation indexation, imports for public consumption	β,**0.50**,0.15	**0.462,**0.089
$\kappa_{m,g,i}$	Inflation indexation, imports for public investment	β,**0.50**,0.15	**0.243,**0.054
$\eta_{g,c}$	Elasticity of substitution, domestic good & imports for public consumption	Γ,**1.50**,0.40	**1.299,**0.145
$\eta_{g,i}$	Elasticity of substitution, domestic good & imports for public investment	Γ,**1.50**,0.40	**1.010,**0.141
α_c	Share of private consumption in aggregate consumption bundle	β,**0.85**,0.075	**0.929,**0.019
ν_c	Elasticity of substitution between private and public consumption	β,**0.90**,0.075	**0.877,**0.045
ν_k	Elasticity of substitution between private and public capital	Γ,**1.50**,0.40	**1.569,**0.201
Fiscal rules			
$\rho_{g,c}$	Fiscal rule, total public consumption expenditure, persistence	β,**0.85**,0.075	**0.839,**0.041
$\rho_{g,i}$	Fiscal rule, public investment expenditure, persistence	β,**0.85**,0.075	**0.803,**0.035
ρ_{tr}	Fiscal rule, total transfers expenditure, persistence	β,**0.85**,0.075	**0.883,**0.044
$\rho_{\tau,c}$	Fiscal rule, consumption tax rate, persistence	β,**0.85**,0.075	**0.975,**0.010
$\rho_{\tau,y}$	Fiscal rule, labour income tax rate, persistence	β,**0.85**,0.075	**0.898,**0.031
$\rho_{\tau,w,e}$	Fiscal rule, social security contributions rate employer, persistence	β,**0.85**,0.075	**0.988,**0.009
$\rho_{\tau,w,w}$	Fiscal rule, social security contributions rate employee, persistence	β,**0.85**,0.075	**0.925,**0.021
ρ_{ls}	Fiscal rule, lump-sum tax, persistence	β,**0.85**,0.075	**0.492,**0.049
$\theta_{g,c,d}$	Fiscal rule, total public consumption expenditure, reaction to public debt gap	N,**-0.15**,0.05	**-0.144,**0.020
$\theta_{g,i,d}$	Fiscal rule, public investment expenditure, reaction to public debt gap	N,**-0.10**,0.05	**-0.089,**0.019
$\theta_{tr,d}$	Fiscal rule, total transfers expenditure, reaction to public debt gap	N,**-0.05**,0.05	**-0.044,**0.016
$\theta_{\tau,c,d}$	Fiscal rule, consumption tax rate, reaction to public debt gap	N,**0.10**,0.05	**0.119,**0.014
$\theta_{\tau,y,d}$	Fiscal rule, labour income tax rate, reaction to public debt gap	N,**0.10**,0.05	**0.096,**0.023
$\theta_{\tau,w,e,d}$	Fiscal rule, social security contributions rate employer, reaction to public debt gap	N,**0.05**,0.05	**0.082,**0.018
$\theta_{\tau,w,w,d}$	Fiscal rule, social security contributions rate employee, reaction to public debt gap	N,**0.10**,0.05	**0.145,**0.018
$\theta_{g,c,y}$	Fiscal rule, total public consumption expenditure, reaction to output gap	N,**0.00**,0.075	**0.046,**0.051
$\theta_{g,i,y}$	Fiscal rule, public investment expenditure, reaction to output gap	N,**0.00**,0.075	**0.066,**0.041
$\theta_{tr,y}$	Fiscal rule, total transfers expenditure, reaction to output gap	N,**0.00**,0.075	**-0.095,**0.052
$\theta_{\tau,c,y}$	Fiscal rule, consumption tax rate, reaction to output gap	N,**0.00**,0.075	**-0.027,**0.030
$\theta_{\tau,y,y}$	Fiscal rule, labour income tax rate, reaction to output gap	N,**0.00**,0.075	**0.023,**0.026
$\theta_{\tau,w,e,y}$	Fiscal rule, social security contributions rate employer, reaction to output gap	N,**0.00**,0.075	**-0.059,**0.035
$\theta_{\tau,w,w,y}$	Fiscal rule, social security contributions rate employee, reaction to output gap	N,**0.00**,0.075	**-0.066,**0.022
ρ_{Φ_g}	Persistence, government risk premium	β,**0.85**,0.075	**0.977,**0.013
Shock standard deviations			
$\sigma_{\tau^{m,g,c}}$	Mark-up, imports for public consumption	Γ^{-1},**0.15**,inf	**0.234,**0.262
$\sigma_{\tau^{m,g,i}}$	Mark-up, imports for public investment	Γ^{-1},**0.50**,inf	**0.314,**0.045
$10\sigma_{g,c}$	Public consumption	Γ^{-1},**0.15**,inf	**0.265,**0.023
$10\sigma_{g,i}$	Public investment	Γ^{-1},**0.50**,inf	**0.231,**0.190
$10\sigma_{tr}$	Government transfers	Γ^{-1},**0.50**,inf	**0.624,**0.053
$10\sigma_{ls}$	Lump-sum tax	Γ^{-1},**0.10**,inf	**0.110,**0.011
$100\sigma_{\tau,y}$	Labour income tax	Γ^{-1},**0.15**,inf	**0.330,**0.039
$100\sigma_{\tau,c}$	Consumption tax	Γ^{-1},**0.15**,inf	**0.190,**0.030
$100\sigma_{\tau,w,e}$	Social security contributions, employer	Γ^{-1},**0.50**,inf	**0.656,**0.075
$100\sigma_{\tau,w,w}$	Social security contributions, employee	Γ^{-1},**0.50**,inf	**0.981,**0.091
$100\sigma_{\Phi_g}$	Government risk premium	Γ^{-1},**0.40**,inf	**0.340,**0.025

Notes: This table contains the estimated parameters for the fiscal block of the model.

a negative shock to foreign demand, to entrepreneurial wealth, to domestic technology, to marginal efficiency of investment, and to private consumption. The government, following loose fiscal policy during the boom period, was not ready for the crisis. The government was constrained by its ability to borrow[15]; therefore, it was unable to perform the much needed counter-cyclical fiscal policy. As a result, the government contributed to the economic meltdown by slashing Latvian GDP growth by about 3 percentage points in the

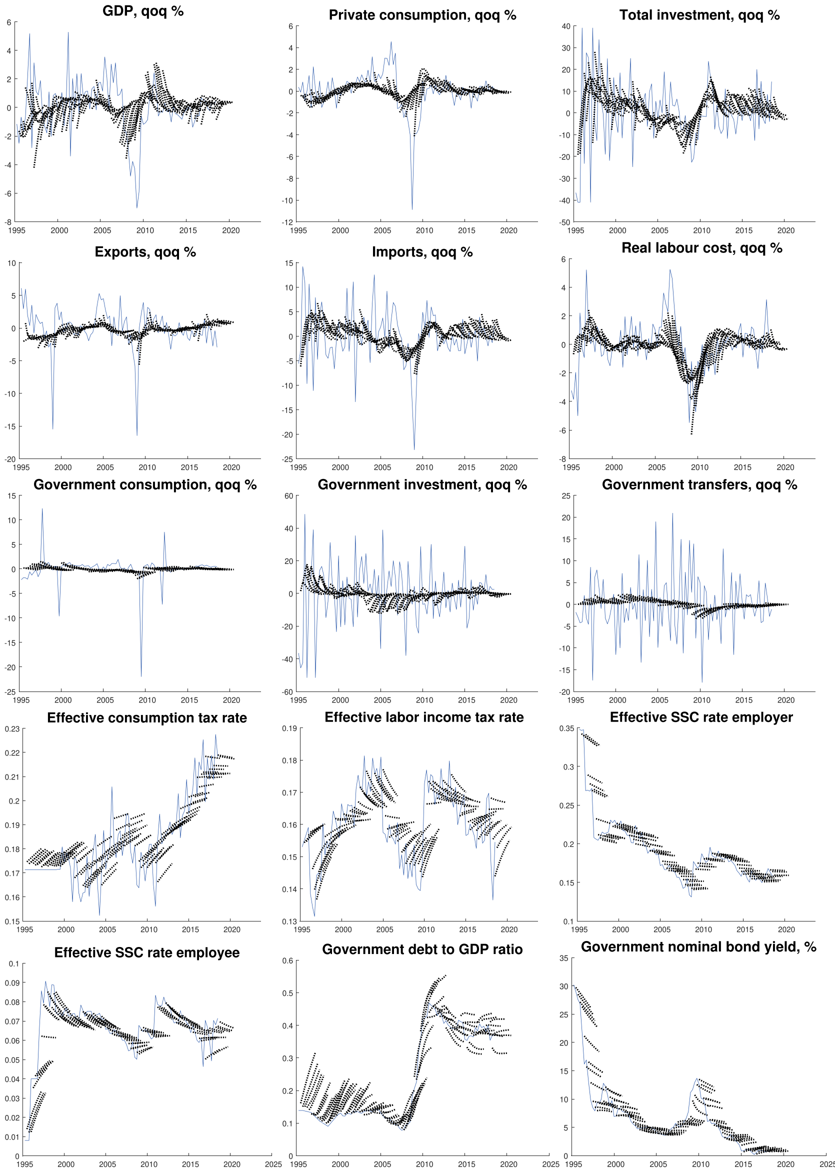

Figure 2. Data fit and forecasting.

Notes: The data series are depicted in solid, iterated forecasts are depicted in dotted lines. All variables are given in net terms of their steady-state values. The expenditure components are in real terms.

heat of the recession.[16] Both government consumption was decreased and several taxes and fees raised (among others, labour income tax, capital income tax, property tax), broadly confirming the negative contribution from the government sector during the recession.

