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Trade Linkages and Fiscal Multipliers in A Currency Union

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Abstract

I study how trade linkages affect fiscal multipliers in a small open economy belonging to a currency union, focusing on unanticipated government spending increase and income tax cut. There are three main results. First, the small open economy's lack of interest rate adjustment implies a larger terms-of-trade appreciation following a government spending increase, amplifying the multiplier through a more significant wealth effect. At the same time, the lack of interest rate adjustment dampens the trade balance following a tax cut, decreasing expenditure flowing towards domestic goods and the fiscal multiplier. Second, the role of trade linkages is not particularly sensitive to the existing business cycle conditions. Fiscal multipliers are similar in normal times and in a recession for a given level of trade linkages. This result suggests that the finding of state-dependent multipliers in previous literature is sensitive to the exchange rate regime. Third, stronger trade linkages imply that the fiscal financing and the import share of public spending have first-order effects in countries belonging to a currency union. Finally, fiscal spillovers in a currency union are positive for both fiscal instruments, at least in the short-to-medium term.

Keywords: Trade Linkages, Terms of Trade, Fiscal Multiplier, Currency Union.

Résumé

En me concentrant sur l'augmentation imprévue des dépenses gouvernementales et la réduction imprévue des impôts sur le revenu, j'étudie comment les liens commerciaux affectent les multiplicateurs fiscaux dans une petite économie ouverte qui appartient à une union monétaire. Trois résultats principaux ont été obtenus. Premièrement, le manque de réglage des taux d'intérêt de la petite économie ouverte implique une plus grande appréciation des termes de l'échange après une augmentation des dépenses gouvernementales, ce qui amplifie le multiplicateur par un effet de richesse plus significatif. En même temps, le manque de réglage des taux d'intérêt affaiblit la balance commerciale après une réduction des impôts, réduisant les dépenses consacrées aux biens nationaux et aux multiplicateurs fiscaux. Deuxièmement, le rôle des liens commerciaux n'est pas très sensible aux conditions du cycle économique actuel. Les multiplicateurs fiscaux sont similaires en temps normal et en période de récession pour un niveau donné de liens commerciaux. Ce résultat suggère que la découverte de multiplicateurs dépendant de l'état dans la littérature antérieure est sensible au régime de taux de change. Troisièmement, les liens commerciaux plus forts impliquent que le financement fiscal et la part d'importation pour les dépenses publiques exercent des effets de premier ordre dans les pays appartenant à une union monétaire. Enfin, les retombées fiscales dans une union monétaire sont positives pour les deux outils fiscaux, au moins à court et moyen terme.

Mots-clés: Liens Commerciaux, Termes de l'Échange, Multiplicateur Fiscal, Union Monétaire.

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List of Abbreviations

SVAR: Structural Vector Autoregression

DSGE: Dynamic Stochastic General Equilibrium (model)

VAR: Vector Autoregression

OECD: Organisation for Economic Co-operation and Development

ZLB: Zero Lower Bound

GDP: Gross Domestic Product

AR(1): Autoregression of order 1

VAT: Value-Added Tax

1 Introduction

Mainstream view dictates that the establishment of a currency union brings benefits by promoting trade and economic growth, internal efficiency, financial stability, and greater resilience to shocks. On the other hand, some scholars argue that it may be counterproductive for a small open economy to join a monetary union since lack of monetary policy independence may result in higher macroeconomic volatility.

Ultimately, this debate shows that the effectiveness of domestic fiscal policy and the strength of trade linkages with the other union members play a central role in the decision of a small open economy to join a currency union. The argument is that stronger trade linkages will boost business cycle co-movement with the other union members, reducing the cost of losing monetary policy independence. At the same time, domestic fiscal policy could address idiosyncratic shocks that are not shared with other union members.

However, the effectiveness of fiscal policy and the strength of trade linkages are not independent phenomena. Fiscal multipliers are indeed influenced by openness to trade, a hypothesis that received much discussion in the literature. The goal of this thesis is to study how the strength of trade linkages affects fiscal multipliers in a small open economy that joins a currency union. I focus on unanticipated increases in public spending and income tax cuts.

The analysis builds a state-of-the-art, quantitative dynamic stochastic business cycle model of a currency union. The model features two countries: the small open economy and the rest of the union (the large open economy). The model shares many ingredients with Cacciatore and Traum (2020), who also study how trade linkages affect fiscal multipliers but focus on countries that feature flexible exchanger rates. I extend this model to a currency union assuming that monetary policy is set by a union-wide monetary authority. As standard in the literature, macroeconomic dynamics in the small open economy do not affect union-wide aggregates, implying the central bank does not respond to fiscal shocks happening in the small open economy. In addition, the common currency implies that real exchange rate dynamics are solely driven by relative inflation differential across the union members.

I first compute fiscal multipliers following an increase in government spending and a tax cut in the small open economy. Then I compare fiscal multipliers to a counterfactually closed economy and to a small open economy that features a flexible exchange rate. Next, I consider the role of additional forces in shaping fiscal multipliers in the currency union, including: (i) the role of prevailing business cycle conditions at the time of the fiscal expansion; (ii) the role of public import share and fiscal financing; (iii) the role of country size. Finally, I discuss international fiscal spillovers in the currency union.

Following Cacciatore and Traum (2020), the effects of trade linkages on the fiscal multipliers depend on the dynamics of trade balance and terms of trade. The terms of trade are defined as the domestic price of exports relative to imports. The key contribution of this thesis is to show how the lack of exchange rate adjustment and monetary policy response affects the dynamics of the terms of trade and the trade balance in response to fiscal shocks.

The main results are the following. First, I find that trade linkages can boost fiscal multipliers in a small open economy that belongs to a currency union. This is the case for the increase in public spending, in which the increase in the terms of trade results in a positive wealth effect that crowds in domestic consumption and investment. Thus, the fiscal multiplier is larger in the small open economy that belongs to the currency union relative to a closed economy, even in the presence of a trade deficit. The negative wealth effect from the deterioration of the terms of trade following an income tax cut explains why the fiscal multiplier is lower in a currency union relative to a closed economy.

Second, and more importantly, the strength of trade linkages has a much larger effect on the fiscal multiplier compared to a flexible exchange rate scenario. For instance, in the baseline calibration of the currency union model, stronger trade linkages imply that the public spending multiplier is 0.15 cents higher relative to a closed economy. The figure is 0.05 cents higher under a flexible exchange rate. The intuition for this result is that lack of exchange rate appreciation and monetary policy response of the union-wide central bank results in a larger appreciation of the terms of trade following the public spending increase. The larger wealth effect ultimately explains why stronger trade linkages boost the multiplier by more in the currency union. By contrast, stronger trade linkages reduce the tax multiplier by more when the small open economy joins a currency union. In this case, the lack of interest rate adjustment dampens the trade balance following a tax cut, decreasing expenditure flowing towards domestic goods and the fiscal multiplier.

Third, prevailing business cycle conditions do not substantially affect how trade linkages affect fiscal multipliers in a small open economy that belongs to a currency union. I study this scenario by assuming that a risk premium shock triggers a recession in the small open economy, focusing on the unanticipated increase in public spending and tax cut in the recession. This result contrasts previous literature that documents state-dependent fiscal multipliers. Intuitively, lack of monetary policy response in normal times already boosts fiscal multipliers relative to a closed economy or a small open economy that features a flexible exchange rate.

Fourth, home bias in government spending and distortionary fiscal financing (e.g., the financing of an increase in public spending with taxes rather than debt) increase the beneficial

effects of trade linkages for the public spending multiplier. With a zero public import share, a government spending increase totally falls on the domestic goods, which causes a larger appreciation in the terms of trade and a larger fiscal multiplier. With a balanced budget rule, trade linkages disproportionally amplify the gains from trade openness following a public spending increase since the tax increase needed to finance higher public spending brings about an even larger terms-of-trade appreciation. However, trade linkages have a larger negative impact on the tax multiplier with a full home bias in public spending. Intuitively, following a tax cut, the terms of trade depreciate more due to the reduction in public spending that now entirely falls on the domestic goods.

The rest of the thesis is organized as follows. Section 2 describes the literature related to my research. Section 3 lays out the quantitative model. Section 4 discusses the model calibration. Section 5 presents the results and the analysis. Section 6 checks the robustness of the results. Section 7 concludes.

2 Literature Review

This thesis relates to three strands of literature. Below I review both theoretical and empirical contributions from the past literature.

2.1 The effects of fiscal policy and fiscal transmission

A strand of literature has theoretically and empirically explored the effects of fiscal stimuli and the channels of fiscal transmission. Firstly, a few papers analyse the effects of trade linkages on fiscal multipliers. For example, Chinn (2013) reviews several studies that assess the size of fiscal multipliers, and indicates that from a conventional perspective, fiscal multipliers should be smaller in open economies following a domestic unanticipated government spending increase because the leakage from the small open economy due to imports or purchases of internationally tradable goods mitigates the positive impact of a higher government spending. From this view, the crowding out of net exports dominates. Similarly, Ilzetzki et al. (2013) empirically study the size of fiscal multipliers with different trade openness following a government spending increase. They employ a Structural Vector Autoregression (SVAR) approach and estimate fiscal multipliers for different groups of countries. In their model, an economy with a trade share higher than 60% is defined as an open economy while a trade share below 60% denotes a closed economy. They find that a relatively closed economy has a larger fiscal multiplier than a relatively open economy. Cacciatore and Traum (2020) also study the role of trade linkages for fiscal transmission under a flexible exchange rate in a dynamic stochastic general equilibrium (DSGE) model. In contrast to the conventional wisdom, they show that the appreciation of terms of consumption following a government spending increase can result in a larger fiscal multiplier in an open economy relative to a counterfactually closed economy, and this happens even when the fiscal expansion implies a trade deficit.

In my thesis, I study the role of trade linkages for the transmission of the domestic government spending increase and income tax cut for a small open economy in a currency union. I find that trade openness can increase fiscal multipliers for an economy in the currency union, which is consistent with the results of Cacciatore and Traum, (2020).

Secondly, a bunch of theoretical literature examines the fiscal transmission using DSGE models without addressing the specific role of trade linkages for fiscal multipliers. For instance, Betts and Devereux (2001) set up a two-country DSGE model in which prices adjust slowly, and they investigate two main characteristics of the international transmission mechanism: the currency of export price invoicing and the degree of completeness of assets markets. In their

framework, the export price is set in terms of the foreign currency, which produces deviations from the law of one price. They find that for fiscal transmission, the degree of pricing-to-the market is of little importance but the structure of international asset markets is critical.

Baxter (1995) develop a two-country model of international trade in which capital accumulation and international investment flows play a central role. In particular, fluctuations in net exports and the current account are shown to be dominated by trade in capital goods. In this model, they examine how the effects of fiscal shock depend on the source of the shock and its expected duration, and also explore the link between fiscal deficits and interest rate dynamics.

Leeper et al. (2017) quantify the government spending multipliers in a closed economy by using a Bayesian prior and posterior analysis in a DSGE model with different fiscal details (government spending valued as a public good, explicit rules for fiscal instruments, a maturity structure of government debt, and distortionary steady-state taxes) and two distinct monetary-fiscal policy regimes (an active monetary policy with a passive fiscal policy and an active fiscal policy with a passive monetary policy). They scrutinize and highlight the importance of monetary-fiscal interactions.

Erceg et al. (2005) study the effects of fiscal shocks on the trade balance in a DSGE model. They suggest that a fiscal deficit has fairly small effects on the U.S. trade balance, irrespective of whether the source is a spending increase or a tax cut. However, they don't analyse how the fiscal shocks affect output and other economic variables through trade linkages.

In addition, there are several papers that study international interdependence without analysing the fiscal policy (Adolfson et al., 2005 and Justiniano and Preston, 2010). The two-country, international business cycle model in my thesis is based on the benchmark, quantitative DSGE model from previous literature, featuring an incomplete assets market, wage-setting frictions, intertemporal trade in assets, and complementarity between private and public consumption (as in Cacciatore and Traum (2020)).

At last, there are some empirical papers exploring fiscal transmission without examining the role of trade integration. For example, by using a SVAR model, Blanchard and Perotti (1999) characterize the dynamic effects of government spending increase and tax increase on economic activity in the United States. They find that both increases in taxes and government spending have a strong negative effect on investment, and the crowding out of investment significantly reduces the fiscal multiplier following a government spending increase.

2.2 Fixed exchange rates and currency unions

Many theoretical and empirical papers discuss the fiscal transmission in a fixed exchange rate regime or in a currency union without analysing the effects of trade linkages in detail. Firstly I review some papers that compare fiscal transmissions under fixed and flexible exchange rates. On the empirical front, Born et al. (2013) identify the effects of a government spending shock in countries with the different flexibility of exchange rate by estimating a panel Vector Autoregression (VAR) model on the data of OECD countries. They find that the fiscal multiplier is considerably larger under a fixed exchange rate and illustrate that differences in the monetary stance across exchange rate regimes are driving the difference in the multiplier. However, these differences play out via an adjustment of the level of private expenditure rather than through a redirection of trade flows. The behaviour of net exports cannot explain the larger fiscal multiplier under a peg because they are crowded out more strongly. Their finding is contrary to the conventional wisdom that the net exports are crowded out less and even unchanged in response to a fiscal expansion with a stickier exchange rate and this causes a larger output increase. They also check to what extent this private expenditure adjustment depends on the different exchange rate regimes.

Corsetti et al. (2012) find that the government spending increase is more effective under a peg. By using a SVAR, Ilzetzki et al. (2013) confirm that the fiscal multipliers in a fixed exchange rate regime are much larger than those with a floating exchange rate arrangement following a government spending shock, and this is mainly because of the different degrees of monetary accommodation.

On the theoretical front, Corsetti et al. (2013) indicate that under plausible medium-term fiscal policies, the government spending shock is not necessarily less effective under a flexible exchange rate, and this is in contrast to the traditional view. They show that long-term interest rate can drop in a flexible exchange rate regime but rise in a fixed exchange rate regime following a fiscal expansion, which will drive down private consumption under a peg.

Different from the papers above, my thesis discusses the fiscal multipliers in a currency union. The central bank in the union doesn't respond to a fiscal shock in the small open economy, so the interest rate and nominal exchange rate in the union are constant. My explanation for the larger fiscal multiplier in the currency union following a government spending increase is tightly biding with the dynamics of the terms of trade. In addition, I also consider the fiscal multipliers across exchange rate regimes following an income tax cut. Many papers in this field only consider the scenario of government spending increase.

Now I review the theoretical literature that studies the effectiveness of fiscal policy in the

currency union. Farhi and Werning (2016) provide explicit solutions for government spending multipliers in a liquidity trap with a flexible exchange rate and in a currency union by using a standard New Keynesian model. They confirm the potential for larger multipliers in the liquidity trap where the nominal interest rate hits zero and can't decrease further. They indicate that private consumption is crowded in in the economy with a liquidity trap due to decreased real interest rate, but it's crowded out by the government spending increase in the currency union, so the government spending is less effective at increasing output for a country in the currency union. In my thesis, the fiscal multipliers in the currency union and in the flexible exchange rate regime are also compared, and the response of monetary rule is essential for the effects of trade linkages on the fiscal transmission. Different from their studies, I also discuss the fiscal multipliers in a small open economy with different business cycle conditions in the currency union.

Erceg and Linde (2012) compare how the effects of fiscal consolidation (mainly the government spending reduction) differ depending on whether monetary policy is constrained by a currency union membership or by a zero lower bound (ZLB) that features a floating exchange rate for a small open economy in a DSGE model. They find that the dynamics of output across different monetary regimes are determined by how the real exchange rate and the long-term real interest rate respond to the fiscal consolidation. Mendoza et al. (2014) develop a two-country model to examine the positive and normative effects of using tax policy to offset large shocks in public debt and to restore fiscal solvency in economies with highly integrated financial and goods markets.

Some papers study the optimal monetary and fiscal policy in a currency union, an issue which I don't address in my thesis. For instance, Gali and Monacelli (2008) develop a tractable multi-country framework for an analysis of monetary and fiscal policy in a currency union. Beetsma and Jensen (2005) provide insights into the interaction of monetary and fiscal stabilization with sticky prices in a New Keynesian model of a monetary union. They find that the optimal fiscal policy in the union aims at stabilizing inflation differences and the terms of trade.