In comparison, a similar historical shock decomposition produced by the model of Bušs (2017) (Figure F.2 in Appendix F) also signals about a negative contribution to GDP growth by the government sector due to the cut in government consumption, but the effect is somewhat smaller in magnitude due to the absence of government instruments

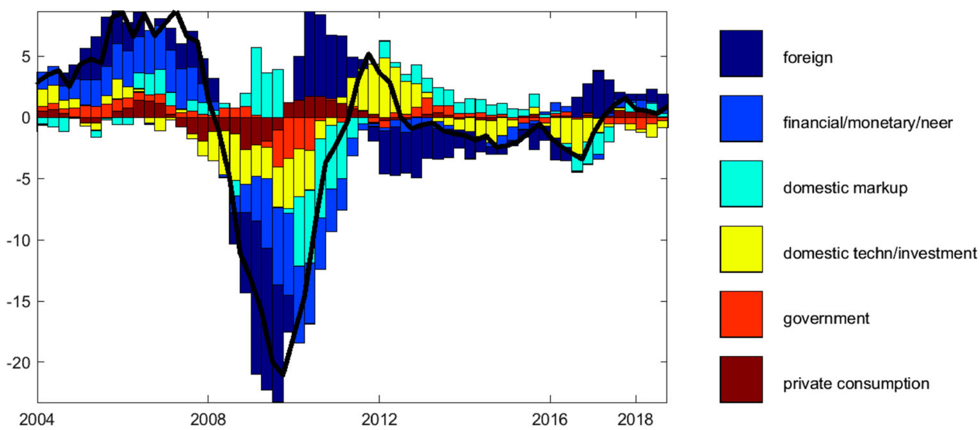

Figure 3. Historical shock decomposition of the annual GDP growth rate.

Notes: This figure depicts the historical shock decomposition of the annual GDP growth rate, produced by the fiscal DSGE model. The model shocks are categorized in six groups – (i) foreign shocks, (ii) financial, monetary, and nominal effective exchange rate shocks, (iii) domestic markup shocks, (iv) domestic technology and investment-specific shocks, (v) government-specific shocks, and (vi) shocks to private consumption.

other than (wasteful) government consumption in that model; likewise, the model without the fiscal block is silent in signalling about the loose fiscal policy before the Global Financial Crisis of 2009–2010.

4. Inspection of model behaviour

In this section, we present results from deterministic simulations of our model. First, in Section 4.1, we inspect the macroeconomic effects of fiscal shocks. In Section 4.2, we investigate how specific model elements and assumptions affect the propagation of shocks. Next, Section 4.3 is devoted to the computation and analysis of fiscal multipliers. Finally, Section 4.4 applies the model to provide insights with respect to the effect of fiscal policy on exemplary 'COVID-19' shocks.

4.1. Fiscal shocks

In this section, we shock the following items of the government balance sheet: (i) public investment expenditure, (ii) public consumption expenditure, (iii) government transfers, (iv) consumption tax rate, (v) labour income tax rate, (vi) SSC rate paid by employers, (vii) SSC rate paid by employees, and (viii) capital income tax rate. All fiscal rules are deactivated for the first 8 quarters; after that, only the lump-sum tax rule becomes active to stabilize public debt. The shock persistence parameters are set to 0.85 for all instruments and the shock size is standardized to imply an increase of 0.5%[17] of steady-state GDP in period 1 in expenditure or revenue, respectively. The resulting impulse response functions are depicted in Figure 4.

4.1.1. Fiscal expenditure shocks

In this paragraph, we analyse the macroeconomic effects of increases in three fiscal public expenditure instruments (Panel A of Figure 4).

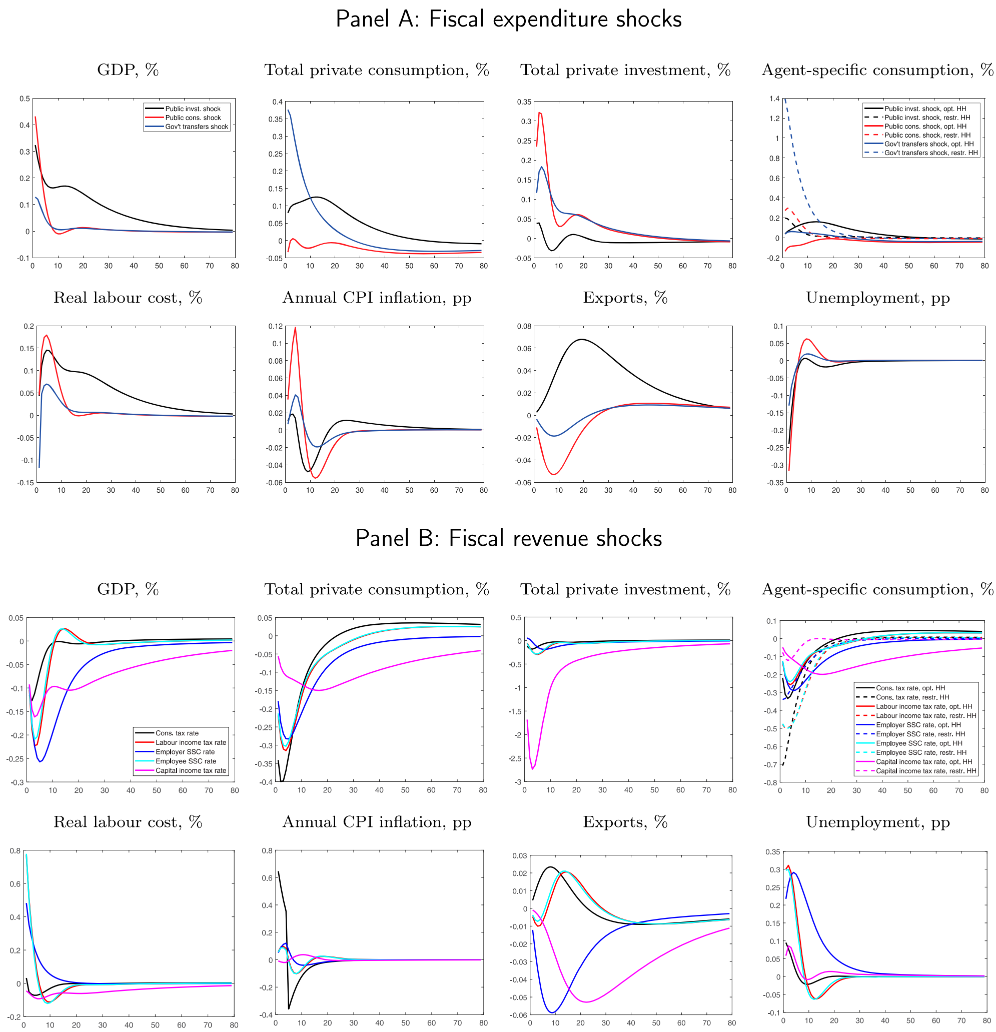

Figure 4. Effect of various fiscal shocks in benchmark model.

Notes: This figure depicts GDP Y_t, total private consumption C_t, total private investment I_t, agent-specific consumption $C_{o,t}$ and $C_{r,t}$, real labour cost $\bar{w}_t^p$, annual CPI inflation $\pi_{c,t}^{tax,yoy} = \sum_{i=0}^{3} 100\{\pi_{c,t-i}(1+\tau_{c,t-i})/(1+\tau_{c,t-i-1})\}$, exports X_t, and unemployment $1 - L_t$ in response to various positive fiscal instrument shocks in the respective fiscal rules, as described in Equation (29). The upper panel A depicts shocks to public investment expenditure, public consumption expenditure, and government transfers, while the lower panel B depicts shocks to the consumption tax rate, the labour income tax rate, the SSC rates for employers and employees, respectively, and the capital income tax rate. The shock size is calibrated to induce an increase in spending or revenue equal to 0.5% of final output in the steady state (Y) in period 1. The length of the impulse response functions is 80 quarters. Fiscal shocks are not anticipated. All fiscal rules are suspended for 8 quarters, and only the lump-sum tax fiscal rule becomes active afterward, assuming a parameter of $\theta_{ls,d} = 0.1$ so that the lump-sum tax amount responds to deviations of the debt-to-GDP ratio to its target while the lump-sum tax amount does not response to the output gap ($\theta_{ls,x} = 0$). All persistence parameters in the fiscal rules are normalized to 0.85.

An increase in public investment expenditure raises GDP directly but also crowds in private investment in the first year and boosts employment. The increased demand for workers causes upward pressures on wages. As both employment and wages go up, so does consumption. The favourable developments in the terms of trade caused by the productivity increase are not outweighed by labour costs; therefore, exports increase. The overall effect on the economy is lasting for an extensive period of time which is due to the share of public capital present in the aggregate capital bundle, as is analysed in detail in Section 4.2.

In response to an increase in public consumption expenditure, the optimizing households obtain more utility and substitute away from private consumption in favour to other budget items such as investment. The resulting rise in private investment and employment leads to higher consumption of restricted households. Therefore, an increase of public consumption is a policy that reduces consumption inequality. On net, there is an upward pressure on domestic prices and exports decline. Also, aggregate private consumption decreases for most of the time.

Comparing these effects with those of raising public investment, it can be seen that an increase of public consumption yields much less persistent effects on GDP. This theme is elaborated on in Latvijas Banka (2019) which, using this model, considers balancing the budget of the government via reducing public consumption or investment. It clearly demonstrates that cutting public consumption would be more favourable for the economy, especially in the medium run.

In the previous version of the model without an extensive fiscal sector, developed in Bušs (2017), there is also (wasteful) public consumption (composed of only the domestic good) by the government as the only fiscal expenditure item. Therefore, we are able to compare the effect of a public consumption shock in both models. The noticeable difference is that in the model without the fiscal block the crowding-out effect on private consumption is stronger. Also, the total private investment in our fiscal model reacts persistently positively, while in the model of Bušs (2017) there is only a short-run positive impact followed by total private investment below trend in the medium run (see Figure F.3 in Appendix F). Since Section 4.2 demonstrates that this cannot be only due to the utility-enhancing property of public consumption in the fiscal model, it might be related to other parameters that are set or estimated differently in the two models or other economic channels present in the model at hand, but not present in the model without the fiscal block.

An increase in government transfers, of which 70% are directed to restricted households, raises restricted households' consumption. In contrast, the optimizing households do not see an increase in their total consumption, as they divert most of the transfer funds increase to investment in face of higher demand. Higher investment leads to higher employment, but the subsequent increase of wages mutes the positive effects on employment in the medium term. Overall, there are a short-lived expansion in GDP and similar macroeconomic effects to those previously established with an increase in public consumption; with the major exception being the behaviour of private consumption which increases in this case, as there is no crowding out of optimizing households' consumption.

4.1.2. Fiscal revenue shocks

In this paragraph, we analyse the macroeconomic effects of increases in five fiscal public revenue instruments (Panel B of Figure 4).

First, we look at an increase in the consumption tax rate. This makes consumption more expensive, reflected in a visible spike of CPI inflation. As a result, consumption decreases. A drop in demand causes a decrease in investment, employment, and wages, especially hurting the restricted households who cannot smooth out consumption by using real or financial assets. The drop in imports caused by the lower demand (and the marginal increase in exports benefiting from lower intermediate goods prices) improves the foreign trade balance.

An increase of the labour income tax rate causes lower incomes for workers. A part of the tax burden is shared with employers via the wage bargaining process. The extent of sharing of the labour tax burden can be partly controlled by a re-calibration of the elasticity of the worker outside option to labour market conditions, which we illustrate in shocking the social security contribution rates below, while in the current case we keep the benchmark calibration. In the benchmark calibration, there is a relatively tight link between the worker outside option and labour market conditions. As a result, there are both demand pressures from lower labour incomes and supply pressures from higher labour costs. Consequently, consumption, investment, employment, and foreign trade deteriorate.

Since economists tend to think that changing the employer SSC rate would mostly affect the employers in the short to medium run, here we utilize our worker outside option specification and calibrate its elasticity to labour market conditions to zero so that gross wages would not decrease much. Essentially, this is the case of a standard Nash wage bargaining. As a result, we obtain that most of the additional tax burden is taken over by the employers in response to an increase in the employer SSC rate, and only a small portion spills over to the employees via lower gross wages. As wages are relatively rigid in this case, there is a protracted period of heightened unemployment in reaction to an increase in the labour cost. Consequently, there is a prolonged decrease in consumption. There is a slight and short-lived increase in investment due to the shift from labour to the relatively cheaper capital before investment is dragged down by a lower demand. The foreign trade balance deteriorates with an increase in the domestic prices. Overall, we see a protracted economic downturn.

In order to differentiate the effects from changing the employer SSC rate and in accord with the perception of many economists that a change in the employee SSC rate mostly affects the employees, we set a unit elasticity of the worker outside option to the labour market conditions in calculating the responses to an increase in the employee SSC rate. As a result, the largest part of the additional tax burden is taken over by the employees, with only a minor share borne by the employers. Consumption mainly drops due to a lower net labour income per worker (less so due to unemployment), sequentially dragging down investment. The effect on output is smaller in both magnitude and duration, compared to that in the case of a raise in the employer SSC rate.

Last but not least, a shock to the (physical) capital income tax rate reduces the rate of return on physical capital. As a result, private investment goes down, dragging down employment, consumption, and GDP. Consumption of the restricted households experiences a sharp decline but recovers with the labour market conditions due to the adjustment in the labour cost. Meanwhile, consumption of optimizing households slowly but persistently declines. Overall, an increase of the capital income tax rate results in a protracted downturn. The long downturn in investment is partly due to substitution away from physical capital to other assets such as foreign bonds which are not subject to the tax increase. Taxing income from all assets, including bonds, thus might reduce the negative effects of capital tax increases on investment in physical capital.

4.2. Sensitivity analysis of channels in the fiscal block

This section is devoted to the sensitivity analysis of the fiscal block by changing specific model features, one at a time. We then compare the model behaviour with and without a particular feature.[18] The benchmark model is the model that employs the parameters reported in Tables 1–2, with all fiscal rules active, unless stated otherwise.[19]

4.2.1. Effect of assumptions in composition and use of public consumption expenditure

Here, we investigate the economic consequences of the presence of public consumption in the utility functions of households and import content in the public consumption bundle in response to increases in public consumption expenditure. Figure 5, Panel A, depicts these impulse response functions.

Public consumption is bundled together with private consumption to enhance the utility of households in the benchmark model. In order to better understand the role of utility-enhancing public consumption, we simulate an alternative model where public consumption is not entering the utility bundle, i.e. public consumption becomes wasteful. For this purpose, we set $\alpha_c = 1$ in the alternative model. This implies an increase of α_c by (only) 0.11. It can be seen from Panel A of Figure 5 that the only stark difference household utility-enhancing public consumption produces is the negative short-term response of private consumption, as households substitute their private consumption for public consumption. Having utility-enhancing public consumption thus decreases the initial co-movement between public and private consumption.

In our benchmark model, a fraction of public consumption is imported from abroad. Alternatively, we assume that all public consumption is sourced domestically. Panel A of Figure 5 demonstrates that having a share of public consumption that is imported makes the reaction of private consumption more negative, and, overall, dampens the reactions of investment, employment, GDP, and inflation.

4.2.2. Effect of assumptions in composition and use of public investment expenditure

In this paragraph, we investigate the economic consequences of the presence of public capital in the intermediate goods production function and import content in the public investment bundle in response to increases in public investment expenditure. Panel B of Figure 5 contains the impulse response functions, underlying the analysis in this paragraph.

In the benchmark model, public investment is enhancing private productivity. Alternatively, we make public investment wasteful. That is, we assume a zero share of public capital in the total capital bundle ($\alpha_k = 1$). An inspection of the impulse responses reveals that the private sector does not have to increase investment after this demand shock that much with productive public capital, since the presence of productive public investment makes the private sector more productive. Therefore, the optimizing households can direct a part of these saved resources to consumption. Therefore, having productive public capital yields a considerably more positive reaction of private consumption and GDP to public investment. Otherwise, without productive public

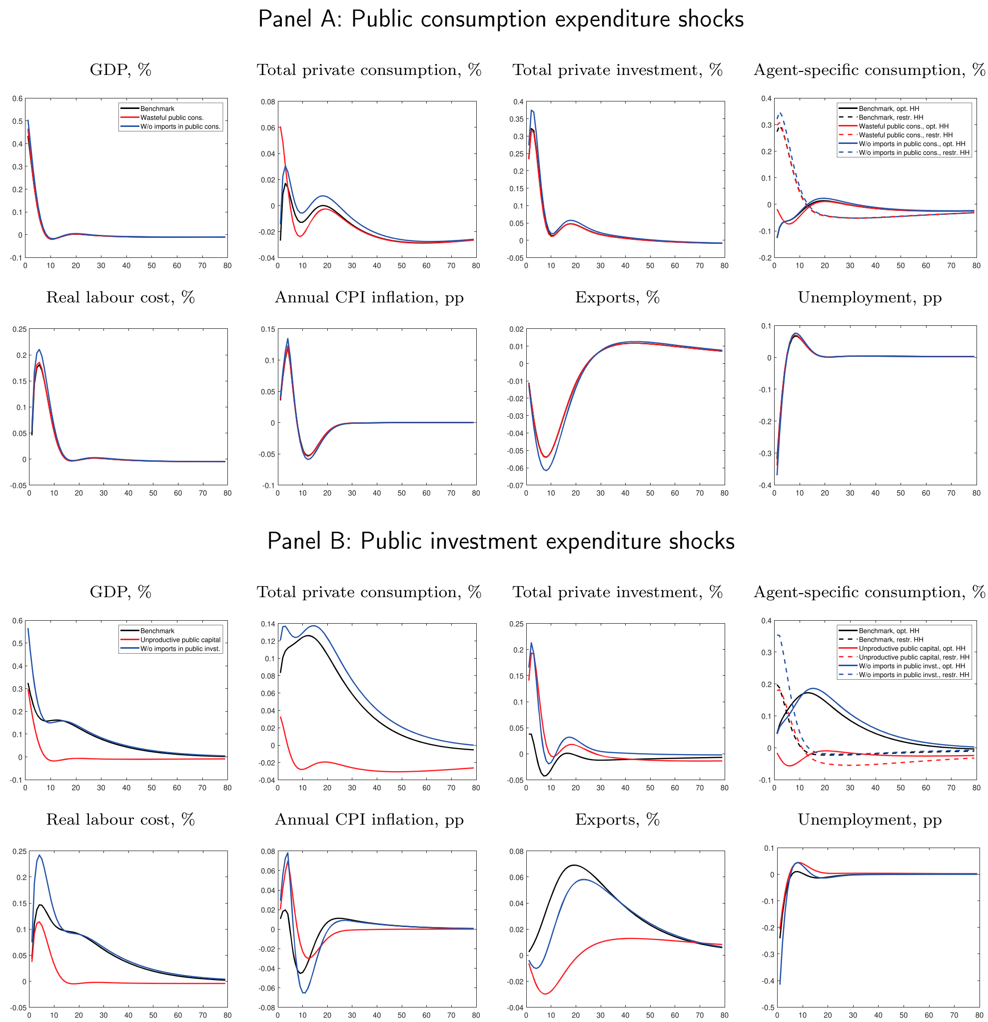

Figure 5. Investigation of economic channels in public consumption and investment.