Ferrero (2006) addresses the interactions and stabilizations of fiscal policy and monetary policy in a currency union by using a two-country DSGE model with a staggered price-setting and a monopolistic competition in the goods market. The central result is that the fiscal policy plays a key role to smooth the impact of idiosyncratic exogenous shocks. Furthermore, he includes an analysis of the role of distortionary taxation and nominal debt. The main finding is that the gains of flexible fiscal rules, as compared to balanced budget rules, are quantitatively substantial. I also discuss the balanced government budget scenario in the currency union and get a similar conclusion: the balanced government budget constraint significantly lowers

the effects of fiscal policy for the small open economy in the currency union through trade linkages.

2.3 International fiscal spillovers

A strand of literature studies international spillovers of fiscal shocks. On the theoretical side, Cacciatore and Traum (2020) show that there are positive cross-country spillovers for a small open economy with a flexible exchange rate due to dynamics of trade linkages. Following a foreign government spending increase, the positive spillover stems from a higher trade balance for the home country, and following a foreign income tax cut the positive spillover is from a higher domestic terms of consumption. Corsetti and Pesenti (2001) develop a baseline model for analysis of monetary and fiscal transmission in the interdependent economies. However, they indicate that domestic fiscal expansions hurt trade partners: fiscal linkages are in general beggar-thy-neighbor in the long run. My finding that foreign fiscal shocks can trigger positive spillovers for the small open economy in a currency union is in favour of the results of the former.

Devereux et al. (2020) find that production networks may play a central role in the international propagation of fiscal shocks, particularly when wages are slow to adjust. After calibrating the model on the data of Eurozone countries, they find the Eurozone production network is very important for the international spillovers. In a model shutting down the international production network, the implied fiscal spillovers are reduced by more than two-thirds.

On the empirical side, Auerbach and Gorodnichenko (2013) shed new light on how fiscal stimuli in one country can have significant effects on the output in other countries and how the strength of spillovers varies over the business cycle by using direct projections with the data from countries in OECD. They find that the fiscal spillovers are significant in general, and particularly high in recessions but quite modest in expansions for the recipient country. The fiscal spillovers are increased further when both recipient and source countries are in recessions.

Faccini et al. (2016) empirically identify the international fiscal spillovers by imposing sign restrictions derived from a theoretical analysis. They suggest that an increase in the U.S. government spending tends to have positive spillovers on its main trading partners. However, the international transmission mechanism of government spending shocks appears to operate through a financial channel in the form of lowering real rates abroad rather than through a trade channel: an expansionary U.S. government spending shock leads to a significant decrease in real rates both domestically and internationally but it only causes a small and insignificant change in the trade balance. On the other hand in my model, a positive trade balance and a lower real interest rate in the small home country both explain the transmission of positive international spillovers following a foreign government spending increase.

3 Model

This section describes the benchmark, DSGE model used in this thesis. I developed a two-country, international business cycle model of a currency union, building on Cacciatore and Traum, (2020).

In the model, a small open economy (the home economy) trades with a large open economy (the foreign economy). The two countries form a currency union in which they share the same currency and the common nominal interest rate. The small open economy is of measure zero relative to the large open economy. Below the terms denoted with $*$ refer to foreign variables. The terms with subscript X refer to quantities and prices of export goods and the terms with subscript D refer to quantities and prices of goods produced and consumed domestically.

Below the exogenous shocks obey a stationary autoregressive process in logs:

$$\log \bar{X}_t = \rho_{\bar{X}} \log \bar{X}_{t-1} + \varepsilon_{\bar{X},t},$$

with $\varepsilon_{\bar{X},t} \overset{iid}{\sim} N(0, \sigma^2_{\bar{X}})$ for any shock $\bar{X}_t$.

3.1 Households

The representative household indexed by j $\in$ [0,1] maximizes the expected intertemporal utility function:

$$E_0 \left\{ \sum_{t=0}^{\infty} \beta^t \left[\log(\tilde{C}_{j,t} - h_C \tilde{C}_{t-1}) - \frac{L_{j,t}^{1+w}}{1+w} \right] \right\}, \tag{1}$$

where $\beta \in (0,1)$ is the discount factor, and $L_{j,t}$ is the hours worked. The household evaluates its consumption today relative to the aggregate consumption in the previous period, $\tilde{C}_{t-1}$, where h_C denotes the degree of habit persistence. ω is the Frisch elasticity. $\tilde{C}_{j,t}$ is total consumption, consisting of private consumption $C_{j,t}$ and public consumption G_t:

$$\tilde{C}_{j,t} = C_{j,t} + \omega_G G_t,$$

where ω_G determines the home public-private consumption substitutability.

Market consumption C_t aggregates domestic and imported consumption goods in Armington form:

$$C_t = \left[(1-\alpha_X)^{\frac{1}{\phi}} (C_{D,t})^{\frac{\phi-1}{\phi}} + \alpha_X^{\frac{1}{\phi}} (C^*_{X,t})^{\frac{\phi-1}{\phi}} \right]^{\frac{\phi}{\phi-1}}, \; 0 \leq \alpha_X \leq 1,$$

where $C_{D,t}$ and $C^*_{X,t}$ denote home demands for domestic and imported consumption goods respectively:

$$C_{D,t} = (1-\alpha_X)\rho_{D,t}^{-\phi} C_t,$$

and

$$C^*_{X,t} = \alpha_X \rho^{*(-\phi)}_{X,t} C_t.$$

α_X is the share of imported goods in the home country and ϕ is the trade elasticity. $\rho_{D,t} \equiv P_{D,t}/P_t$ is the real price of home consumption goods, and $\rho^*_{X,t} \equiv P^*_{X,t}/P_t$ is the real price of imported goods (in home consumption units). Correspondingly, the aggregate price index satisfies:

$$1 = (1-\alpha_X)\rho_{D,t}^{1-\phi} + \alpha_X \rho^{*(1-\phi)}_{X,t}.$$

The sub-basket $C_{D,t}$ aggregates the differentiated domestic consumption varieties:

$$C_{D,t} \equiv \left[\int_0^1 C_{D,t}(j)^{(\bar{\theta}-1)/\bar{\theta}} dj\right]^{\bar{\theta}/(\bar{\theta}-1)},$$

where $\bar{\theta}$ is the elasticity of substitution across domestic goods. Similarly,

$$C^*_{X,t} \equiv \left[\int_0^1 C^*_{X,t}(j)^{(\bar{\theta}^*-1)/\bar{\theta}^*} dj\right]^{\bar{\theta}^*/(\bar{\theta}^*-1)}.$$

The effective capital rented to the firm by households, K^j_t, is the product of physical capital $\tilde{K}^j_t$ and the utilization rate $u^i_{K,t}$:

$$K^j_t = u^j_{K,t}\tilde{K}^j_t.$$

Physical capital $\tilde{K}^j_{t+1}$ equals to the undepreciated capital from the previous period plus the physical investment I^j_t, net of a quadratic investment adjustment cost. The capital law of motion is:

$$\tilde{K}^j_{t+1} = (1-\delta_K)\tilde{K}^j_t + \left[1 - \frac{\upsilon_K}{2}\left(\frac{I^j_t}{I^j_{t-1}} - \bar{z}\right)^2\right] I^j_t, \tag{2}$$

where υ_K is a scale parameter, $\bar{z}$ is the growth rate of productivity, and δ_K is the capital depreciation rate. Similar to the consumption, investment I_t also consists of domestic and imported investment goods in Armington form:

$$I_t = \left[(1-\alpha^I_X)^{\frac{1}{\phi}}(I_{D,t})^{\frac{\phi-1}{\phi}} + (\alpha^I_X)^{\frac{1}{\phi}}(I^*_{X,t})^{\frac{\phi-1}{\phi}}\right]^{\frac{\phi}{\phi-1}},\ 0 \le \alpha^I_X \le 1,$$

where α_X^I is the share of imported investment goods in the home country. $I_{D,t}$ and $I_{X,t}^*$ denote home demands for domestic and imported investment goods respectively:

$$I_{D,t} = (1-\alpha_X^I)(\tfrac{\rho_{D,t}}{\rho_{I,t}})^{-\phi} I_t,$$

and

$$I_{X,t}^* = \alpha_X^I (\tfrac{\rho_{X,t}^*}{\rho_{I,t}})^{-\phi} I_t.$$

The investment sub-baskets $I_{D,t}$ and $I_{X,t}^*$ have the same composition of the private consumption goods $C_{D,t}$ and $C_{X,t}^*$. The price index of investment goods satisfies:

$$\rho_{I,t}^{1-\phi} = (1-\alpha_X^I)\rho_{D,t}^{1-\phi} + \alpha_X^I \rho_{X,t}^{*(1-\phi)},$$

where $\rho_{I,t} \equiv P_{I,t}/P_t$ is the real price of investment goods in home consumption units.

The international asset market is incomplete as only one non-contingent bond A_t^j dominated in units of the common currency is traded internationally. Households can also buy a riskless nominal government bond B_t^j. Households are taxed on their consumption spending and on their income (labor income and capital rental income) at τ_t^C and τ_t^I. The household's budget constraint in each period is:

$$\begin{aligned} &B_t^j + A_t^j + P_t C_t^j (1+\tau_t^C) + P_t I_t^j + \Psi(u_{K,t}^j) P_t \tilde{K}_t^j = (1+i_{t-1}) B_{t-1}^j + \\ &(1+i_{t-1})\Gamma_{t-1} A_{t-1}^j + (1-\tau_t^I)(w_{jt}^n L_{jt} + P_t r_{K,t} K_t^j) + P_t (T_t^j + T_{G,t}^j). \end{aligned} \tag{3}$$

The left side in the equation is the household's expenditure and the right side is its revenue. T_t^j is a lump-sum rebate of producer profits and $T_{G,t}^j$ is a government lump-sum transfer. Households can rent their accumulated physical capital to the intermediate-good producers at the rate $r_{K,t}$. $\Psi(u_{K,t}^j)$ is the cost of utilization per unit of physical capital, and it's a function of utilization rate:

$$\Psi(u_{K,t}^j) = \delta_{1K}(u_{K,t}^j - u_{K,ss}) + (\tfrac{\delta_{2K}}{2})(u_{K,t}^j - u_{K,ss})^2.$$

Subscript ss denotes a steady-state value so that $u_{K,ss}$ is the steady-state utilization rate.

In the budget constraint, i_t is the common interest rate in the currency union. The risk premium of the home country is an exponential function of the ratio of economy's debt $(-A_t)$ to GDP (denoted as Y_t):

$$\Gamma_t = \exp\{-\gamma \tfrac{Q_t A_t}{Y_t}\} \bar{\Lambda}_{at},$$

where $\bar{\Lambda}_{at}$ is an exogenous risk-premium shock and γ is the risk-premium coefficient which is greater than 0. $Q_t \equiv P_t^*/P_t$ is the real exchange rate. In the currency union, the nominal exchange rate is one and keeps constant, so the real exchange rate satisfies:

$$Q_t/Q_{t-1} = (1+\pi_{C,t}^*)/(1+\pi_{C,t}),$$

where $\pi_{C,t}$ is the inflation rate:

$$\pi_{C,t} = P_t/P_{t-1}.$$

The household's nominal wage w_{jt}^n is subject to the following adjustment cost:

$$\frac{\upsilon_W}{2}\left[\frac{1}{\tilde{z}}\frac{w_{jt}^n}{w_{jt-1}^n}(1+\pi_{C,t-1})^{-\iota_w}-1\right]^2 w_{jt}^n L_{jt},$$

where ι_w denotes home wage indexation and υ_W is the size of the wage adjustment cost. Meanwhile,

$$L_{jt} = (\frac{w_{jt}^n}{w_t^n})^{-\eta} L_t, \tag{4}$$

where η is the elasticity of substitution of labor inputs. The wage adjustment cost and equation (4) above can be substituted into the budget constraint.

The household maximizes its expected intertemporal utility subject to the equations (2) and (3) by choosing $B_t^j, A_t^j, u_{K,t}^j, C_t^j, \tilde{K}_{t+1}^j, I_t^j, L_t^j$ and w_{jt}^n.

The Euler equation for the home holdings of international bond A_t^j is:

$$1 = (1+i_t)\Gamma_t E_t(\frac{Q_{t+1}}{Qt}\frac{\beta_{t,t+1}}{1+\pi_{C,t+1}^*}).^1$$

Here

$$\beta_{t,t+1} = \beta uc_{t+1}/uc_t,$$

where uc_t is the marginal utility of consumption, which is derived by the first-order condition for the consumption C_t^j:

$$uc_t(1+\tau_t^C) = (\tilde{C}_t - h_c\tilde{C}_{t-1})^{-1}.$$

The Euler equation for the foreign holdings of foreign bond B_t^{j*} is:

[1]There is only one interest rate in the currency union, and the international bond A_t^j and the home government bond B_t^j are assumed to be subject to the same risk premium, so the Euler equation for the home holdings of home bond is same as the Euler equation for the home holdings of international bond.

$$1 = (1 + i_t)E_t(\tfrac{\beta^*_{t,t+1}}{1+\pi^*_{C,t+1}}).$$

In addition, the first-order condition for utilization rate implies:

$$\Psi'(u^j_{K,t}) = (1 - \tau^I_t)r_{K,t}.$$

The Euler equation for capital indicates:

$$\zeta_{K,t} = E_t\left\{\beta_{t,t+1}\left[(1-\tau^I_{t+1})r_{K,t+1}u_{K,t+1} + (1-\delta_{t+1})\zeta_{K,t+1} - \Psi(u^j_{K,t+1})\right]\right\},$$

where $\zeta_{K,t}$ is the shadow value of capital and is defined by the first-order condition for physical investment:

$$\begin{aligned}\rho_{I,t} = \zeta_{K,t}\left[1 - (\upsilon_K/2)(I_t/I_{t-1} - 1)^2 - \upsilon_K(I_t/I_{t-1} - 1)(I_t/I_{t-1})\right] + \\ \upsilon_K\beta_{t,t+1}E_t\left[\zeta_{K,t+1}(I_{t+1}/I_t - 1)(I_{t+1}/I_t)^2\right].\end{aligned}$$

The first-order condition for the nominal wage w^n_{jt} implies that the real wage $w_t \equiv w^n_t/P_t$ is a time-varying markup $\mu_{W,t}$ over the marginal rate of substitution between hours and consumption:

$$w_t = \tfrac{\mu_{W,t}\bar{\beta}_t\bar{h}_t L^{\omega}_t}{uc_t(1-\tau^I_t)},$$

where

$$\mu_{W,t} = \frac{\eta}{(\eta-1)(1-\frac{\upsilon_W}{2}\Delta^2_{W,t})+\upsilon_W\left[(\Delta_{W,t}(1+\pi_{C,t-1})^{-\iota_w}(1+\pi_{W,t})-\beta_{t,t+1}\Delta_{W,t+1}(1+\pi_{C,t})^{-\iota_w}\frac{(1+\pi_{W,t+1})^2}{(1+\pi_{C,t+1})}(\frac{L_{t+1}}{L_t})\right]}.$$

In the above expression,

$$\pi_{W,t} = w^n_t/w^n_{t-1} - 1,$$

where $\pi_{W,t}$ denotes the wage inflation, and

$$\Delta_{W,t} = \tfrac{1}{\bar{z}}\tfrac{w^n_t}{w^n_{t-1}}(1 + \pi^*_{C,t-1})^{-\iota_w} - 1.$$

Finally, the first-order condition for $L_{j,t}$ yields:

$$\frac{w^n_{j,t}}{P_t} = \frac{\bar{h_t}L^w_{jt}\bar{\beta}_t}{uc_t(1-\tau^I_t)\left\{1-\frac{\upsilon_W}{2}[\frac{1}{\bar{z}}\frac{w^n_{jt}}{w^n_{jt-1}}(1+\pi^*_{C,t-1})^{-\iota_p}-1]^2\right\}}.$$

3.2 Production

There are two vertically integrated production stages in each country. In the first stage, perfectly competitive firms in the upstream use labor and capital as inputs to produce non-tradable intermediate goods. In the second stage, firms in the downstream use the intermediate goods to produce the final tradable goods for domestic and foreign consumption.