Notes: This figure depicts GDP Y_t, total private consumption C_t, total private investment I_t, agent-specific consumption $C_{o,t}$ and $C_{r,t}$, real labour cost $\bar{w}_t^p$, annual CPI inflation $\pi_{c,t}^{tax,yoy} = \sum_{i=0}^{3} 100\{\pi_{c,t-i}(1+\tau_{c,t-i})/(1+\tau_{c,t-i-1})\}$, exports X_t, and unemployment $1 - L_t$ in response to shocks to public consumption expenditure (Panel A) and public investment expenditure (Panel B) in the two respective fiscal rules, as described in Equation (29). The upper panel A compares the benchmark model's reaction functions with the alternative model's reaction functions in which either public consumption is wasteful or there is no import content in the public consumption bundle. The lower panel B depicts the benchmark model's reaction functions with the alternative model's reaction functions in which either public capital is unproductive or there is no import content in the public investment bundle. The shock size is calibrated to induce an increase in spending equal to 0.5% of GDP in the steady state (Y) in period 1. The length of the impulse response functions is 80 quarters. Fiscal shocks are not anticipated. All fiscal rules are active according to the parameters supplied in Tables 1–2. However, the persistence parameters are normalized to 0.85 in contrast to the values reported in these tables.

capital, there would be a prolonged decrease in consumption and only a rather short-lived increase in GDP.

In the benchmark model, a fraction of public investment is imported from abroad. Alternatively, we assume that all public investment is sourced domestically. Panel B of Figure 5 depicts the impulse response functions for this alternative model. Similarly to the results for the import content in public consumption in the last paragraph, we find that having import content in public investment dampens the reactions of macroeconomic variables. The differences are more sizeable in the public investment case due to a larger import content in public investment than in public consumption.

4.2.3. Foreign ownership of public debt channel

In the benchmark model, we assume that a large part of public debt is held abroad. Alternatively, we assume that all the public debt is held domestically by the optimizing households (i.e. $\omega_h = 1$). The model behaviour for a shock to the government risk premium (by 10% or about 0.3pp) is compared to the benchmark model Figure 6, Panel A.

When all public debt is held domestically, the increased public debt service payments flow into the pockets of optimizing households; thus, there is only a small impact on the economy overall, with the optimizing households consuming slightly more. With a substantial share of foreign-held public debt, a higher government risk premium implies more money leaving the economy and optimizing households accordingly cutting their consumption. The consequences on the economy become more negative.

A different angle of what the foreign-held public debt channel produces is depicted in Panel B of Figure 6. In this case, we direct all government transfers to optimizing households, increase those transfers by an amount of 0.5% of steady-state GDP, and activate only the lump-sum tax rule. Then, we compare two cases – with versus without foreign-held public debt. If all public debt is held domestically, the well-known Ricardian equivalence holds, since the total amount of money in the economy stays unchanged–the government borrows from optimizing households and gives the same amount back to them. However, with a positive share of public debt held abroad, the total amount of money in the economy temporarily increases, as part of the borrowed money comes from abroad. Therefore, optimizing households have more money temporarily, which they utilize for buying foreign bonds. This channel generally breaks the Ricardian equivalence.

The effect on the domestic economy depends on the specification of two domestic risk premia. In the benchmark model, we separate the government sector's risk premium from the private sector's risk premium. The former defines the dynamics of the government bond yield, while the latter forms the dynamics of the deposit rate. Historically, the two series have behaved differently; therefore, in order to fit the data, we distinguish the two underlying processes. The government risk premium depends on the public debt-to-GDP ratio (plus a government-specific exogenous shock). The private sector's risk premium is subject to the net private foreign assets-to-GDP position (plus a private-sector specific exogenous shock), and this mechanism is key to stabilize the net private foreign assets position. Note that the public sector's foreign debt is stabilized via a debt anchor in fiscal rules.

Given our risk premia specifications, a transfer to optimizing households financed at least partly with foreign-held debt prompts the optimizing households to invest the received money in foreign bonds. As a result, the private sector's risk premium decreases, thus consumption and investment increases, despite an increase of the government's risk premium due to an increase of its debt.[20]

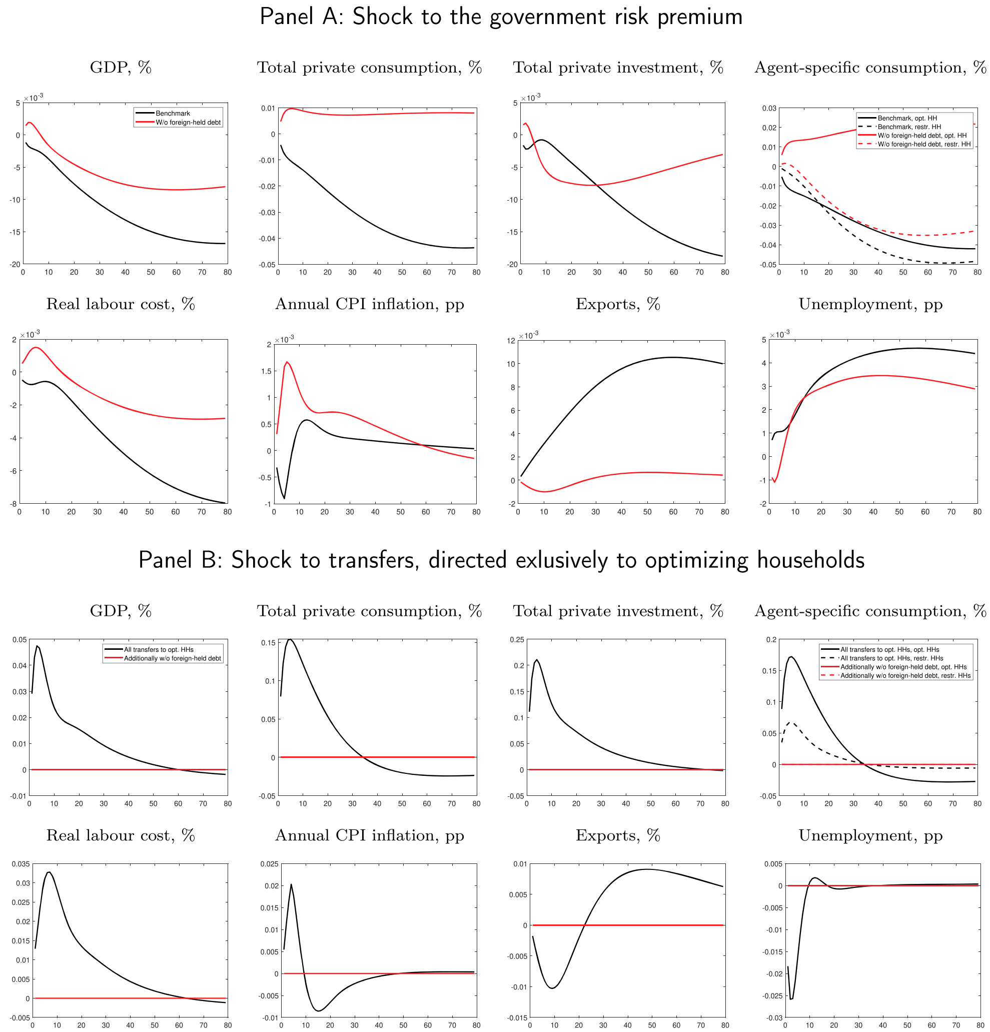

Figure 6. Investigation of foreign-held debt channel.

Notes: This figure depicts GDP Y_t, total private consumption C_t, total private investment I_t, agent-specific consumption $C_{o,t}$ and $C_{r,t}$, real labour cost $\bar{w}_t^p$, annual CPI inflation $\pi_{c,t}^{tax,yoy} = \sum_{i=0}^{3} 100\{\pi_{c,t-i}(1+\tau_{c,t-i})/(1+\tau_{c,t-i-1})\}$, exports X_t, and unemployment $1 - L_t$ in response to shocks to the government risk premium (Panel A), as described in Equation (22), and to an increase in government transfers, directed exclusively to optimizing transfers via setting $\tau_r^{tr} = 0$ (Panel B), with and without foreign-held debt, i.e. $\omega_h = 0.1$ versus $\omega_h = 1$. The shock size is calibrated to induce an increase in the public debt interest rate by 10% or about 30 basis points in Panel A and to induce an increase in government transfers expenditure equal to 0.5% of GDP in the steady state (Y) in period 1 in Panel B. The length of the impulse response functions is 80 quarters. Fiscal shocks are not anticipated. All fiscal rules are active according to the parameters supplied in Tables 1–2 in Panel A, while all fiscal rules are suspended with the exception of the lump-sum tax rule $(\theta_{ls,d} = 0.1)$ in Panel B. However, the persistence parameters are normalized to 0.85 in both panels.

4.2.4. Pro-cyclical unemployment benefits

In the benchmark model, unemployment benefits are pro-cyclical $(\alpha^u > 0)$, as discussed in detail in Section 2.1.2. In this section, we analyse the effects of removing the unemployment benefits' pro-cyclicality on private consumption for selected fiscal shocks. The resulting impulse response functions are depicted in Panel A of Figure 7.

By comparing the effects in the benchmark calibration to the alternative calibration without pro-cyclical unemployment benefits, one can see that pro-cyclical unemployment benefits work as a pro-cyclical labour cost via the wage bargaining mechanism, thus dampening the effects on employment, consumption, and GDP.