Intermediate producer chooses labor L_t and capital K_t to maximize per-period profits:

$$\varphi_t Y_t^I - (w_t^n/P_t)L_t - r_{K,t}K_t,$$

where the output Y_t^I is produced with a constant-return to scale technology:

$$Y_t^I = K_t^\alpha (\bar{Z}_t L_t)^{(1-\alpha)}.$$

The term φ_t denotes the real price of intermediate goods. In the production function, α is the share of income received by capital owners. $\bar{Z}_t$ is the exogenous productivity, and $\bar{z} \equiv \bar{Z}_t/\bar{Z}_{t-1}$ is the growth rate of productivity which follows an AR(1) process in logs. L_t aggregates the differentiated labor inputs supplied by households:

$$L_t \equiv \left[\int_0^1 (L_{jt})^{(\eta-1)/\eta} dj\right]^{\eta/(\eta-1)}.$$

The first-order condition for labor equates the value of the marginal product of labor to the real wage:

$$(1-\alpha)\varphi_t Y_t^I/L_t = w_t^n/P_t.$$

The first-order condition for capital implies that the value of the marginal product of capital equals to the rental rate of capital:

$$\alpha\varphi_t Y_t^I/K_t = r_{K,t}.$$

The representative final producer i maximizes the expected present discounted value of current and future real profits $E_t \sum_{s=t}^{\infty} \beta_{s,t} d_s^i$ by choosing $P_{D,t}^i$, the price of variety i for domestic sales. In a currency union the law of one price holds, so the export price $P_{X,t}^i$ satisfies:

$$P_{X,t}^i = P_{D,t}^i = P_t^i,$$

and

$$d_t^i = \left\{ \left[1 - \frac{\upsilon_T}{2} \left(\frac{P_t^i}{P_{t-1}^i} (1+\pi_{C,t-1})^{-\iota_p} - 1 \right)^2 \right] \frac{P_t^i}{P_t} - \varphi_t \right\} (Y_{D,t}^i + Y_{X,t}^i),$$

where

$$Y_{D,t}^i = \left(\frac{P_t^i}{P_t} \right)^{-\bar{\theta}} Y_{D,t},$$

$$Y_{X,t}^i = \left(\frac{P_t^i}{P_t} \right)^{-\bar{\theta}} Y_{X,t}.$$

In the equation of d_t^i, ι_p is the home price indexation and υ_T is the size of the quadratic cost for adjusting price. The real price $\rho_{i,t}$ equals to the markup $\mu_{i,t}$ over the marginal cost φ_t:

$$\rho_{i,t} \equiv \frac{P_{i,t}}{P_t} = \mu_{i,t} \varphi_t,$$

where the time-varying markup $\mu_{i,t}$ is defined by:

$$\mu_{i,t} = \frac{\bar{\theta}}{(\bar{\theta}-1)(1-\frac{\upsilon_T}{2}\Delta_{i,t}^2) + \upsilon_T \left\{ (1+\pi_{i,t})\Delta_{i,t}(1+\pi_{C,t-1})^{-\iota_p} - E_t \left[\beta_{t,t+1} \frac{(1+\pi_{i,t+1})^2}{1+\pi_{C,t+1}} \Delta_{i,t+1} (1+\pi_{C,t})^{-\iota_p} \frac{Y_{i,t+1}}{Y_{i,t}} \right] \right\}}.$$

In the above expression,

$$\pi_{i,t} = \frac{P_{i,t}}{P_{i,t-1}} - 1,$$

$$\pi_{C,t} = \frac{P_t}{P_{t-1}} - 1,$$

$$\Delta_{i,t} = (1+\pi_{i,t})(1+\pi_{C,t-1})^{-\iota_p} - 1.$$

$Y_{i,t}$ is the total demand faced by producer i and it's the sum of $Y_{D,t}^i$ and $Y_{X,t}^i$.

In the symmetric equilibrium,

$$P_{i,t} = P_{D,t} = P_{X,t}.$$

The real price for domestic consumption is $\rho_{D,t} \equiv P_{D,t}/P_t$, and it is also equal to the time-varying markup multiplied by the marginal cost:

$$\rho_{D,t} = \mu_t \varphi_t,$$

where μ_t has the same composition as $\mu_{i,t}$. The real export price (in units of foreign consumption) is defined by:

$$\rho_{X,t} \equiv P_{X,t}/P_t^* = \rho_{D,t}/Q_t.$$

The prices and quantities of foreign exports and imports are determined by assuming that foreign producers solve a profit maximization problem which is equivalent to that faced by home producers. In the currency union, the two countries share the same nominal interest rate, but the foreign economy operates like a closed economy because the macroeconomic developments in home country have no effect on the foreign economy.

3.3 Monetary and fiscal policy

The central bank in the currency union follows a Taylor rule to set interest rate:

$$\hat{i}_t = \rho_i \hat{i}_{t-1} + (1-\rho_i)\left[\rho_\pi \hat{\pi}_{C,t} + \rho_Y \hat{Y}_t\right].$$

The symbol hat denotes variable in percentage deviation from a steady state.

The government's budget constraint in each period is:

$$0 = -(B_t + \tau_t^I r_{K,t} K_t P_t + \tau_t^I w_t^n L_t + \tau_t^C C_t P_t) + P_{G,t} G_t + T_{G,t} P_t + (1+i_{t-1}) B_{t-1}.$$

The fiscal instruments, $X = \left\{G, \tau^I\right\}$, follow the rule:

$$\hat{X}_t = \rho_X \hat{X}_{t-1} - (1-\rho_X)\gamma_X \hat{S}_{t-1} + \varepsilon_{X,t},$$

where $\varepsilon_{X,t} \overset{iid}{\sim} N(0, \sigma_X^2)$. S_t is the ratio of debt to GDP:

$$S_t \equiv \tfrac{B_t}{Y_t P_t}.$$

Government can issue debt or raise income tax to finance its expenditure G_t. Government spending aggregates expenditures on both domestic and imported goods:

$$G_t = \left[(1-\alpha_X^g)^{\frac{1}{\phi}} (G_{D,t})^{\frac{\phi-1}{\phi}} + (\alpha_X^g)^{\frac{1}{\phi}} (G_{X,t}^*)^{\frac{\phi-1}{\phi}}\right]^{\frac{\phi}{\phi-1}}, \; 0 \le \alpha_X^g \le 1,$$

where α_X^g is the share of imported government goods in home country, and $\rho_{G,t} \equiv P_{G,t}/P_t$ is the real price of government consumption in home consumption units. $G_{D,t}$ and $G_{X,t}^*$ denote the government consumptions for domestic and imported goods in home country:

$$G_{D,t} = (1-\alpha_X^g)(\tfrac{\rho_{D,t}}{\rho_{G,t}})^{-\phi} G_t,$$

$$G^*_{X,t} = \alpha^g_X (\frac{\rho^*_{X,t}}{\rho_{G,t}})^{-\phi} G_t.$$

The government consumption sub-baskets $G_{D,t}$ and $G^*_{X,t}$ have the same composition as the private consumption goods $C_{D,t}$ and $C^*_{X,t}$. The price index of government consumption is:

$$\rho^{1-\phi}_{G,t} = (1-\alpha^g_X)\rho^{1-\phi}_{D,t} + \alpha^g_X \rho^{*(1-\phi)}_{X,t}.$$

3.4 Market clearing

The domestic demand for home output, $Y_{D,t}$, is:

$$Y_{D,t} = [1 - (\upsilon_T/2)\Delta^2_{i,t}]^{-1}(C_{D,t} + G_{D,t} + I_{D,t}),$$

and the export demand for home output, $Y_{X,t}$, is:

$$Y_{X,t} = [1 - (\upsilon_T/2)\Delta^2_{i,t}]^{-1}(C_{X,t} + G_{X,t} + I_{X,t}).$$

Goods market clearing requires

$$K^\alpha_t (\bar{Z}_t L_t)^{(1-\alpha)} = Y_{D,t} + Y_{X,t}.$$

This means the output has to satisfy the market demands. Furthermore, the final consumption demand is given by:

$$Y_{C,t} = C_t + (\upsilon_W/2)\Delta^2_{W,t} w_t L_t + K_t \Psi(u^j_{K,t}),$$

and GDP is defined by:

$$Y_t = C_t + \rho_{I,t} I_t + \rho_{G,t} G_t + K_t \Psi(u^j_{K,t}) + TB_t.$$

3.5 Trade balance and net foreign assets

The trade balance TB_t is the difference between the exports and imports in a country:

$$TB_t = Q_t \rho_{X,t}(C_{X,t} + G_{X,t} + I_{X,t}) - \rho^*_{X,t}(C^*_{X,t} + G^*_{X,t} + I^*_{X,t}).$$

The current account is the change in net foreign assets:

$$CA_t = Q_t(a_{*,t} - \frac{a_{*,t-1}}{1+\pi^*_{C,t}}) = Q_t r_t a_{*,t-1} + TB_t,$$

where $Q_t a_{*,t}$ is net foreign assets, $a_{*,t} \equiv A_t/P^*_t$ is the real holdings of international bond (in foreign consumption units), and r_t is the real interest rate:

$$r_t = \frac{(1+i_{t-1})\Gamma_{t-1}-1}{(1+\pi^*_{C,t})}.$$

3.6 Fiscal multiplier

Here I define the fiscal multiplier used in the analysis below. The fiscal multiplier is the change in the present value of GDP when the present value of government spending or income tax revenue changes by one unit over the same time horizon, thus in the academic research it's used as the measurement of the effectiveness of the fiscal policy. The fiscal multiplier M_Y is given by:

$$M_Y = \frac{E_t \sum_{j=0}^{k} \left[\prod_{i=0}^{k}(1+r)^{-1}\right] \Delta P_{t+j} Y^{nipa}_{t+j}}{E_t \sum_{j=0}^{k} \left[\prod_{i=0}^{k}(1+r)^{-1}\right] \Delta P_{t+j} F_{t+j}},$$

where k is the time horizon, r is the real interest rate in a steady state, and F includes government spending or income tax revenue. Y^{nipa}_t is the GDP in constant price:

$$Y^{nipa}_t = C_t + \rho_{I,ss} I_t + \rho_{G,ss} G_t + K_t \Psi(u^j_{K,t}) + Q_{ss}\rho_{X,ss}(C_{X,t}+G_{X,t}+I_{X,t}) - \rho^*_{X,ss}(C^*_{X,t}+G^*_{X,t}+I^*_{X,t}).$$

The government spending in constant price G^{nipa}_t, which is the F_t in the denominator following a government spending shock, is defined as:

$$G^{nipa}_t = \rho_{G,t} G_t \frac{Y^{nipa}_t}{Y_t}.$$

The tax revenue in constant price TR^{nipa}_t, which is the F_t in the denominator following a tax cut shock, is defined as:

$$TR^{nipa}_t = TR_t \frac{Y^{nipa}_t}{Y_t},$$

where TR_t is the income tax revenue:

$$TR_t = \tau^I_t (w_{jt} L_{jt} + r_{K,t} K^j_t).$$

I also introduce here the concept of the terms of trade which play an essential role in the fiscal transmission across countries. The home price of exports relative to the price of imports in units of home currency is denoted as the terms of trade TOT_t:

$$TOT_t \equiv Q_t \rho_{X,t} / \rho^*_{X,t}.$$

With complete international risk sharing, the terms of trade are also equal to the relative price of domestic goods to imported goods:

$$TOT_t = \rho_{D,t} / (\rho^*_{D,t} Q_t).$$

In a currency union with a law of one price, TOT_t satisfy:

$$TOT_t \equiv Q_t \rho_{X,t} / \rho^*_{X,t} = \rho_{D,t} / (\rho^*_{D,t} Q_t).$$

4 Calibration

I calibrate the model using the conventional values from the literature and the posterior mean estimates projected by Cacciatore and Traum, (2020). The latter is matched to the macroeconomic data of the U.S. and Canada, because these two countries are particularly suitable for us to analyse the role of trade linkages on the effects of fiscal policies with a flexible exchange rate. I condition the model on the same posterior estimates to keep the analysis as transparent as possible. In Section 6, I also calibrate the model to match features of the euro area data. The variable below without time subscript denotes the steady-state level.

The discount factor β is set to 0.99. The capital share α in the Cobb-Douglas production function is 0.33, and the capital depreciation rate δ_K is 0.026. Furthermore, I set the elasticity of substitution between home and foreign goods ϕ to 1.0306. The scale parameter for the cost of adjusting prices υ_T is equal to 23.042 and the risk premium coefficient γ is 0.0321.

The elasticity of substitution across domestic goods $\bar{\theta}$ is set to 6 to generate a 20 percent steady-state markup μ, and the elasticity of substitution of labor η is set to 11 to generate a 10 percent steady-state wage markup μ_W. I calibrate the import share of private consumption goods α_X to 0.1933, the import share of public consumption goods α_X^g to 0.0644, and the import share of investment goods α_X^I to 0.2578 to match the statistics of Canadian import shares. To calibrate the coefficients of the monetary rule in the currency union, I set the inflation weight, ρ_π, the GDP gap weight, ρ_Y, and the smoothing parameter, ρ_i, to 1.8297, 0.0591, and 0.7699 respectively. The calibration of fiscal variables is as following. The annualized ratio of government debt to GDP, $\frac{S}{4}$, is 0.73 for Canada and 0.61 for the U.S. The responses to the debt-to-GDP ratio, γ_G, γ_{τ^I}, γ_{τ^C}, are set to 0.4043, 0.129, 0.2402 respectively to ensure the stabilization of home government debt. The income tax rate τ^I is equal to 0.25 and the VAT rate τ^C is equal to 0.14, which are consistent with the Canadian tax rates. The share of government spending to GDP, $\frac{G}{Y}$, is 0.22 for Canada and 0.18 for the U.S. In terms of other variables, the substitutability between private and public consumption goods ω_G is set to 0.0767. The size of investment adjustment cost υ_K is equal to 4.581, and the wage stickiness parameter υ_W is 314.1513. Finally, the ratio of total trade (imports plus exports) to GDP in a steady state is set to 0.35 to match the bilateral trade data between the U.S. and Canada.

5 Results

I consider the different situations in which the government implements unanticipated, 1% public spending increase and income tax cut, and present the domestic fiscal multipliers in the first row of each figure for both open economy and closed economy. For the closed economy, $\alpha_X = \alpha_X^g = \alpha_X^I = 0$ and the trade share is also 0. Besides, the closed economy has its own monetary rule which follows the Taylor rule, without being affected by any other foreign macroeconomic dynamics. Except for these differences, the closed economy shares the same economic features with the open economy. The gap between the fiscal multipliers in these two economies, "open - closed fiscal multiplier", is plotted in the second row of each figure, with an aim to visually show the effects of trade linkages on the effectiveness of fiscal shocks.

Six counterfactual scenes are laid out corresponding to six subsections from 5.1 to 5.6. In each scenario, the economy is assumed in a steady state when the fiscal shocks happen, except in scenario 3 where the fiscal shocks confront an economic recession. Scenario 1 is set as the benchmark scenario where the fiscal shocks happen in a small open economy belonging to a currency union, and the "open - closed fiscal multipliers" in scenario 1 are also set as the benchmarks which will appear in other scenarios for comparison. In scenario 1, I show the macroeconomic dynamics under the fiscal shocks in the open economy and closed economy, and analyse how the disparity between the fiscal multipliers in these two economies forms through trade linkages. In the other scenarios, I mainly focus on explaining how the trade linkages with different economic characteristics shapes the fiscal multipliers different from those in the benchmark scenario. For each scenario, I also plot the impulse response functions of nine domestic macroeconomic variables: GDP, private consumption, physical investment, household's hours worked, inflation rate, nominal interest rate, terms of trade, trade balance, and real exchange rate.

Furthermore, to verify the effects of international spillovers, the fiscal multipliers for the small open economy in the currency union following the two foreign fiscal shocks are drawn in subsection 5.7, and corresponding domestic impulse response functions are also presented in the appendix.

I solve the model as a nonlinear, forward-looking, deterministic system using a Newton-Raphson global solution method.

5.1 Small open economy in a currency union

First of all, I examine the fiscal multipliers for a small open economy in a currency union following two domestic fiscal shocks. Figure 1 presents in the first row the fiscal multipliers in the open and closed economies following unanticipated government spending increase and income tax cut, and displays in the second row the difference between the fiscal multipliers in these two economies. To build intuition, the impulse response functions are plotted in figure 2 (a) and (b) respectively.

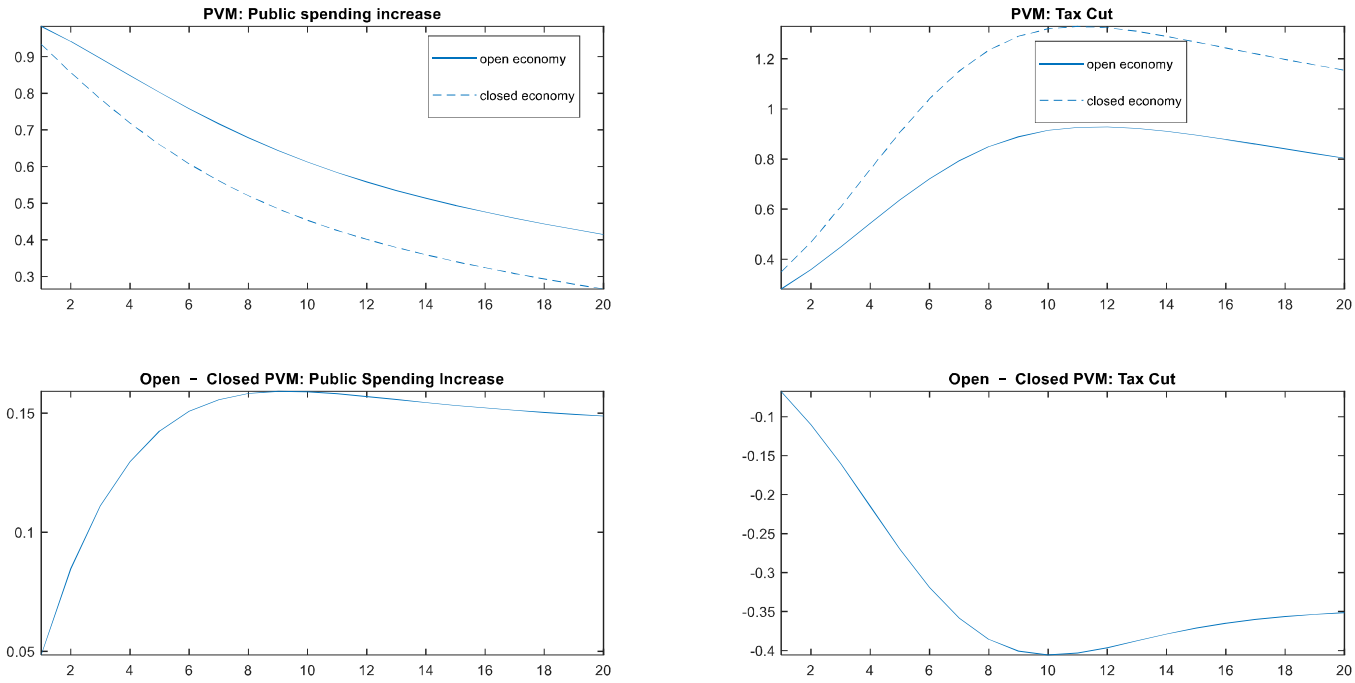
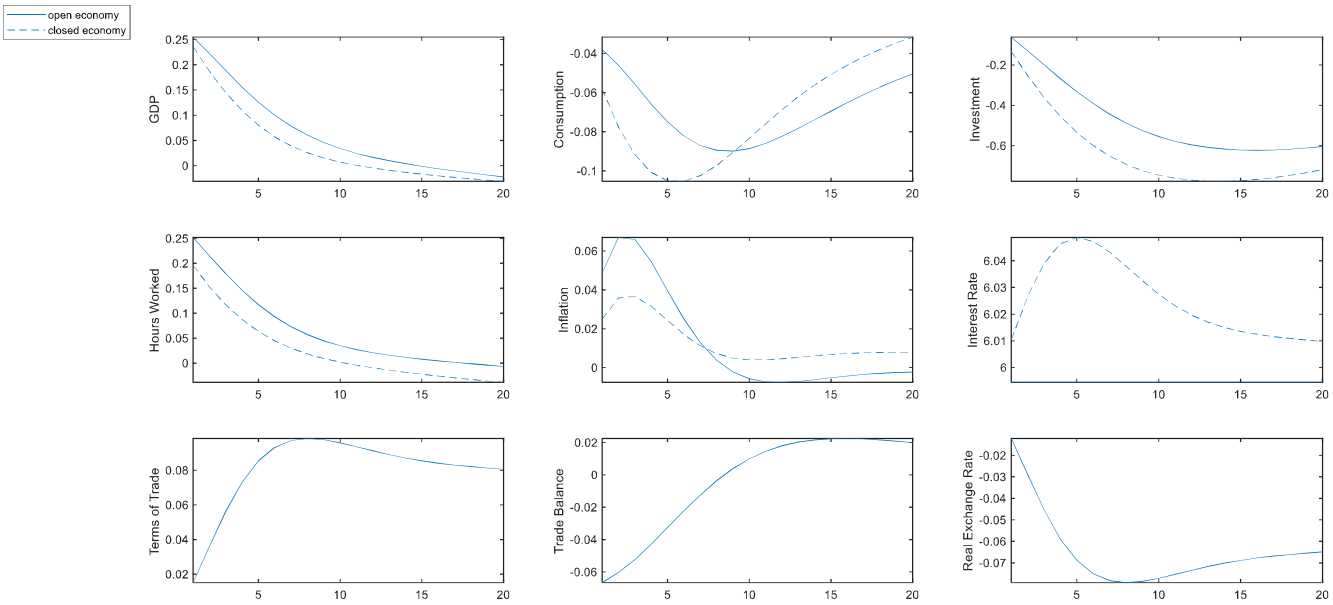
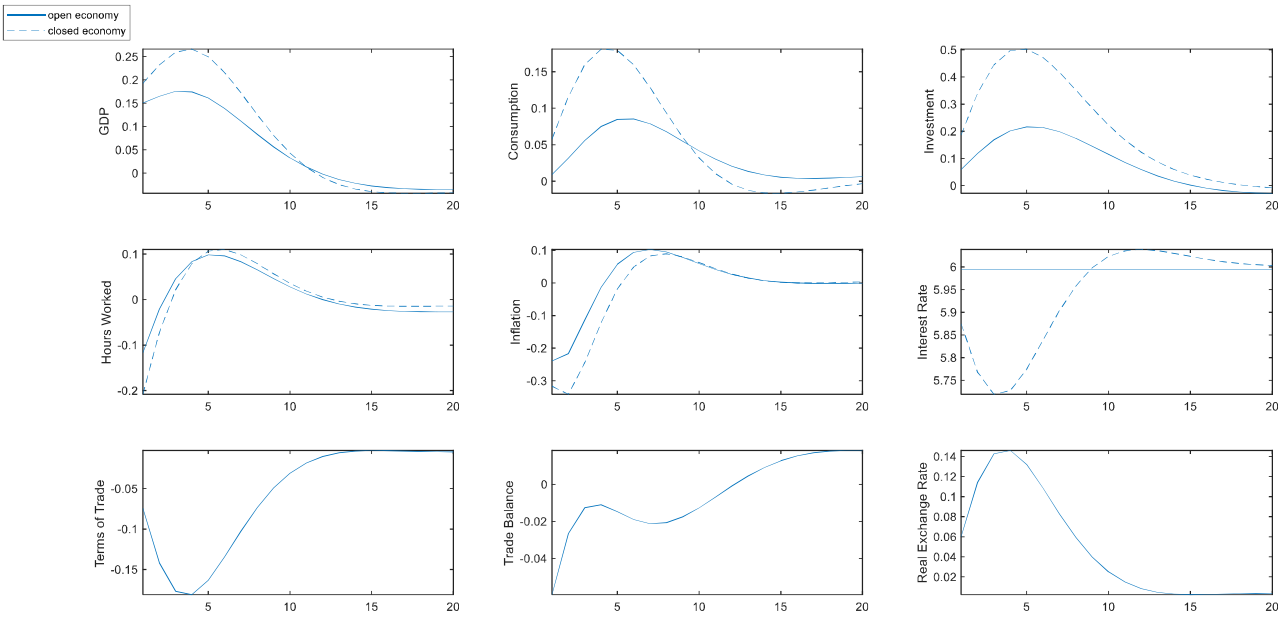


Figure 1: Fiscal multipliers for the small open economy in the currency union. First row: present values of multipliers following a public spending increase and an income tax cut for both open and closed economies; Second row: the difference between fiscal multipliers in open and closed economies following the two fiscal shocks. X-axis measures quarters.



(a) Impulse response functions following a public spending increase



(b) Impulse response functions following an income tax cut

Figure 2: Impulse response functions following the two domestic fiscal shocks for the small open economy in the currency union and for the closed economy. X-axis denotes quarters.

In both open and closed economies, an expansion in government spending needs more labor to produce more public goods, thus the labor (hours worked) rises. The increased labor supply leads to a higher level of output, while the higher public consumption also raises the domestic

price of goods, which brings two consequences: firstly, the inflation rate goes up and private consumptions are crowded out; secondly, investment decreases due to an increased cost of capital. For the closed economy, the rising inflation rate appreciates the nominal interest rate, whereas in the currency union, the nominal interest rate remains the same as before since it's set by the central bank which doesn't respond to the fiscal shocks in the small open economy.

The terms of trade in the currency union equal to the relative price of domestic goods to the imported goods:

$$TOT_t = \rho_{D,t}/(\rho^*_{D,t}Q_t).$$

Therefore in the small open economy, the increased price of goods appreciates the terms of trade. Home consumers thus could consume more units of foreign goods per unit of home goods, which is called the positive wealth effect brought by the appreciated terms of trade. The real exchange rate also appreciates due to the higher home price relative to the foreign price, given the nominal exchange rate stays constant in the currency union. At the same time, foreign consumers switch to cheaper foreign goods, which brings about the negative substitution effect for the home country. The negative substitution effect combined with the positive wealth effect generates trade deficits for the home country when exports decrease and imports increase. However, the positive wealth effect from the increased terms of trade more than offsets the negative substitution effect, leading to a crowding in of the private consumption in the small open economy. Hence following one unit increase in the present value of government spending, the output increases more, and the fiscal multiplier in the small open economy is larger than that in the closed economy.

Following an income tax cut, the labor supply increases in both open economy and closed economy, which causes a lower wage. Meanwhile, the decreased rental rate of capital due to the lower tax increases demands for capital, leading to a higher investment. As the price of goods decreases due to the lower cost of capital and the lower wage, domestic consumption rises. Thus the increased consumption, investment, and labor improve the output for both economies. On the other hand, the decreased inflation rate following a lower domestic price reduces the interest rate in the closed economy. In the currency union, the union-wild nominal interest rate always remains at the steady-state level.

The tax cut depreciates the terms of trade in the small open economy following a lower home price of goods. Home consumers hence can consume fewer units of foreign goods per unit of home goods, which is called the negative wealth effect drawn from the decreased terms of trade. The real exchange rate also depreciates due to the lower home price relative to the

foreign price, given the constant nominal exchange rate in the currency union. Although there is a positive substitution effect when foreign consumers more purchase the cheaper imported goods from the home country, the negative wealth effect can't be fully offset by the positive substitution effect in the small open economy. Hence the private consumption is crowded in less, which leads to a smaller increase in output, and the fiscal multiplier is smaller than that in the closed economy.

Furthermore, I calculate the fiscal multiplier of 60% trade share and compare it with the baseline of 35% trade share in figure 3. The result corroborates the economic intuition above: Following a government spending increase, the positive wealth effect through the channel of the terms of trade is stronger with a higher trade openness, which magnifies the fiscal multiplier relative to the baseline; Following an income tax cut, the stronger negative wealth effect brought by a larger depreciation in the terms of trade dampens the fiscal multiplier with a higher trade share.

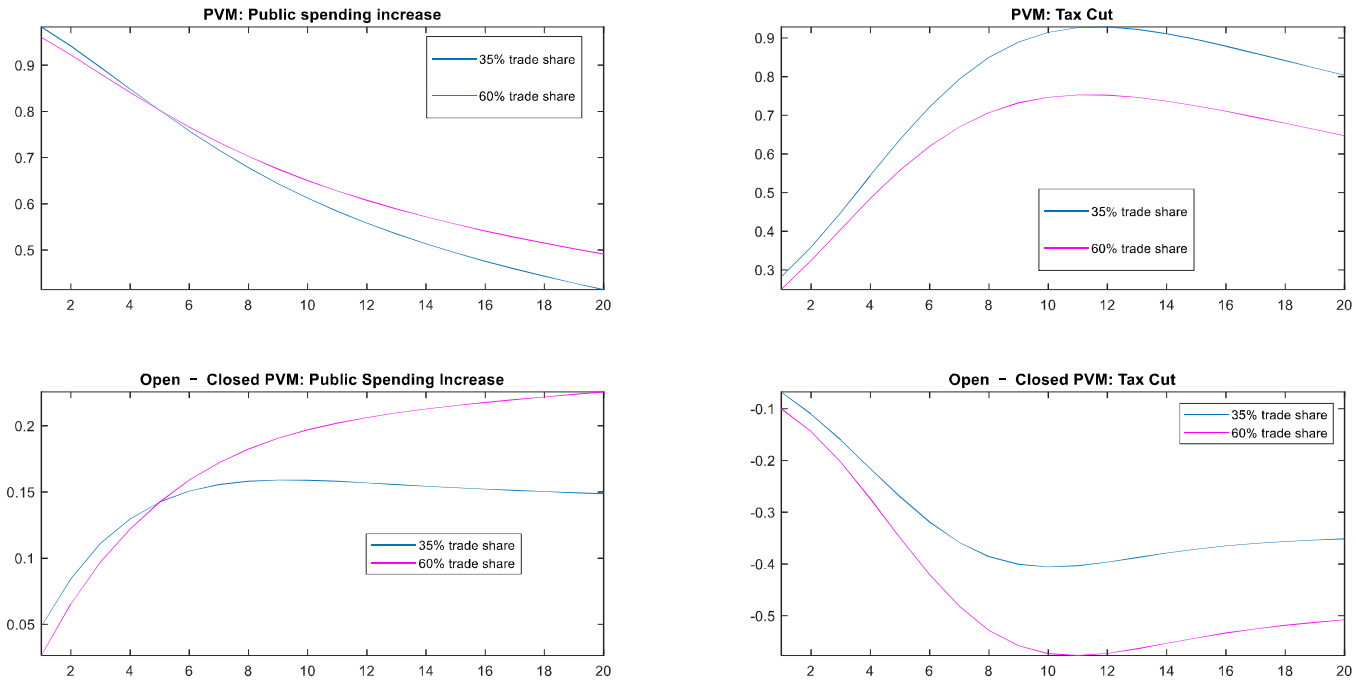


Figure 3: Fiscal multipliers for the small open economy with different trade shares in the currency union. First row: present values of multipliers with different trade shares following a public spending increase and an income tax cut; Second row: the blue line is the difference between fiscal multipliers in the open economy with 35% trade share and in the closed economy; the purple line is the difference between fiscal multipliers in the open economy with 60% trade share and in the closed economy. X-axis measures quarters.

5.2 Small open economy with a flexible exchange rate

In this part, I examine the fiscal multipliers in the small open economy that features a flexible exchange rate. In this case, the small open economy has its own independent monetary authority which stipulates the domestic nominal interest rate according to the Taylor rule:

$$\hat{i}_t = \rho_i \hat{i}_{t-1} + (1-\rho_i)\left[\rho_\pi \hat{\pi}_{C,t} + \rho_Y \hat{Y}_t\right].$$

The Euler equation for the home holdings of home bond B_t^j is:

$$1 = (1+i_t)E_t(\tfrac{\beta_{t,t+1}}{1+\pi_{C,t+1}}).$$

Besides, the other economic features remain the same with those in the baseline scenario.

I compare the fiscal multipliers for the small open economy in the currency union and in the flexible exchange rate regime, and discuss how the response of the monetary rule and exchange rate affects the effects of trade linkages on the fiscal multipliers. The first row in figure 4 records the fiscal multipliers for the small open economy with a flexible exchange rate and for the closed economy respectively, and the second row plots their difference, while the green lines in the second row cite the "open - closed fiscal multipliers" from the benchmark scenario (scenario 1). The impulse response functions following the two fiscal shocks for the small open economy are plotted in figure 15 (a) and (b) respectively in the appendix.