4.2.5. Financial frictions channel

The model features a financial accelerator mechanism as financial friction as in Bernanke et al. (1999). In this section, we study how the presence of this financial friction alters the implications of a shock to the capital income tax rate. Therefore, we use an alternative calibration in which the financial accelerator is essentially taken out of the model by equipping entrepreneurs with all the funds so that they do not need to take out loans, removing the start-up funds for new entrepreneurs, and discouraging loan issuance by banks via increasing the monitoring costs. This implies setting the steady-state amount of loans to essentially $B = 0$ (i.e. $n/(p'_k k) = 0.999$), the start-up funds to zero ($W^e = 0$), and monitoring costs to 100% ($\mu = 1$) in this alternative calibration.

As the fiscal shock to analyse, we opt for a shock to the (physical) capital income tax rate since this shock affects the financial accelerator mechanism most directly due to the fact that entrepreneurs manage physical capital. The impulse response functions are depicted in Panel B of Figure 7. The results show that having the financial accelerator mechanism in place increases the persistence and the amplitude of the effects after the shock. GDP, private consumption, and real labour cost take much more time to recover to pre-shock levels than in the model without the financial accelerator mechanism.

4.3. Fiscal multipliers

In this section, we compute cumulative present-value fiscal multipliers for three expenditure instruments and three revenue instruments. For computing these multipliers, we standardize the shock persistence parameters to 0.85 and the shock size to 0.5% of steady-state output. Also, we suspend the fiscal rules except for a weak lump-sum tax rule to stabilize public debt in the long run. Otherwise, the benchmark model calibration is applied, as reported in Tables 1–2.

The fiscal multipliers are computed as the cumulative discounted present value of the change in output versus the change in government expenditure or revenue, for up to 40 quarters in response to a one-time shock in the government instrument:

$$m^{pv}_{exp,t} = \frac{\sum_{k=0}^{t} (R_{ss}/\Pi_{c,ss})^{-k}(Y_k - Y_{ss})}{\sum_{k=0}^{t} (R_{ss}/\Pi_{c,ss})^{-k}(G_k - G_{ss})}, \quad m^{pv}_{tax,t} = -\frac{\sum_{k=0}^{t} (R_{ss}/\Pi_{c,ss})^{-k}(Y_k - Y_{ss})}{\sum_{k=0}^{t} (R_{ss}/\Pi_{c,ss})^{-k}(T_k - T_{ss})}. \tag{36}$$

The discount rate applied is the steady-state domestic real interest rate ($R_{ss}/\Pi_{c,ss}$).

Figure 8 depicts the fiscal multipliers. Panel A reports the results for the benchmark model with foreign-held government debt. As discussed above, this channel triggers non-Ricardian effects. This is true even for lump-sum tax changes affecting optimizing households. Therefore, we also plot the fiscal multipliers in the case of fully domestically held government debt in Panel B of Figure 8.

The results are the following ones. First, foreign ownership of public debt amplifies fiscal multipliers. Raising the foreign-held government debt share from zero to 90%

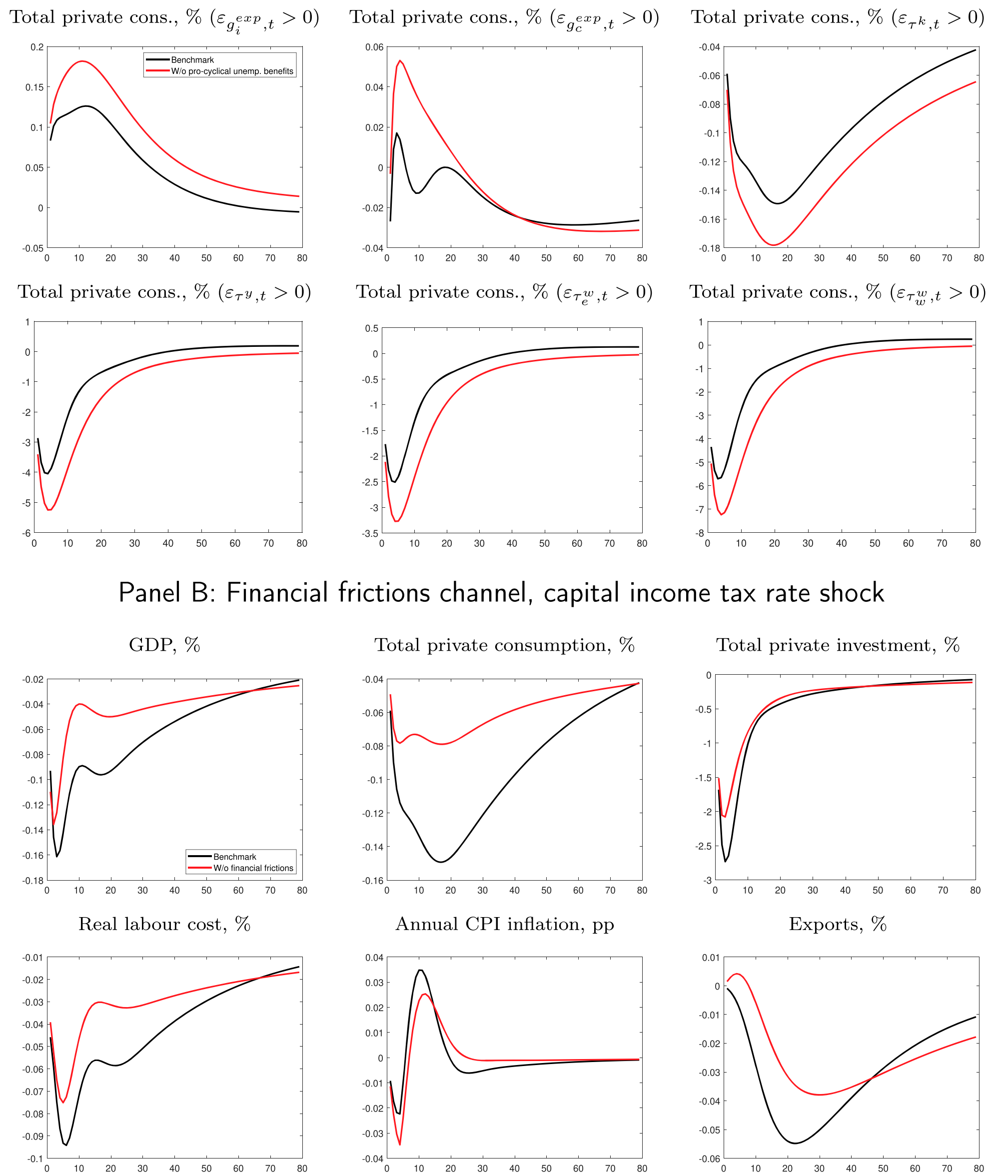

Figure 7. Pro-cyclical unemployment benefits and financial friction channels.

Notes: This figure depicts total private consumption C_t in Panel A and GDP Y_t, total private consumption C_t, total private investment I_t, real labour cost $\bar{w}_t^p$, annual CPI inflation $\pi_{c,t}^{tax,yoy} = \sum_{i=0}^{3} 100\{\pi_{c,t-i}(1+\tau_{c,t-i})/(1+\tau_{c,t-i-1})\}$, and exports X_t in Panel B in response to various fiscal shocks–public investment expenditure, public consumption expenditure, capital income tax rate, labour income tax rate, SSC employer rate, SSC employee rate – in the respective fiscal rules (Panel A), as described in Equation (29), and to an increase in the capital income tax rate (Panel B), respectively. The figure depicts the benchmark model's reaction functions and the alternative model's reaction functions without pro-cyclical unemployment benefits, i.e. $\alpha_u = 0$ (Panel A), or without an active financial accelerator mechanism, i.e. $n/(p_k'k) = 0.999$, $W_e = 0$, $\mu = 1$ (Panel B). The shock size is calibrated to induce an increase in expenditure or revenue equal to 0.5% of GDP in the steady state (Y) in period 1. The length of the impulse response functions is 80 quarters. Fiscal shocks are not anticipated. All fiscal rules are active according to the parameters supplied in Tables 1 and 2. However, the persistence parameters are normalized to 0.85.

inflates long-run (10-year horizon) expenditure multipliers by about 0.2 and tax multipliers by about 0.4. The difference of the impact multipliers becomes less pronounced.

Second, the largest long-run multiplier on the expenditure side and overall is the public investment multiplier, reaching almost 1.5 in the benchmark model. Without foreign-held debt, the multiplier is only equal to 1.2. In comparison, the government consumption multiplier is between 0.1 and 0.3 and the transfers multiplier is between 0 and 0.2 in the long run, depending on the model configuration. Third, the largest long-run multiplier on the revenue side is clearly the labour income tax multiplier, reaching levels between 0.4 and 1.1, compared to values between −0.1 and 0.4 for the consumption tax multiplier.

Third, the largest impact multiplier is associated with public consumption (0.6), followed by public investment (0.5); this is because of the larger home bias in public consumption, relative to public investment. Tax and transfers multipliers on impact reach up to 0.4. On the one hand, imports content reduces impact fiscal multipliers. On the other hand, the share of foreign-held government debt raises impact (and long-run) fiscal multipliers.

How do financial frictions affect fiscal multipliers? The graphs in Panel C, for which we use the model without a financial accelerator mechanism in place, gives some

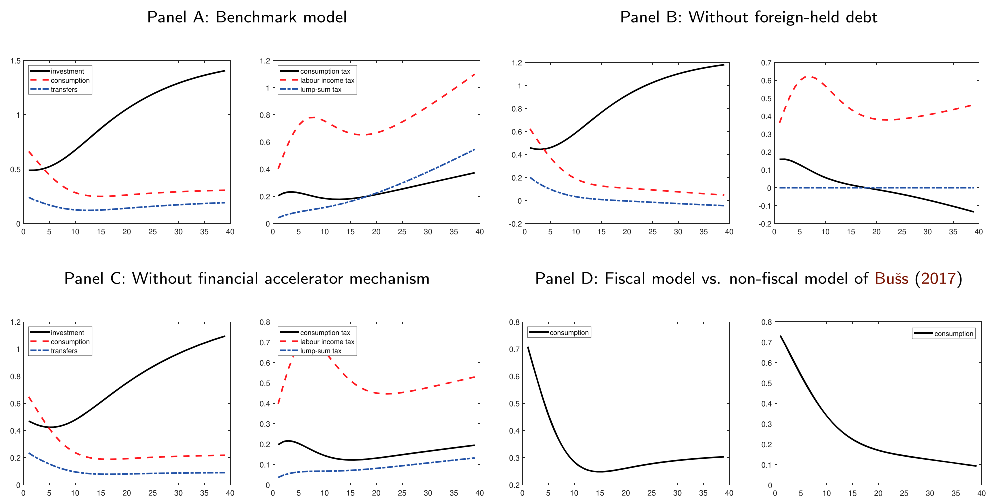

Figure 8. Fiscal multipliers.

Notes: This figure depicts the present value discounted fiscal multipliers for horizons up to 40 quarters. Specifically, the figure depicts, in the left figure of Panels A–C, fiscal multipliers for public investment expenditure (solid line), public consumption expenditure (dashed line), government transfers (dashed-dotted line), and, in the right figure of Panels A–C, fiscal multipliers for consumption tax rate (solid line), labour income tax rate (dashed line), and lump-sum tax (dashed-dotted line). Panel A depicts the fiscal multipliers for the benchmark model, Panel B for the alternative calibration without foreign-held debt, Panel C for the alternative calibration without an active fiscal accelerator mechanism, and Panel D depicts the wasteful or non-utility-enhancing public consumption multipliers for both the benchmark model and for the previous version of the model without a fiscal sector developed in Bušs (2017) (the only fiscal instrument available in both models is wasteful or non-utility-enhancing public consumption). Fiscal shocks are not anticipated. All fiscal rules are suspended with the exception of the lump-sum tax fiscal rule for which a parameter of $\theta_{ls,d} = 0.1$ is assumed so that the lump-sum tax amount responds to deviations of the debt-to-GDP ratio to its target while the lump-sum tax amount does not response to the output gap ($\theta_{ls,x} = 0$). All persistence parameters in the fiscal rules are normalized to 0.85. For Panel A and unless otherwise noted below, all the parameters of Tables 1–2 are used. For Panel B, $\omega_h = 1$ is assumed. For Panel C, the parameter settings $n/(p'_k k) = 0.999$, $W^e = 0$, and $\mu = 1$ are assumed. For Panel D, left-hand side figure, $\alpha_c = 1$ is assumed.

indication. Fiscal policy becomes less effective or distortive for expenditure or revenue, respectively, instruments, since all fiscal multipliers shrink relative to the benchmark model's multipliers. For some multipliers, the effect is quite sizeable. So does the long-run public investment multiplier decrease by about 0.3 to roughly 1.1, the labour income tax multiplier decreases below 1, and the long-run lump-sum tax multiplier becomes about four times smaller. For the other multipliers, only negligible effects are recorded. The reason is that financial frictions work via affecting the physical capital supply in the economy. Since the Ricardian households own the physical capital and entrepreneurs are part of this household type, these households are affected by financial frictions, but restricted households are not. Therefore, fiscal policy affecting only or to a much larger extent restricted households, such as transfers, public consumption, and consumption taxes, are much less affected by the absence of financial frictions than fiscal policies that mostly affect Ricardian households.

Finally, Panel D of Figure 8 reports again the fiscal multiplier for public consumption in our model and the corresponding wasteful government consumption multiplier of the model in Bušs (2017) without an extensive fiscal sector. This is the only fiscal multiplier we can compute in the previous version of the model for Latvia. The impact multiplier is about the same, but due to the utility-enhancing nature of public consumption in our new fiscal model, fiscal policy that increases public consumption expenditure is more effective in the longer run with the long-run utility-enhancing public consumption fiscal multiplier converging to around 0.3, while the wasteful government consumption multiplier converges to around 0.1 after 40 quarters.

4.4. Model insights for fiscal policy during the COVID-19 pandemic

In this section, we simulate large shocks that are exemplary for the economic effects of the recent COVID-19 pandemic and the containment measures against the spread of this disease such as travel and social interaction restrictions in the case of a small open economy such as Latvia.

Specifically, we simulate the consequences of two negative supply and two negative demand shocks within our model, where one shock of each kind is a foreign shock that spills over to the Latvian economy and one shock of each kind is a domestic shock. We calibrate each shock size to induce a reduction of annual GDP growth of 5 percentage points, absent any reaction of fiscal policy.

Besides this benchmark 'COVID-19' shock scenario, we add three fiscal policy responses, one at a time, exemplary for the fiscal support granted by Latvia's government (and many other governments around the world), to learn in which way and to what extent a specific fiscal policy response can help alleviate the negative effects of one of the specific, previously outlined 'COVID-19' shocks. The fiscal response comes in the form of an increase of public consumption expenditure, of public investment expenditure, or of government transfers expenditure. The size of the fiscal response is standardized to be equal to 5% of quarterly steady-state GDP on impact.

Figure 9 depicts the impulse response functions of key economic quantities in response to negative demand shocks (a negative domestic consumption preference shock in Panel A and a negative foreign demand shock in Panel B). Demand shocks are a part of the synthetic pandemic shock also in Bartocci et al. (2020) and Garcia et al. (2021). Inspecting the responses to a negative consumption preference shock, we find first that for net GDP growth, i.e. realized quarterly GDP growth minus the steady-state quarterly GDP growth rate, the increase of public consumption expenditure alleviates the recession in period 1, at the time of the shock, the most. This comes, however, at the expense of a more serious recession in the medium run between quarters 2 and 10, even compared to no fiscal response. The reason for this short-term success is that more private consumption expenditure can be re-routed to private investment due to the substitution of private for public consumption. Second, GDP growth, private investment growth, and unemployment fair much better in the medium term when public investment or transfers expenditure is increased instead due to larger private investment growth in the medium term. Third, an increase in transfers particularly helps stabilizing consumption growth of restricted households in the short run. Fourth, inflation is stabilized most substantially with a fiscal response that increases public consumption expenditure.

Moving to inspecting the effects of a negative foreign demand shock in Panel B of Figure 9, the negative effect on GDP growth mainly comes from a huge decline in net exports. The recession is more short-lived than in the case of a collapse of domestic consumption demand, while the impact of the different fiscal policy responses for GDP growth is similar. Differences appear for aggregate private consumption growth, which increases in all fiscal response scenarios in the short term, while the largest positive reaction is realized with an increase in transfers expenditure. The increase in the debt to GDP ratio over the long run is again the largest with an increase in public consumption expenditure as the fiscal response to the 'COVID-19' shock. Unemployment increases on impact much more than in response to a consumption preference shock due to the immediate substantial down-sizing of economic activities due to the decline in foreign demand. In the case of a consumption preference shock, the negative effects take more time to propagate through the economy, thus affecting unemployment later.

Similar to our results, transfers in conjunction with public consumption are uncovered to be effective fiscal responses in both Bartocci et al. (2020) and Garcia et al. (2021). Both studies do not use public investment increases as fiscal policy response to the pandemic shock, which we find to be also an effective policy response.

Figure 10 depicts the impulse response functions of key economic quantities in response to negative supply shocks (a negative domestic total factor productivity shock in Panel A and a negative foreign unit-root technology shock in Panel B). Supply shocks as pandemic shocks are also utilized by Mihailov (2020), Faria-e-Castro (2021), Gomme (2021), and Guerrieri et al. (2022). In contrast to the previously analysed demand shocks, these supply shocks take some time to unfold their full destructive potential. Therefore, the initial first quarter does not necessarily see the largest decline in quarterly GDP growth and the recession is much more persistent. In Panel A, where stationary total factor productivity declines, net GDP growth is −1pp in the first quarter but −2pp in the second quarter. The first quarter recession is effectively undone by all fiscal policy responses, but increasing transfers expenditure is the only policy that does not fair much worse than the 'no fiscal policy response' scenario in the longer run. The cost is quite large in terms of debt to GDP ratio increases and increased inflation volatility, especially for the fiscal policy that increases public consumption expenditure to respond to the pandemic shock. This is due to an increase in demand for investment goods that is