With a flexible exchange rate, an expansion in government spending raises the domestic price of goods, and consequently appreciates the terms of trade. The positive wealth effect brought by the higher terms of trade more than offsets the negative substitution effect after a few quarters, so that the fiscal multiplier in the open economy is higher than that in the closed economy. In the small open economy with a flexible exchange rate, a higher price increases the inflation rate, which further appreciates the domestic interest rate, triggering capital inflows and an appreciation of the nominal exchange rate. As a result, the real exchange rate climbs higher than that in the currency union, which in turn, crowds out more net exports and eventually partly offsets the positive effect of the expanded public demand for domestic goods. In addition, the higher interest rate also crowds out more investment due to increased borrowing costs. In contrast, in the currency union where the interest rate doesn't respond to the fiscal shock in the small open economy, the nominal exchange rate keeps constant, meaning that the real exchange rate increases less and then fewer net exports are crowded out. More importantly, the lack of interest rate response brings about a more persistent appreciation in the domestic price and in the terms of trade over a longer time horizon, which

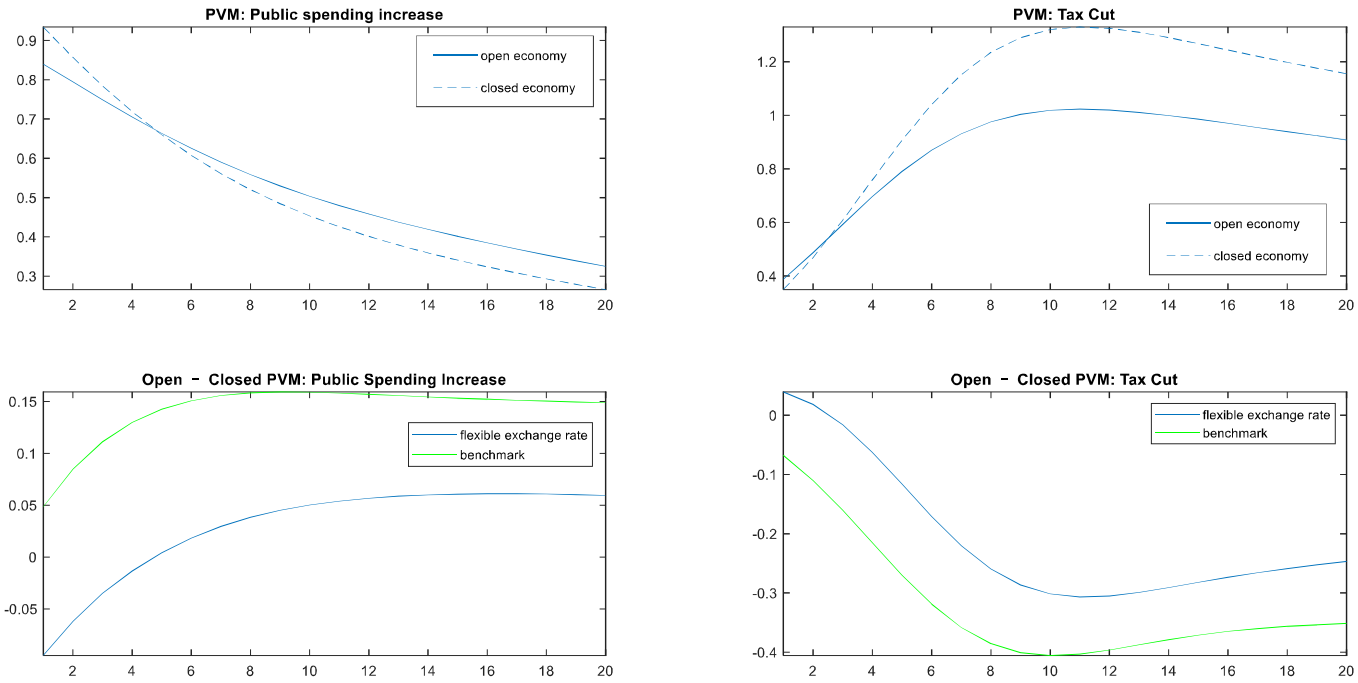


Figure 4: Fiscal multipliers for the small open economy with a flexible exchange rate. First row: present values of multipliers following a public spending increase and an income tax cut for both open and closed economies; Second row: the difference between fiscal multipliers in open and closed economies following the two fiscal shocks. X-axis measures quarters. The green lines in the second row are the benchmarks.

arouses a stronger positive wealth effect in the small open economy. Therefore, the increase in government spending serves more effectively to increase the fiscal multiplier in the currency union than in the flexible exchange rate regime.

Similarly, following an income tax cut, a lower wage and a less cost of capital lead to a lower domestic price, as well as the negative terms of trade. Afterwards, as the negative wealth effect can't be offset by the positive substitution effect brought by the decreased terms of trade, the fiscal multiplier in the open economy is smaller than that in the closed economy. After the inflation rate turns down, the interest rate decreases here, under which case, the nominal exchange rate decreases, indicating that the real exchange rate depreciates more than that in the currency union. A lower real exchange rate contributes to a higher trade balance. On the other hand, as the monetary authority responds to a lower inflation rate, the domestic price becomes lower in the long run and the terms of trade depreciate more with a flexible exchange rate, meaning that the positive substitution effect is stronger and then more net exports are crowded in. Therefore, with a larger trade balance the fiscal multiplier here is

larger than that in the currency union after a tax cut.

5.3 The role of business cycle conditions

It has been demonstrated in previous literature that the public spending multiplier can be amplified by economic slackness with a flexible exchange rate. In this subsection, I discuss the fiscal multipliers over the business cycle (a recession versus normal times) in a small open economy belonging to a currency union. I assume that a domestic risk premium shock triggers a recession in the small open economy, and such a risk premium shock reproduces a 4.3% GDP decline, which is consistent with that observed in the Great Recession. The risk premium shock happens in time t, and at time t+1, the economy witnesses unanticipated fiscal shocks. Figure 5 presents the fiscal multipliers for the open and closed economies in a recession in the first row, and displays the difference between the fiscal multipliers in these two economies in the second row. The green lines in the second row are the benchmarks cited from scenario 1. In the appendix, I plot the impulse response functions following only a domestic risk premium shock in figure 16 and the impulse response functions following the two domestic fiscal shocks after the risk premium shock in figure 17 (a) and (b). The two kinds of impulse response functions are both drawn from quarter 3 to quarter 22 after the risk premium shock happens. I use the difference between the two impulse response functions of a given variable to construct the fiscal multipliers for the small open economy in a recession. These differences for different variables are reported in figure 6 below.

When the economy is in a recession, the fiscal shock increases the fiscal multiplier following either a government spending increase or an income tax cut. The economic intuition of the rise in the fiscal multiplier is same as that in normal times (the benchmark scenario). However, the fiscal multipliers in the two business cycle conditions are very similar here following either of the two shocks. Generally, it is said in the literature that the government spending increase is much more effective to raise the fiscal multiplier in a recession with a flexible exchange rate, especially when the economic recession gets the economy at the ZLB, in which the interest rate doesn't respond to any domestic fiscal shock. This is the same logic that applies to the larger fiscal multiplier in the currency union relative to the flexible exchange rate regime.

The reason why the effectiveness of the fiscal shock is almost state-independent here is as follows. In the currency union, the monetary rule doesn't respond to the risk premium shock in the small open economy, keeping the interest rate in a recession same as that in normal times. In another word, the fiscal shock happens in an economic recession as if it happened in normal times, generating a fiscal multiplier similar to that in the benchmark scenario. From another perspective, it suggests that the non-linearity in the model plays little role. Without a major effect of non-linearity, the fiscal multipliers nearly remain the same over the business

cycle.

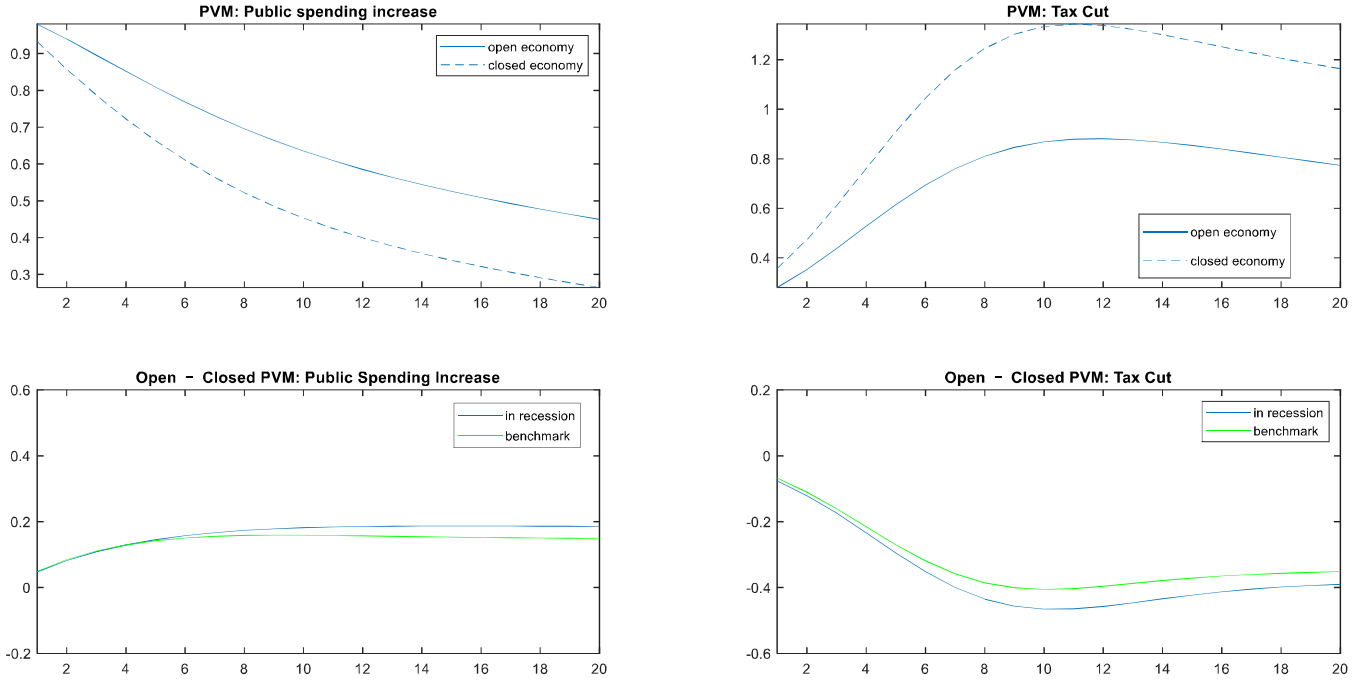
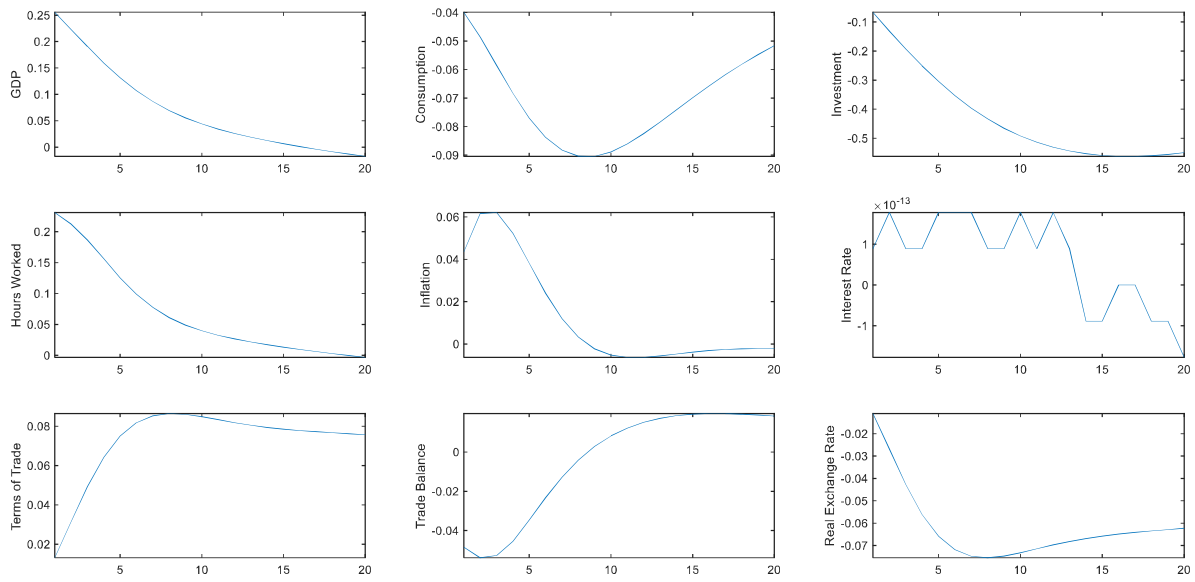
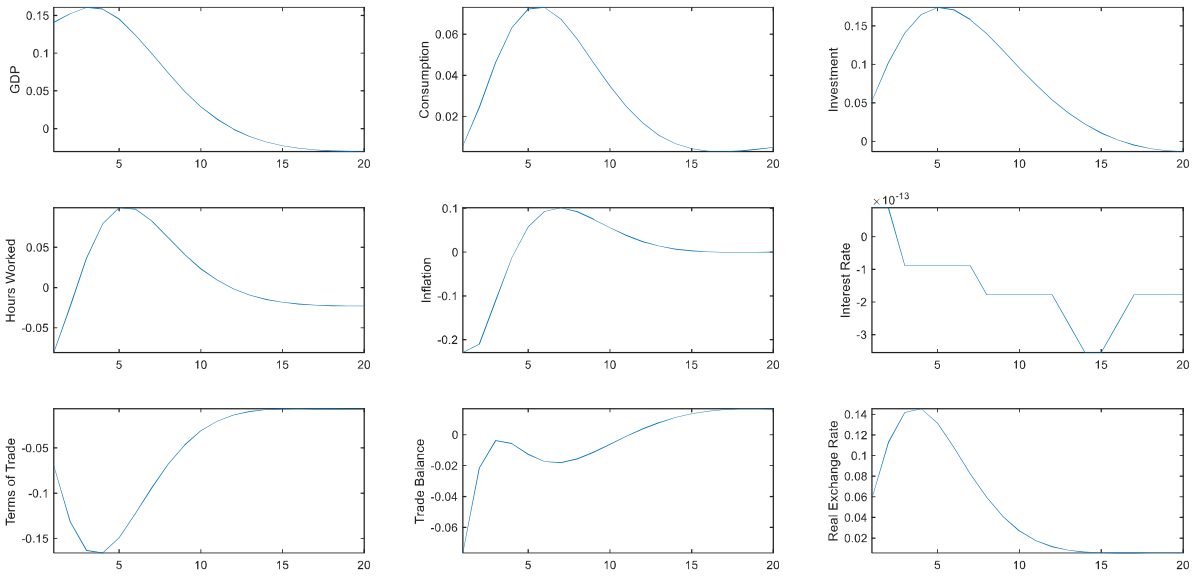


Figure 5: Fiscal multipliers for the small open economy under a recession in the currency union. First row: present values of multipliers following a public spending increase and an income tax cut for both open and closed economies in a recession; Second row: the difference between fiscal multipliers in open and closed economies under a recession following the two fiscal shocks. X-axis measures quarters. The green lines in the second row are the benchmarks.



(a) Difference between impulse response function following a public spending increase after a risk premium shock and impulse response function following just a risk premium shock



(b) Difference between impulse response function following an income tax cut after a risk premium shock and impulse response function following just a risk premium shock

Figure 6: Difference between impulse response function following the two domestic fiscal shocks after a risk premium shock and impulse response function following just a risk premium shock for the small open economy in the currency union. X-axis denotes quarters.

5.4 The role of home bias in government spending

Now I explore the influence of public import share on the fiscal multipliers for the small open economy in the currency union. To do so, I assume a full home bias in government spending (a zero public import share). Figure 7 describes the fiscal multipliers for the small open economy with a zero public import share and for the closed economy in the first row, and the difference between the fiscal multipliers in these two economies are put down in the second row. The green lines in the second row refer to the benchmarks from scenario 1. The impulse response functions under the two fiscal shocks for the small open economy are plotted in figure 18 (a) and (b) respectively in the appendix.