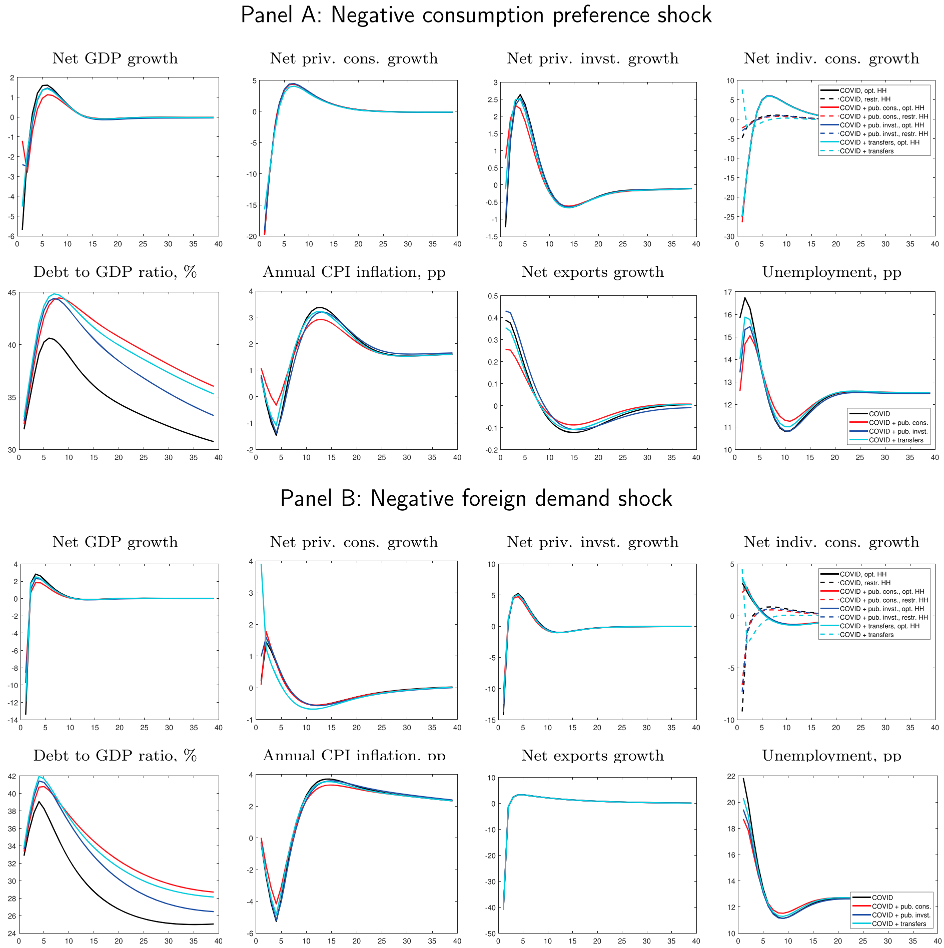

Figure 9. Pandemic simulations – Demand shocks and fiscal policy.

Notes: This figure depicts net GDP growth $\Delta y_t = \ln(Y_t) - \ln(Y_{t-1}) + \mu_{z^+,t} - \mu_{z^+}$, net private consumption growth $\Delta c_t = \ln(C_t) - \ln(C_{t-1}) + \mu_{z^+,t} - \mu_{z^+}$, net private investment growth $\Delta i_t = \ln(I_t) - \ln(I_{t-1}) + \mu_{z^+,t} - \mu_{z^+}$, net individual consumption growth $\Delta c_{o,t} = \ln(C_{o,t}) - \ln(C_{o,t-1}) + \mu_{z^+,t} - \mu_{z^+}$ and $\Delta c_{r,t} = \ln(C_{r,t}) - \ln(C_{r,t-1}) + \mu_{z^+,t} - \mu_{z^+}$, annualized debt to GDP ratio $D_{g,t}/(Y_t + Y_{t-1} + Y_{t-2} + Y_{t-3})$, annual CPI inflation $\pi_{c,t}^{tax,yoy} = \sum_{i=0}^{3} 100\{\pi_{c,t-i}(1 + \tau_{c,t-i})/(1 + \tau_{c,t-i-1})\}$, net exports growth $\Delta x_t = \ln(X_t) - \ln(X_{t-1}) + \mu_{z^+,t} - \mu_{z^+}$, and unemployment $1 - L_t$ in response to a negative shock to the consumption preference process ($\zeta_{c,t}$, $\varepsilon_{\zeta^c,t} < 0$) in Panel A and to the foreign demand process (Y_t^f, $\varepsilon_{y^f,t} < 0$) in Panel B. The figure depicts impulse response functions with just this 'pandemic-specific' shock, and with additional positive shocks in fiscal expenditure instruments–public consumption expenditure, public investment expenditure, or government transfers. The demand shock sizes are calibrated to induce an annual GDP growth rate of −5pp, while the fiscal policy responses are calibrated to be equal to 5% of steady-state quarterly GDP on impact. The length of the impulse response functions is 40 quarters. Fiscal shocks are not anticipated. All fiscal rules are active according to the parameters supplied in Tables 1–2, while all fiscal rules are suspended for the first 11 quarters. The persistence parameters are normalized to 0.85 in all fiscal rules. Additionally, the consumption preference shock persistence is set to 0.85.

met with a scarce supply of domestic intermediate goods due to lower productivity. Therefore, inflation rises in response to negative supply shocks but decreases in response to negative demand shocks, as can be expected. Fiscal policy counter-acting negative

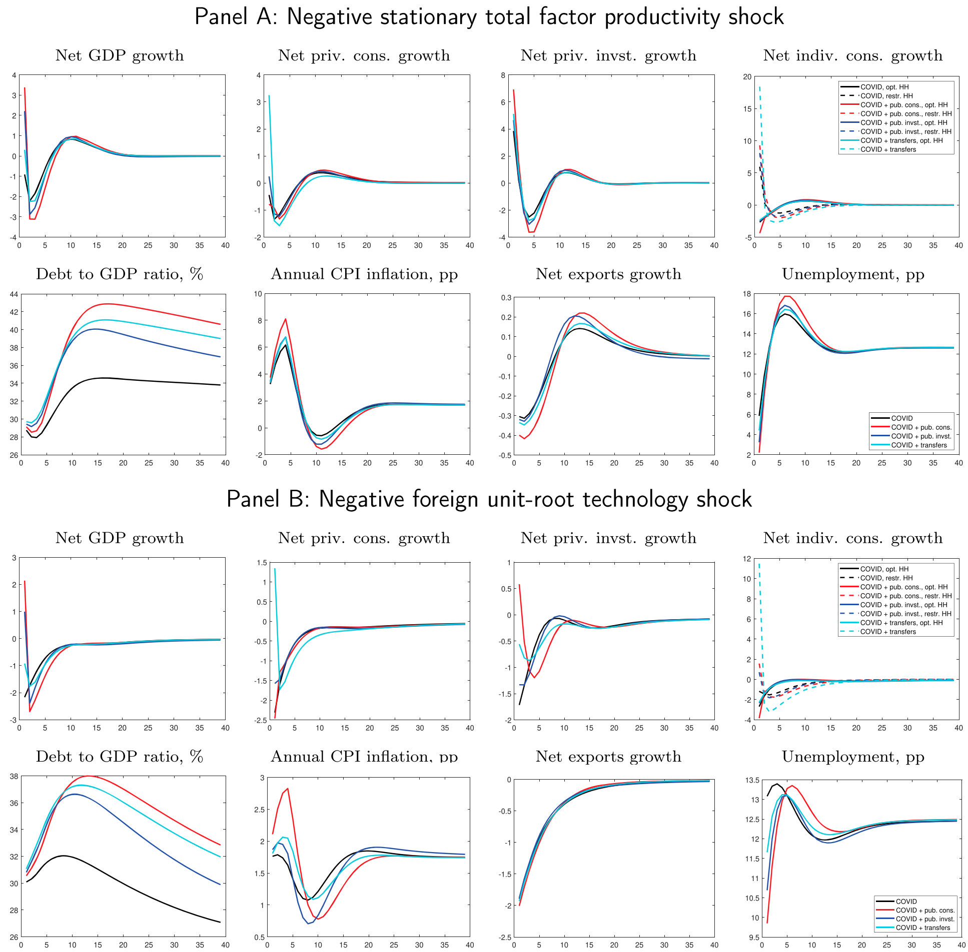

Figure 10. Pandemic simulations – Supply shocks and fiscal policy.

Notes: This figure depicts net GDP growth $\Delta y_t = \ln(Y_t) - \ln(Y_{t-1}) + \mu_{z^+,t} - \mu_{z^+}$, net private consumption growth $\Delta c_t = \ln(C_t) - \ln(C_{t-1}) + \mu_{z^+,t} - \mu_{z^+}$, net private investment growth $\Delta i_t = \ln(I_t) - \ln(I_{t-1}) + \mu_{z^+,t} - \mu_{z^+}$, net individual consumption growth $\Delta c_{o,t} = \ln(C_{o,t}) - \ln(C_{o,t-1}) + \mu_{z^+,t} - \mu_{z^+}$ and $\Delta c_{r,t} = \ln(C_{r,t}) - \ln(C_{r,t-1}) + \mu_{z^+,t} - \mu_{z^+}$, annualized debt to GDP ratio $D_{g,t}/(Y_t + Y_{t-1} + Y_{t-2} + Y_{t-3})$, annual CPI inflation $\pi^{tax,yoy}_{c,t} = \sum_{i=0}^{3} 100\{\pi_{c,t-i}(1 + \tau_{c,t-i})/(1 + \tau_{c,t-i-1})\}$, net exports growth $\Delta x_t = \ln(X_t) - \ln(X_{t-1}) + \mu_{z^+,t} - \mu_{z^+}$, and unemployment $1 - L_t$ in response to a negative shock to the stationary total factor productivity process (ϵ_t, $\varepsilon_{\epsilon,t} < 0$) in Panel A and to the foreign unit-root technology process (z_t, $\varepsilon_{z,t} < 0$) in Panel B. The figure depicts impulse response functions with just this 'pandemic-specific' shock, and with additional positive shocks to fiscal expenditure instruments–public consumption expenditure, public investment expenditure, or government transfers. The supply shock sizes are calibrated to induce an annual GDP growth rate of −5pp, while the fiscal policy responses are calibrated to be equal to 5% of steady-state quarterly GDP on impact. The length of the impulse response functions is 40 quarters. Fiscal shocks are not anticipated. All fiscal rules are active according to the parameters supplied in Tables 1–2, while all fiscal rules are suspended for the first 11 quarters. The persistence parameters are normalized to 0.85 in all fiscal rules. Additionally, the supply shock persistence parameters are both set to 0.85.

demand effects thus counter-acts deflationary pressure while it strengthens the inflation increase in the case of negative supply shocks.