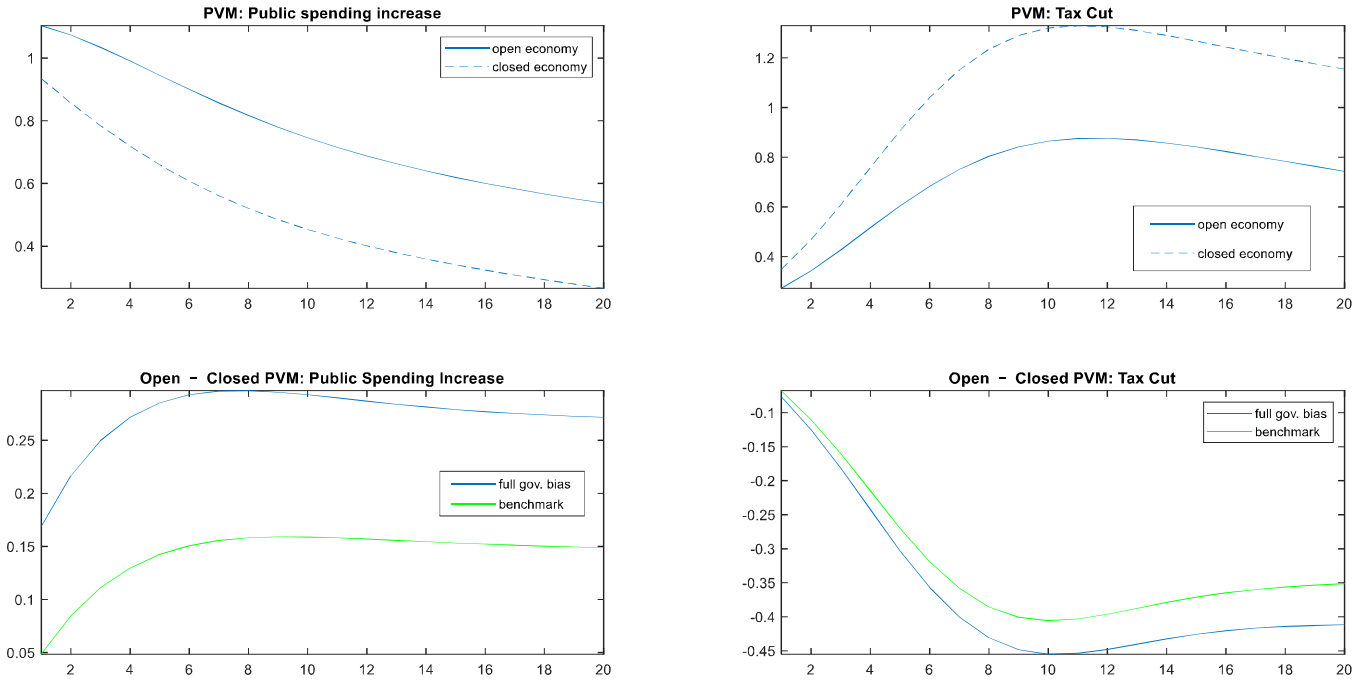


Figure 7: Fiscal multipliers for the small open economy with a full home bias in government spending in the currency union. First row: present values of multipliers following a public spending increase and an income tax cut for both open and closed economies; Second row: the difference between fiscal multipliers in open and closed economies following the two fiscal shocks. X-axis measures quarters. The green lines in the second row are the benchmarks.

After an increase in government spending with a zero public import share, the expanded public consumption totally falls on home goods, causing a surging domestic price as well as the terms of trade which is much higher than that with a non-zero public import share (in scenario 1). Consequently, the corresponding larger positive wealth effect reduces the squeezing out of the private consumption in the small open economy. Therefore, domestic output increases much

more, and the fiscal multiplier is higher than that in the benchmark scenario.

Since the government finances itself through debt and income tax, following an income tax cut, the government spending decreases. With a full home bias in government spending, the reduction of government spending totally falls on the home goods rather than foreign goods, although the government can issue debt to partly offset the reduction on its spending. The decreased public consumption puts downward pressure on the inflation rate. Additionally, the tax cut itself reduces the price level, hence the economy sees much larger declines in the domestic price of goods and in the terms of trade compared with those in scenario 1. Therefore, the corresponding negative wealth effect is more apparent, further alleviating the increase in output. The fiscal multiplier is thus lower than that in the benchmark scenario.

5.5 The role of fiscal financing

In this part, I explore, by comparing the fiscal multipliers with and without a balanced government budget, how the different means of government financing affect the fiscal multipliers through trade linkages for the small open economy in the currency union. In the benchmark scenario, the government can use both income tax and debt to finance its expenditure, but in this scenario, government spending is constrained by a balanced government budget, indicating that the government can only use the income tax to cover its expenditure. Figure 8 presents the fiscal multipliers for both the open and closed economies with a balanced government budget in the first row, and plots the difference between the fiscal multipliers in these two economies in the second row. The green lines in the second row are the benchmarks from scenario 1. The impulse response functions following the two fiscal shocks for the small open economy are plotted in figure 19 (a) and (b) respectively in the appendix.

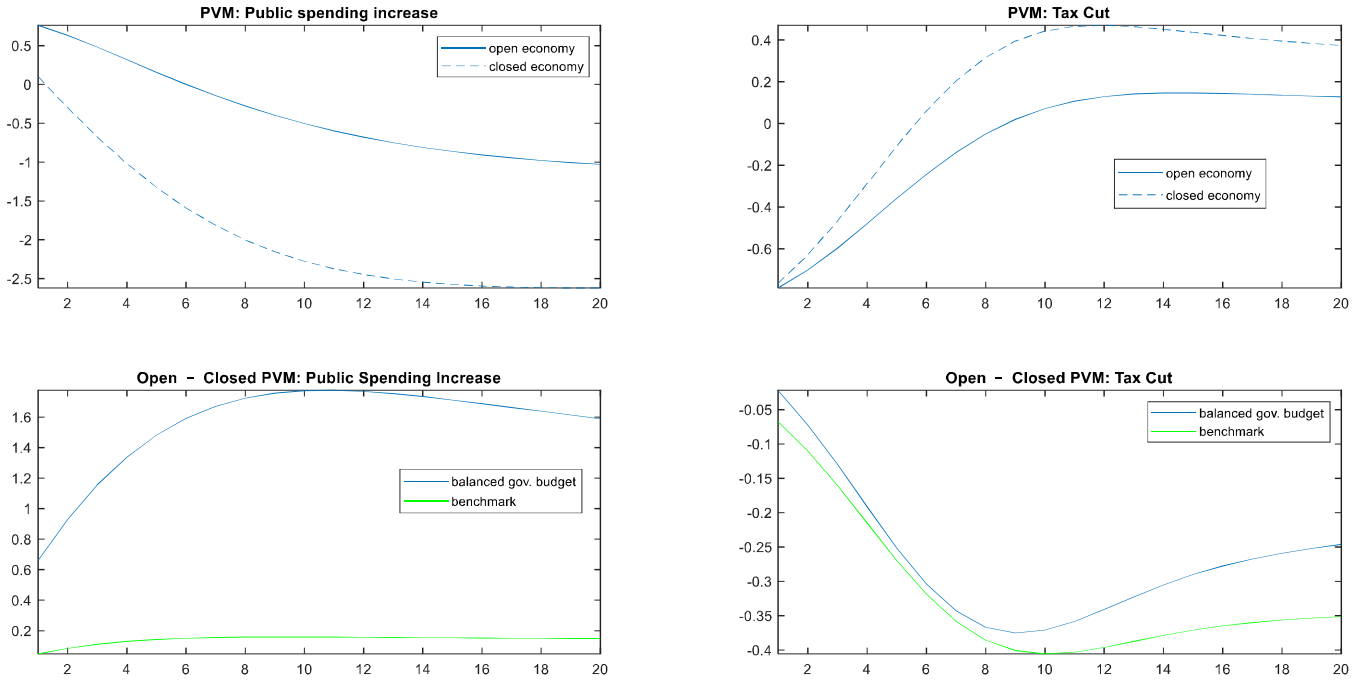


Figure 8: Fiscal multipliers for the small open economy with a balanced government budget in the currency union. First row: present values of multipliers following a public spending increase and an income tax cut for both open and closed economies; Second row: the difference between fiscal multipliers in open and closed economies following the two fiscal shocks. X-axis measures quarters. The green lines in the second row are the benchmarks.

Under a constraint of the balanced government budget, the government's ability to issue debt is limited, with the only choice of using income tax to support an increase in government spending. In the closed economy, home GDP drops after a public spending expansion, due to

a decline in labor and investment caused by a higher tax on labor income and on capital costs. However, for the small open economy in the currency union, the output rises, because the positive wealth effect brought by the appreciated terms of trade following a higher domestic price surpasses the negative effect of the lower labor and the lower capital. Thus the fiscal multiplier in the open economy is larger than that in the closed economy. At the same time, because of the higher tax, the domestic price and the terms of trade become much higher than those in the benchmark scenario, and the positive wealth effect also becomes much stronger.

Due to the negative effect of the higher income tax after a public spending expansion, the fiscal multipliers in both open and closed economies are lower than those in the benchmark scenario. In addition, unlike the open economy, there is no positive wealth effect aroused by the terms-of-trade appreciation in the closed economy to offset the negative effect of the higher income tax. Consequently, the gap between the two multipliers, "open - closed fiscal multiplier", is much larger than the benchmark, drawing a conclusion that the government spending increase is more effective to raise the fiscal multiplier in the open economy relative to the closed economy with a balanced government budget.

When an income tax cut is supported by lower government spending, the reduction in government spending following the tax cut becomes more severe because the government can't issue more debt to finance its expenditure. In both the open and closed economies, the heavier decline in public demand brings a more negative effect on the output, so the fiscal multipliers in both economies are lower than those in the benchmark scenario. In the small open economy, the tax cut plus lower public spending leads to a lower home price of goods and then the negative terms of trade, causing a smaller fiscal multiplier relative to that in the closed economy through the negative wealth effect. On the other hand, a heavier decrease in public spending results in the lower terms of trade compared to that in the benchmark scenario, which brings a stronger positive substitution effect and a higher trade balance to the small open economy. The higher trade balance narrows the gap between the fiscal multipliers in the closed economy and in the open economy, hence the "open - closed fiscal multiplier" is higher than the benchmark.

Furthermore, I compare the fiscal multipliers with a balanced government budget in the small open economy across exchange rate regimes in figure 9. Following a government spending increase, the lack of the interest rate response magnifies the positive wealth effect through a larger terms-of-trade appreciation in the currency union, so the gains from the trade openness become larger; With an income tax cut, a lower trade balance due to the lack of interest rate adjustment dampens the losses from the trade openness in the currency union.

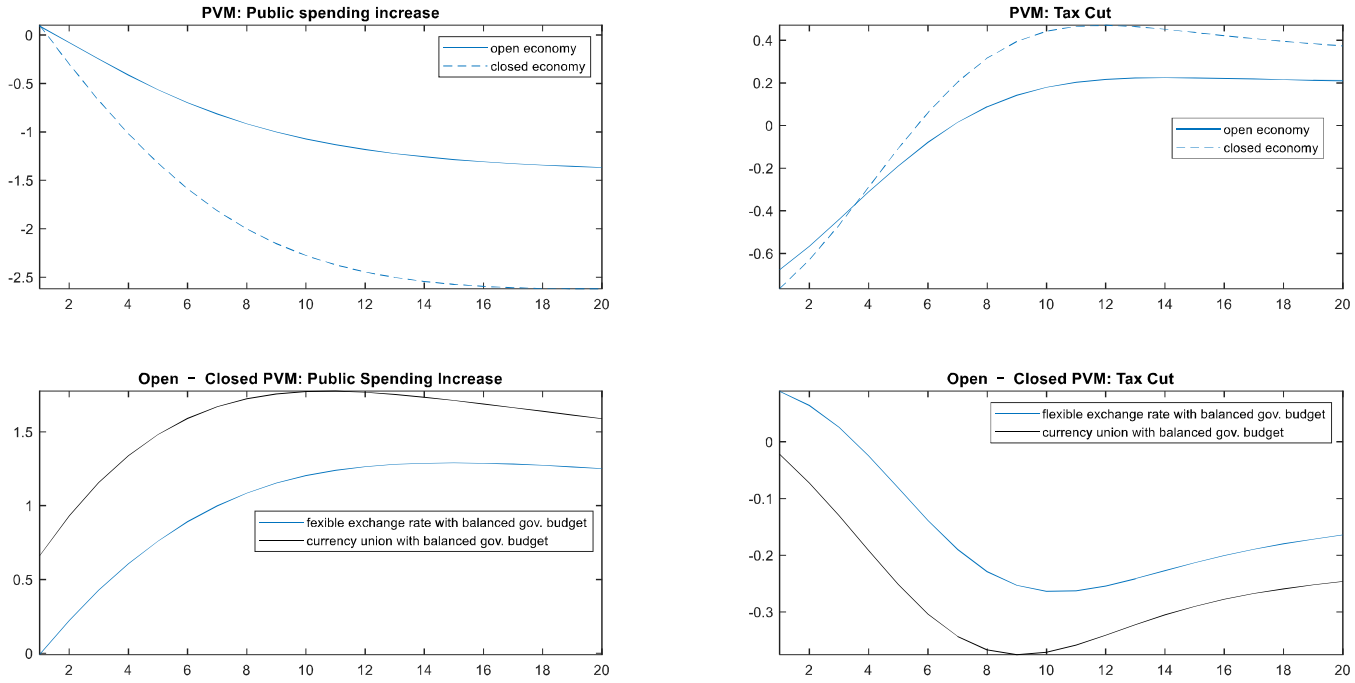


Figure 9: Fiscal multipliers for the small open economy with a balanced government budget and with a flexible exchange rate. First row: present values of multipliers following a public spending increase and an income tax cut for both open and closed economies; Second row: the blue line is the difference between fiscal multipliers with a balanced government budget in the small open economy with a flexible exchange rate and in the closed economy; the black line is the difference between fiscal multipliers with a balanced government budget in the small open economy belonging to a currency union and in the closed economy. X-axis measures quarters.

5.6 Large open economy in a currency union

In order to explore how the country size affects the fiscal multipliers through trade linkages, I consider a large open economy in a currency union. In the two-country DSGE model from section 3, the foreign economy is such a large open economy. The fiscal shocks in the large open economy can affect the union-wild interest rate and the economic development of the small open economy, but the large open economy itself is not affected by the economic turbulence of the small open economy. Figure 10 presents the fiscal multipliers for both the open and closed economies in the currency union in the first row, and plots the difference between the fiscal multipliers in these two economies in the second row. The green lines in the second row are the benchmarks set in scenario 1. The impulse response functions following the two fiscal shocks for the large open economy are put down in figure 20 (a) and (b) respectively in the appendix.

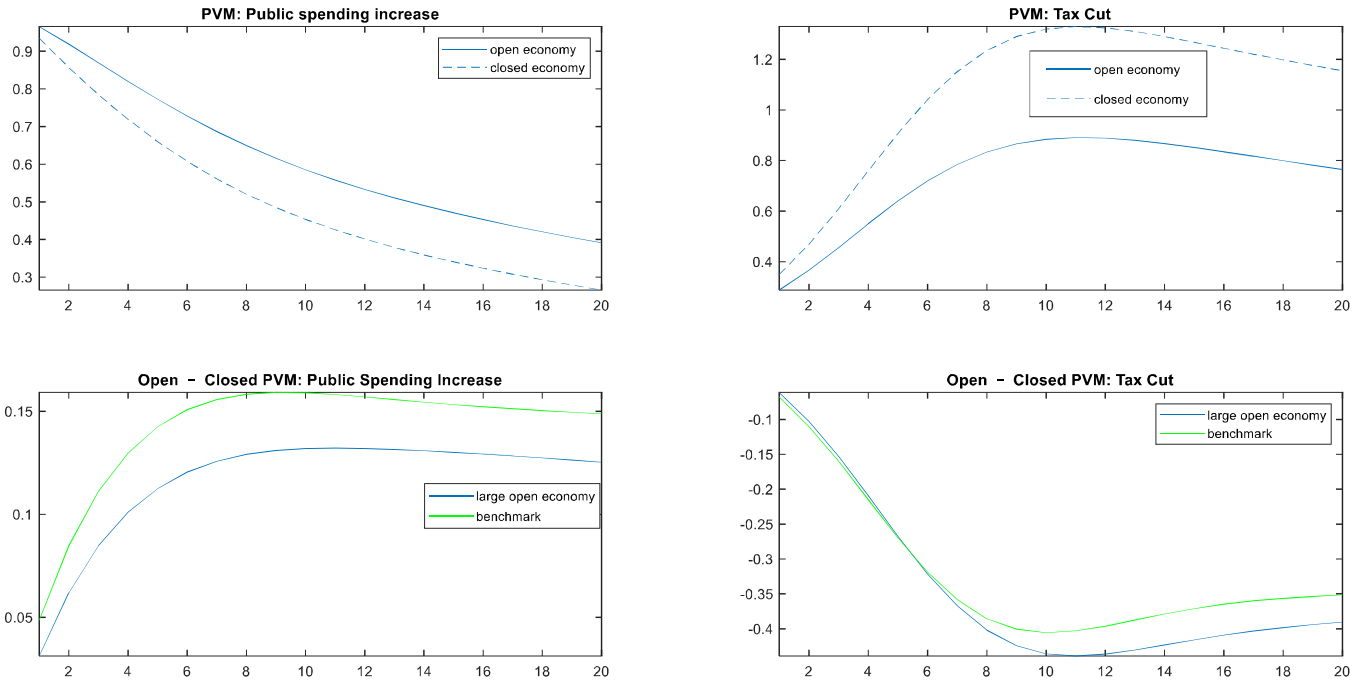


Figure 10: Fiscal multipliers for the large open economy in the currency union. First row: present values of multipliers following a public spending increase and an income tax cut for both open and closed economies; Second row: the difference between fiscal multipliers in open and closed economies following the two fiscal shocks. X-axis measures quarters. The green lines in the second row are the benchmarks.

After a government spending increase, the union-wide interest rate goes up following an in-

creased inflation rate, which in turn curbs the further surging of the domestic price level because the higher interest rate attracts more savings and reduces consumptions. Therefore, the terms of trade appreciate less than that in the benchmark scenario, which means the positive wealth effect brought by the appreciation of the terms of trade in the large open economy is less strong. Although the positive wealth effect can still more than offset the negative substitution effect, the fiscal multiplier for the large open economy is smaller than that in the benchmark scenario.

After an income tax cut, the domestic price of goods decreases in the large open economy belonging to a currency union due to cheaper labor and cheaper capital cost. Meanwhile, the common interest rate goes down following a decreased inflation rate, which mitigates the downward trend of the domestic price for the reason that the lower interest rate, in turn, boosts consumption and inflation. Hence the terms of trade decrease less than that in the benchmark scenario, indicating that the positive substitution effect is less strong. Besides, due to a smaller depreciation in the real exchange rate, fewer net exports are crowded in. Adverse trade balance curbs the output increase. The negative wealth effect is still greater than the positive substitution effect in the large open economy, thus the relevant fiscal multiplier is lower than that in the closed economy, which however, is smaller than that in the benchmark scenario.

5.7 International fiscal spillovers

In this part, I examine how the trade linkages affect the international spillovers for the home economy in the currency union following the two foreign fiscal shocks. Figure 11 presents the fiscal multipliers for the small open economy, and the corresponding impulse response functions are plotted in figure 21 (a) and (b) respectively in the appendix.

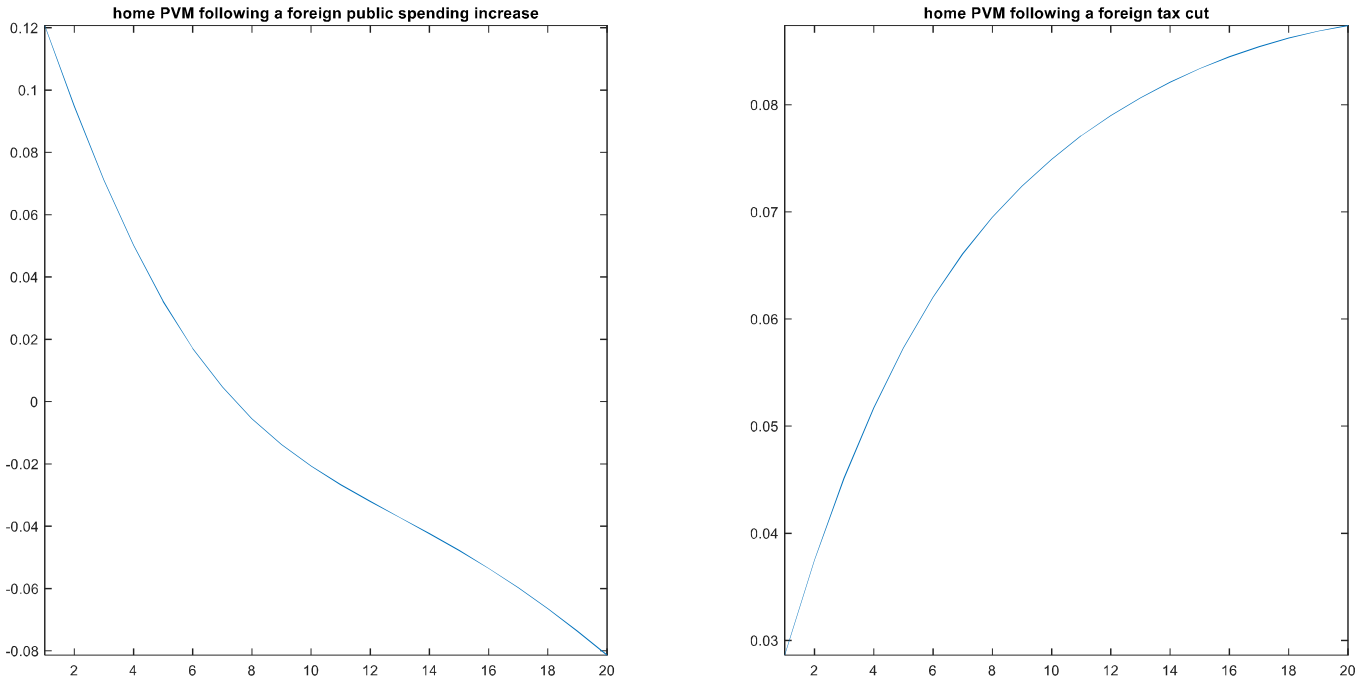


Figure 11: Fiscal multipliers for the small open economy in the currency union following the foreign fiscal shocks. Left panel: present value of multiplier following a foreign public spending increase; Right panel: present value of multiplier following a foreign income tax cut. X-axis measures quarters.

Facing an expansion in foreign public spending, the foreign price of goods goes up, so the home terms of trade go down. The negative wealth effect and the positive substitution effect aroused by the lower terms of trade crowd net exports in, and the trade balance increases. For the home country, the positive effect of trade surplus dominates and exceeds the negative wealth effect, so private consumption is crowded in and home output increases. Therefore, the fiscal multiplier rises in the small open economy belonging to a currency union.

An income tax cut in the large foreign economy also triggers positive spillovers for the home country. With an income tax cut, the foreign price of goods drops, which leads to the higher

home terms of trade. The higher terms of trade bring a positive wealth effect to the home country, which means domestic consumers can consume more units of foreign goods per unit of home goods. Meanwhile, foreign consumers switch to buy more foreign cheaper goods, and the home net exports are crowded out. The declined trade balance is also aligned with the increased domestic real exchange rate. The positive wealth effect brought by the higher terms of trade can more than offset the negative effect of the trade deficit in the home country, so private consumption is crowded in and the output increases. Therefore, the fiscal multiplier rises in the small open economy belonging to a currency union.

6 Robustness

In order to verify the robustness of the results, I condition the model on European data. The values of monetary and fiscal parameters for the euro area are based on Cacciatore et al. (2021). The inflation weight ρ_π, the GDP gap weight ρ_Y, and the smoothing parameter ρ_i, are set to 1.93, 0.75, 0.87 respectively for the monetary rule of the currency union. The values of fiscal variables in a steady state are matched to the averages for the euro area. The annualized ratio of government debt to GDP, $\frac{S}{4}$, is 0.9, and the share of government spending to GDP, $\frac{G}{Y}$, is 0.2. The income tax rate τ^I is equal to 0.325 and the VAT rate τ^C is equal to 0.2.

By using the European data, I calculate the fiscal multipliers for the small open economy under normal times and under a recession in the currency union, as well as the multipliers with a flexible exchange rate. Similarly, the fiscal multipliers in the counterfactual closed economy and the "open - closed fiscal multipliers" are also considered in each scene. The "open - closed fiscal multipliers" from the baseline scenario (the small open economy under normal times in the currency union) are presented in other scenarios as benchmarks (the red lines in figures below). The fiscal multipliers on the euro-area data are qualitatively and quantitatively similar to those on the U.S. and Canadian data, and the multipliers on these two calibrations bear the same economic intuitions. The figures below show that the results in section 5 are robust.

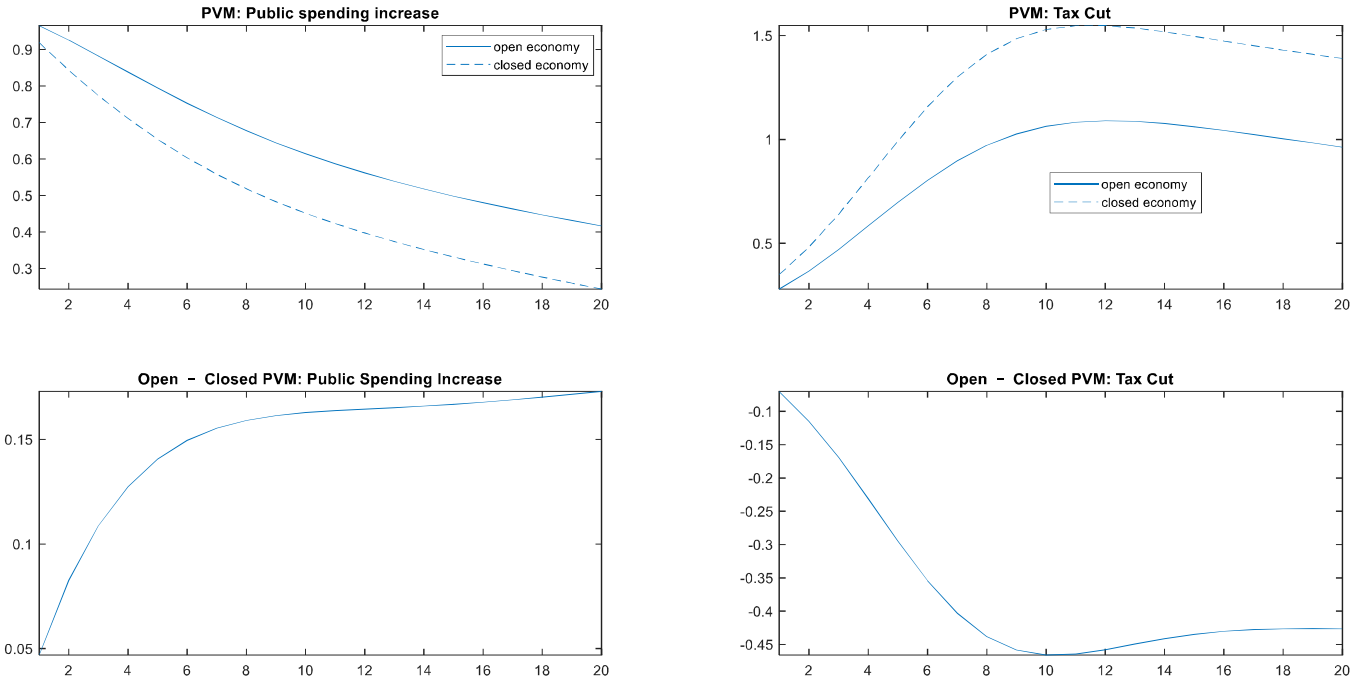


Figure 12: Fiscal multipliers for the small open economy in the currency union (euro data). First row: present values of multipliers following a public spending increase and an income tax cut for both open and closed economies; Second row: the difference between fiscal multipliers in open and closed economies following the two fiscal shocks. X-axis measures quarters.

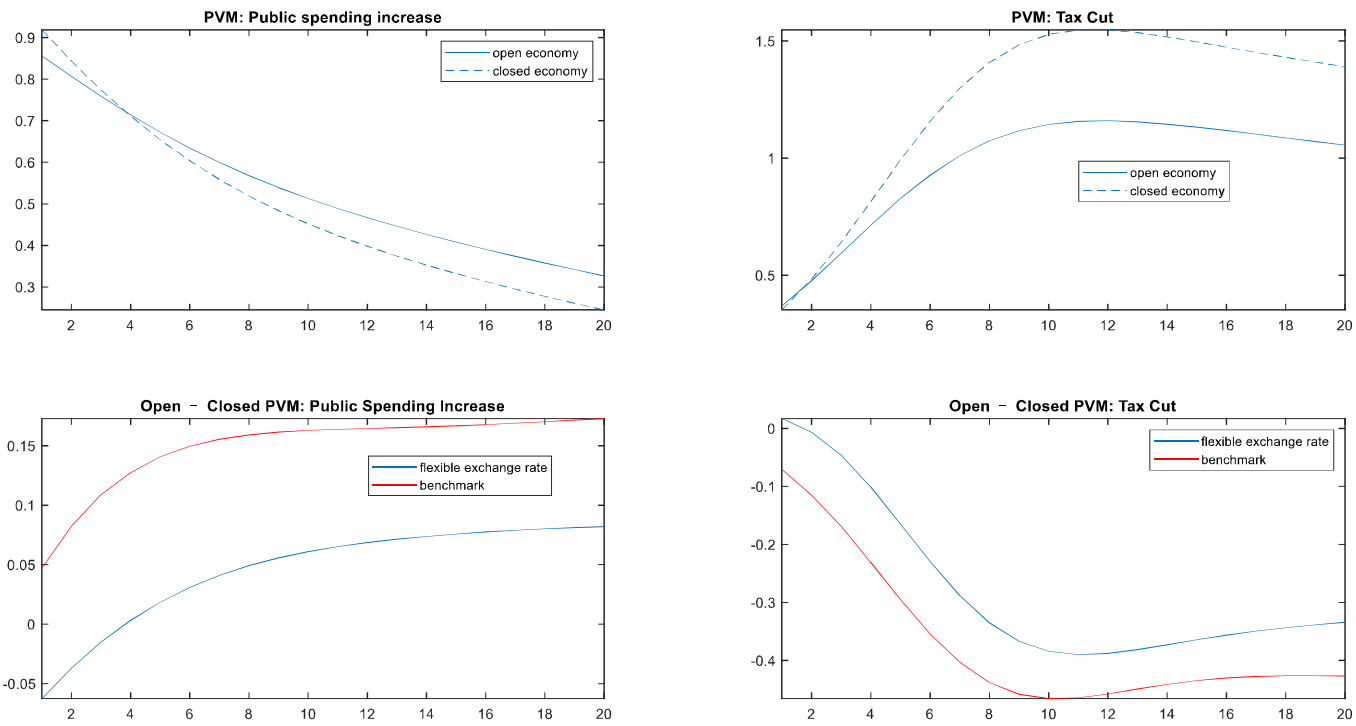


Figure 13: Fiscal multipliers for the small open economy with a flexible exchange rate (euro data). First row: present values of multipliers following a public spending increase and an income tax cut for both open and closed economies; Second row: the difference between fiscal multipliers in open and closed economies following the two fiscal shocks. X-axis measures quarters. The red lines in the second row are the benchmarks.

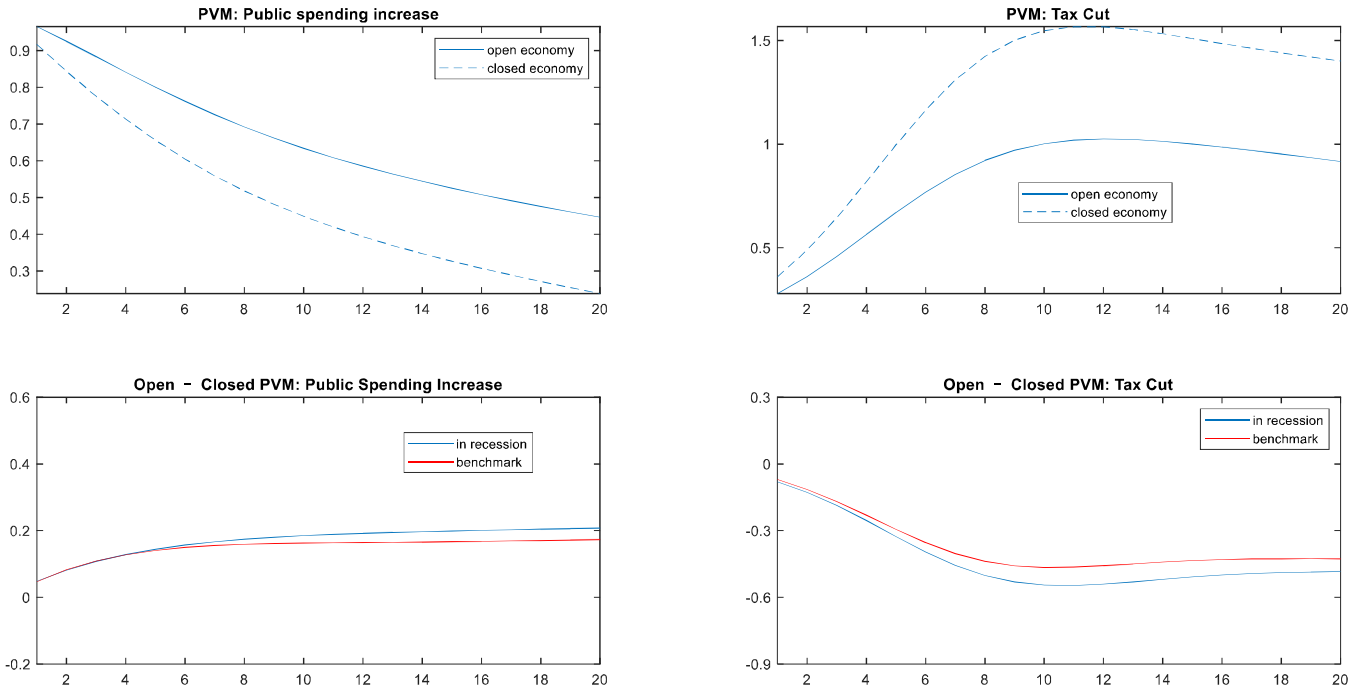


Figure 14: Fiscal multipliers for the small open economy under a recession in the currency union (euro data). First row: present values of multipliers following a public spending increase and an income tax cut for both open and closed economies; Second row: the difference between fiscal multipliers in open and closed economies following the two fiscal shocks. X-axis measures quarters. The red lines in the second row are the benchmarks.