The picture is similar when foreign unit-root technology declines (see Panel B of Figure 10). Interestingly, the unemployment increase is very effectively contained by using increased public investment expenditure, as a higher public capital stock serves as an effective antidote against large production declines and thus stimulates employment. Inflation is much more volatile and a lot higher in the short run, when fiscal measures are implemented against this 'COVID-19' supply shock.

Studying a number of different fiscal responses to a supply-driven pandemic shock, Faria-e-Castro (2021) finds in his closed economy model for the US that increasing unemployment benefits has the largest fiscal multiplier in the pandemic, higher than labour income tax reductions and unconditional transfer increases. We confirm this finding in our small open economy model, since our transfers are mostly targeted to restricted households and also prove highly effective in stabilizing consumption, GDP, and employment. Fiscal responses in the form of public consumption and unemployment benefit increases are studied for a related two-sector economy for the US in Guerrieri et al. (2022), and the unemployment benefit policy is again found to be the better one.

In all our scenarios we consistently find that the debt-to-GDP ratio increases the most and declines the slowest once the fiscal stimulus period is over with a public consumption expenditure increase as fiscal policy response. A similar finding is uncovered by Gomme (2021) where the debt-to-GDP ratio increase is the second-highest among the fiscal policy responses he considers and displays the slowest trajectory after the fiscal stimulus. Only a policy where the capital tax is increased after the pandemic stimulus to converge back to steady-state levels of public debt leads to a higher peak of the debt-to-GDP ratio, but also a faster recovery. The third policy he studies with the lowest peak is labour income tax adjustments.

5. Conclusion

In this paper, we develop a fiscal DSGE model for Latvia, a small open economy within a monetary union. The key fiscal sector elements comprise public investment, public consumption, import content in public investment and consumption, asymmetric directed transfers to optimizing and restricted households, cyclical unemployment benefits, foreign-held public debt, six types of taxes, and fiscal rules. Beyond the fiscal sector, the model features search-and-matching labour market frictions with pro-cyclical wages, a financial accelerator mechanism, as well as import content in consumption, investment, and exports. The model is estimated using Latvian data for the period 1995:Q2–2018:Q3.

First, the estimated fiscal rule parameters and the historical shock decomposition give some evidence on the pro-cyclical behaviour of Latvian fiscal policy, especially during the boom-bust episode of 2004–2010. The Latvian government contributed to the crisis of 2009 by cutting about 3 percentage points from Latvian GDP growth in the middle of the recession.

Second, having productive public capital is key to generate a persistent increase in GDP and private consumption in response to a shock to public investment. In contrast, having public consumption in the household utility function induces a minor boost of GDP, while crowding out private consumption.

Third, foreign-held domestic public debt amplifies the economic response to a government risk premium shock, as a part of taxpayers' money leaves the economy to service public debt. Including foreign-held public debt also breaks the Ricardian equivalence in the case of directing transfers solely to optimizing households. Temporarily, as there is a change of total money in the economy, the optimizing households alter their foreign bond holdings, affecting the domestic risk premium and thus their consumption and investment in response to changes in transfers. Moreover, the long-run fiscal multipliers are amplified by about 0.2pp on the expenditure side and 0.4pp on the revenue side, as compared to the model without foreign-held public debt.

Fourth, we compute present-value fiscal multipliers in our model for horizons of up to 40 quarters. We find that the largest multiplier in the long run is associated with public investment, reaching almost 1.5 in the benchmark model. In contrast, the public consumption multiplier is 0.3 and the transfers multiplier is 0.2 in the long run. On the revenue side, the labour tax multiplier reaches 1.1, while it only reaches 0.4 without foreign-held debt. The consumption tax multiplier is 0.4 in the benchmark model and −0.1 without foreign-held debt. On impact, the largest multiplier is observed for public consumption (0.6), followed by public investment (0.5), while tax and transfers multipliers do not exceed 0.4. These numbers are broadly comparable to those in the small open economy literature.

Fifth, the recent 'COVID-19' pandemic induced several economic shocks due to the health measures taken by authorities around the world. Our small open economy model is equipped with several domestic and foreign shocks that are exemplary for the 'COVID-19' pandemic and we utilize four of them and three fiscal policy responses (increases in expenditure items) to each shock. We find that fiscal policy for the short run should make use of increases in public consumption expenditure, while transfers and public investment seem to be helping the economy in the medium to long run better.

Overall, the rich structure of the model is able to contribute meaningfully to various fiscal policy scenario analyses in a small open economy within a monetary union such as Latvia. It has already been extensively field-tested at Latvijas Banka in studying the effects of various fiscal policy measures.

Notes

1. We have experimented with this approach, but found little difference in model behaviour for appropriate calibrations.
2. Using another multi-country model, i.e. the 4-country EAGLE model with a rich fiscal sector, Clancy et al. (2016) emphasize the role of cross-country spillovers from fiscal shocks.
3. Garcia et al. (2021) provides an overview of these fiscal measures for a number of small open economies in the euro area, and Faria-e-Castro (2021) provides the details of the 2020 CARES act in the US.
4. As an alternative, we have experimented with public capital as an additional factor in the production function (see Appendix E for the derivation of the equilibrium conditions in this case). Our preliminary results suggest that, using proper calibrations, both specifications yield a similar model behaviour.
5. Assuming such a time-to-build friction induces slightly higher volatility in several macro variables, as found in unreported impulse response functions that are available upon request from the authors. The intuition is as follows. Given there is a positive shock to public investment, GDP rises. The private sector faces higher demand, thus there is motivation to create jobs and invest. Given that public investment does not become productivity-enhancing capital initially, private firms invest more than in the situation without time-to-build frictions. As productivity-enhancing public capital appears, the private sector divests. Thus, the time-

to-build friction raises the volatility of private investment, along with other macroeconomic aggregates.

6. The notion here is that the intermediate good firm must pay the inputs with foreign currency and because they have no resources themselves at the beginning of the period, they must borrow those resources for buying the foreign inputs needed to produce $G^m_{i,t}$. The financing need is in foreign currency, so the loan is taken in that currency. There is no risk within the duration of this working capital loan about the realization of prices and exchange rates, because all shocks are realized at the beginning of the period.
7. Alternatively, we could assume transfers are symmetrically distributed ($\tau^{tr}_r = 0.5$). In unreported impulse response functions, which are available upon request from the authors, we find that having a larger share of transfers going to the restricted households amplifies the reaction of private consumption in response to an increase in government transfers, dominated by an asymmetrically higher consumption of the restricted households. Consequently, the reaction of GDP is amplified as well.
8. Lump-sum taxes are levied on optimizing households. If $T_{ls,t}$ is negative, these are actually transfers.
9. Plus, optionally, by exogenous changes to wasteful government spending (suspended in estimation).
10. Lower-case variables (e.g. $g^{exp}_{c,t}$, tr_t, or y_t) denote normalized quantities, i.e. divided by the growth variable z^+_t (e.g. $g^{exp}_{i,t} = G^{exp}_{i,t}/z^+_t$, $g^{exp}_{c,t} = G^{exp}_{c,t}/z^+_t$, $\text{tr}_t = \text{TR}_t/z^+_t$).
11. These terms are important for the convergence of the model back to the steady state after an expenditure of tax shock. Especially, the debt-to-GDP ratio term is important in keeping debt dynamics stable. The output gap term only plays a minor role for the stability of the debt-to-GDP ratio after fiscal shocks, as established in non-reported simulations of the model that are available from the authors upon request.
12. One of the key model elements driving the realistic estimated share of restricted households is the incorporation of these households in the wage bargaining process via their stochastic discount factor. Absent that channel, the estimated share of restricted households would be about 50–60%.
13. This procedure is triggered in `dynare` by setting mode_compute = 6.
14. When we started estimating the model, we first set the prior of ν_k to a beta distribution. However, over many estimation iterations, we evidenced the posterior of ν_k to settle close to unity. Therefore, we ultimately changed the prior of ν_k to a gamma distribution with a prior mean above unity (yet a significant share of its mass below unity), and found the posterior settling a comfortable distance above unity. Thus, our taking is that the data are supporting the capital substitution story.
15. It was not the size of the public debt that caused the borrowing issue, as Latvia entered the crisis with a relatively low level of government debt-to-GDP level. It was rather the lack of trust to the Latvia's government by the foreign lenders, and the fears of devaluation of the national currency 'Lats'. Yet, a more prudent fiscal policy before the crisis would have allowed to build reserves and trust from international partners.
16. These shocks occur to the estimated fiscal rules, some of which are pro-cyclical. If we calibrated acyclical fiscal rules, the negative contribution would be even larger.
17. The effects caused by 1% of GDP shocks to fiscal instruments seemed too large in some cases.
18. Note that most of the modified models we analyse in this section have (slightly) different steady states than the benchmark model, which may affect some of the magnitudes in the reported impulse responses.
19. We, however, still equalize the persistence of fiscal rules to 0.85.
20. In order to restore the Ricardian equivalence in face of foreign-held public debt, a specific–not necessarily realistic–constellation of calibrated parameters is needed. One way is to define the private sector's risk premium as a function of the *total* net foreign assets position as follows:

Moreover, one needs to remove the government sector's risk premium process by assuming a constant government bond yield for all times (and being equal to the steady-state deposit rate). Then, as the public foreign debt would offset the private sector's holdings of foreign bonds one-to-one, the deposit rate, consumption, and investment would not move. However, the above assumption that the private sector's risk premium takes fully into account the public foreign debt, while the public sector does not face any risk premium – neither from its own debt nor via spillovers from the debt of the private sector–is a strong one. If relaxed, the Ricardian equivalence does not hold in general. With the total net foreign assets position and total public debt in the private sector's and government risk premium, respectively, one can generate a negative reaction of private consumption and investment to an increase of optimizing households' transfers.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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