7 Conclusion

This thesis examines the effects of trade linkages on fiscal multipliers for a small open economy belonging to a currency union. Using a state-of-the-art, quantitative international business cycle model with real and nominal frictions, I first show that lack of interest rate response and exchange rate appreciation implies that trade openness results in a larger public spending multiplier relative to a flexible exchange rate scenario. This happens because a larger appreciation of the terms of trade enlarges the positive wealth effect brought by the trade openness. Thus stronger trade linkages can strengthen the effectiveness of public spending for the individual member in a monetary union, reducing the cost of losing monetary policy independence. This result does not extend to a tax cut. In this case, lack of interest rate adjustment dampens capital inflows, resulting in larger output losses from the trade openness relative to a flexible exchange rate scenario.

Second, the role of trade linkages is not particularly sensitive to the existing business cycle conditions. Fiscal multipliers are similar in normal times and in a recession for a given level of trade linkages. This result suggests that the finding of state-dependent multipliers in previous literature is sensitive to the exchange rate regime. Third, stronger trade linkages imply that the fiscal financing and the import share of public spending have first-order effects in countries belonging to a currency union. Finally, fiscal spillovers in a currency union are positive for both fiscal instruments, at least in the short-to-medium term.

These results have policy implications for countries that belong to a currency union and for countries considering joining a currency union.

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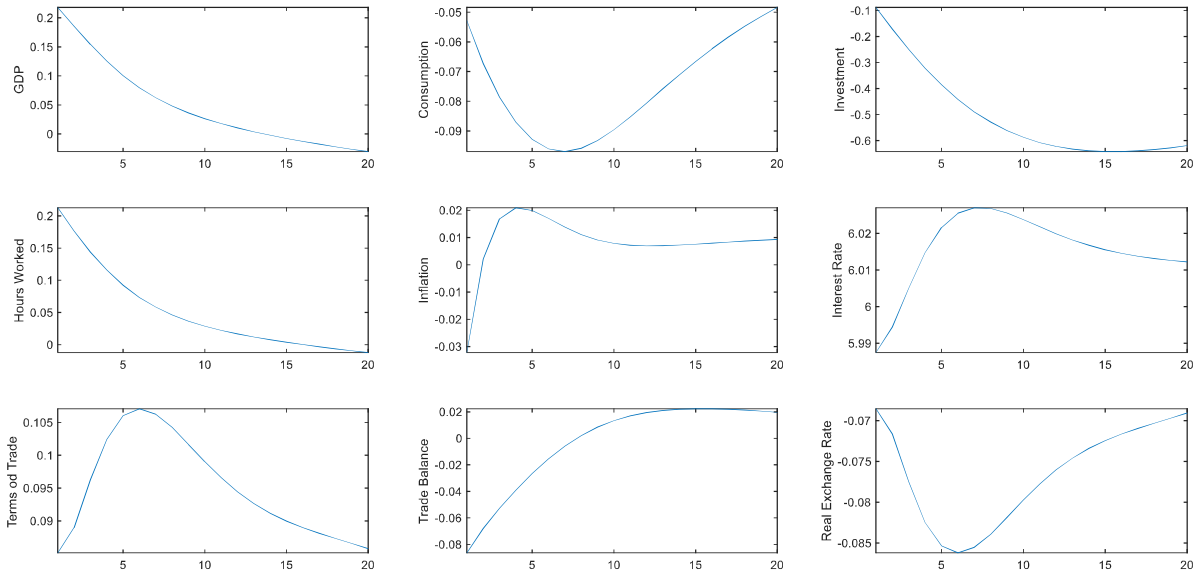
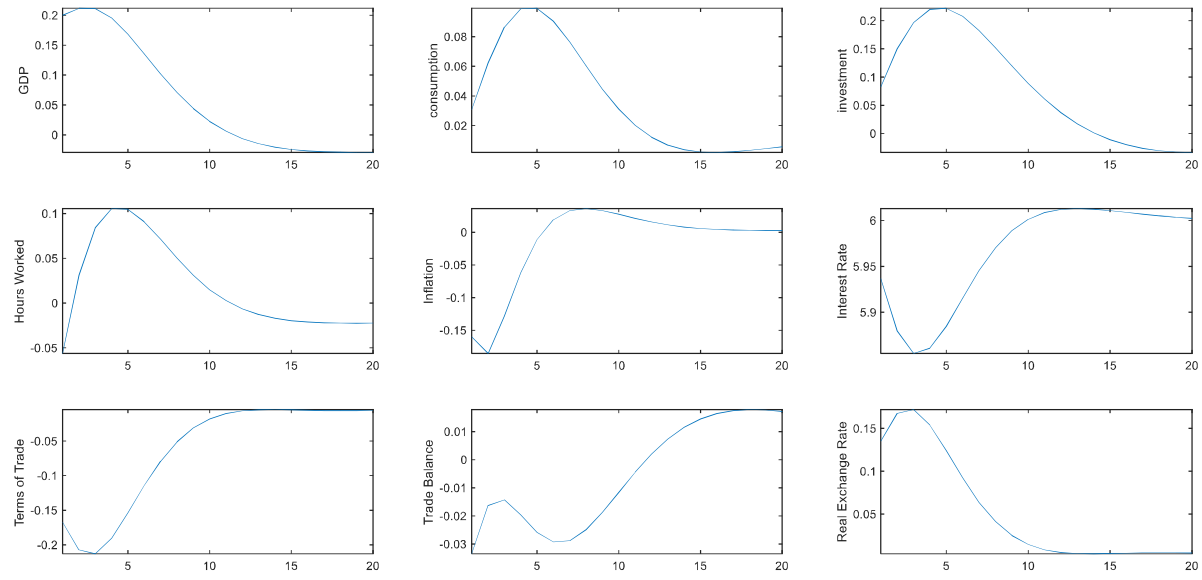
Appendix

The impulse response functions for each scenario:



(a) Impulse response functions following a public spending increase



(b) Impulse response functions following an income tax cut

Figure 15: Impulse response functions following the two domestic fiscal shocks for the small open economy with a flexible exchange rate. X-axis denotes quarters.

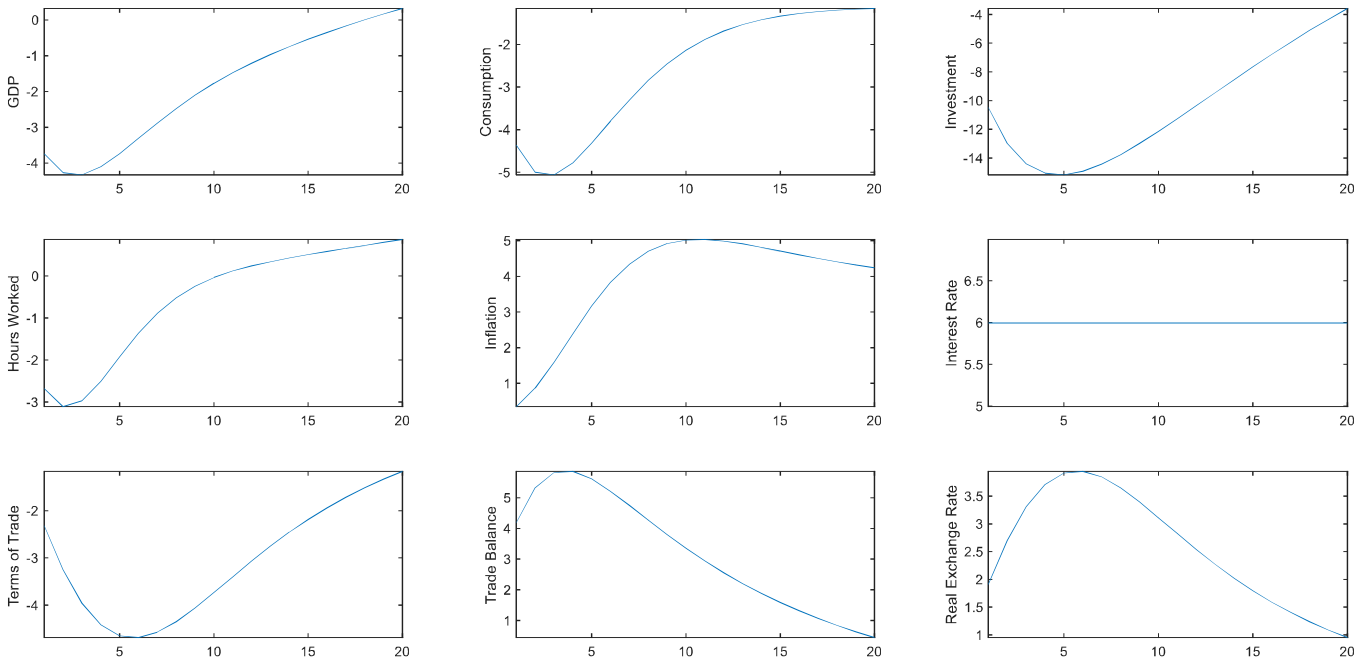
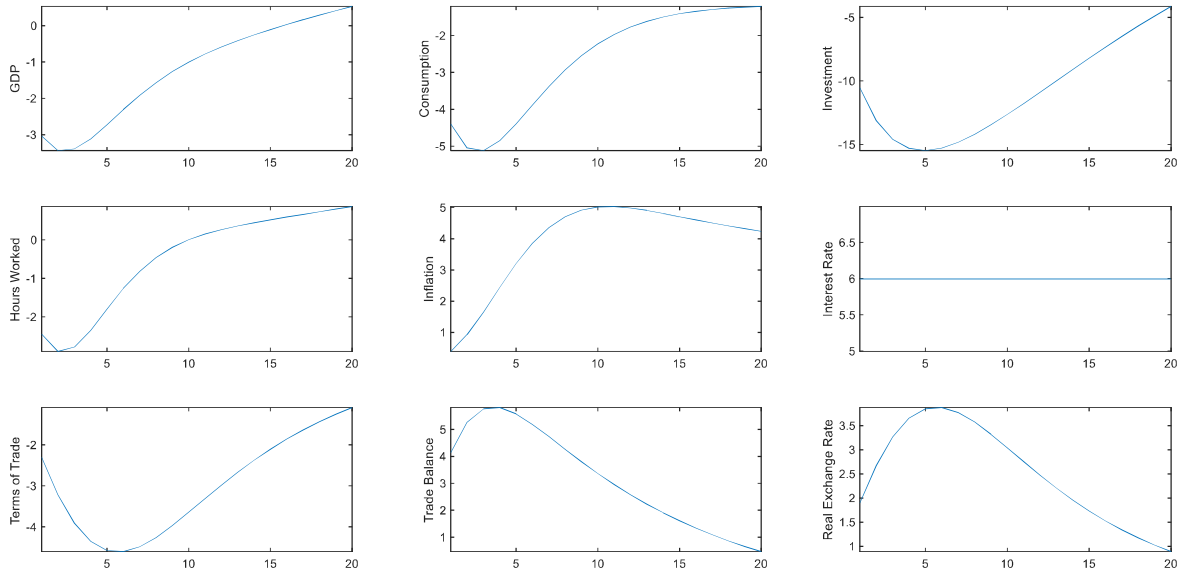
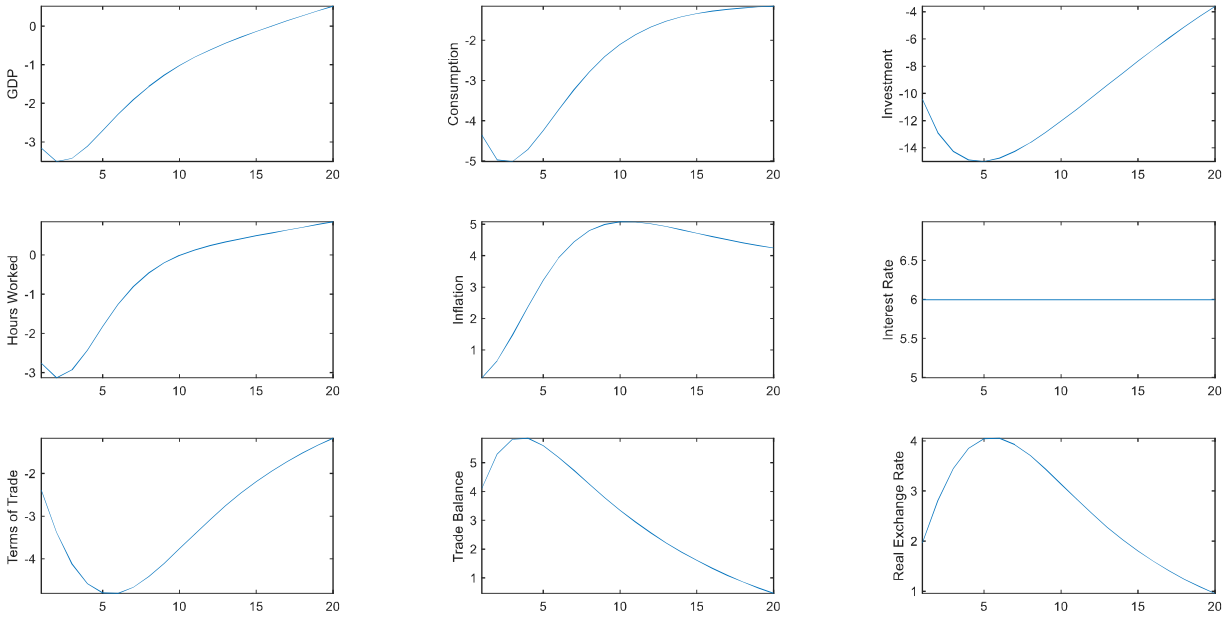


Figure 16: Impulse response functions following a domestic risk premium shock for the small open economy in the currency union. X-axis denotes quarters.

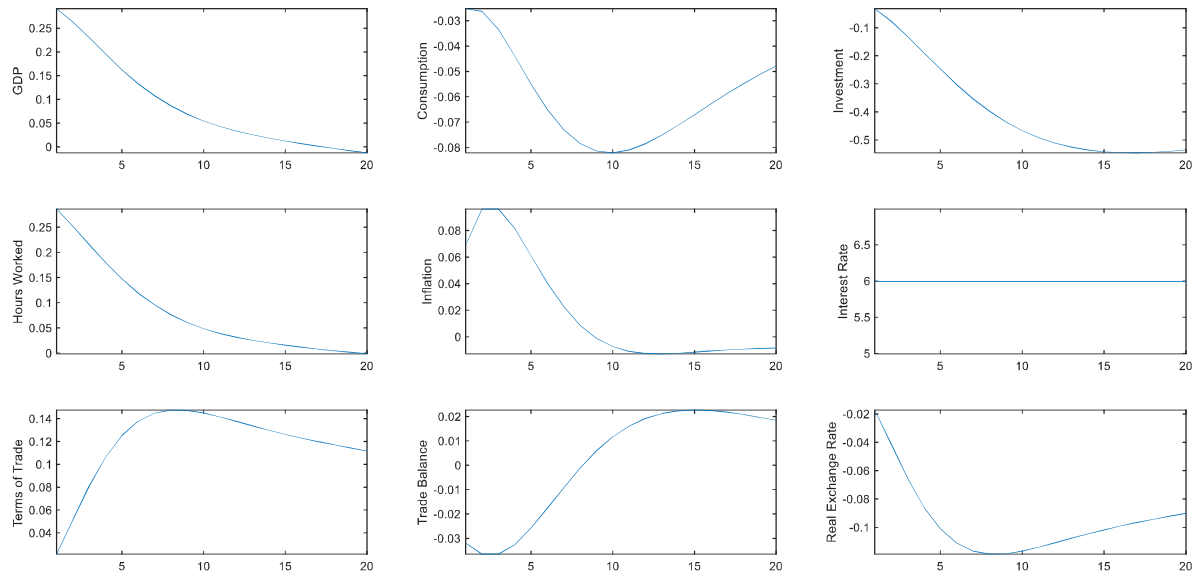


(a) Impulse response functions following a public spending increase after a risk premium shock

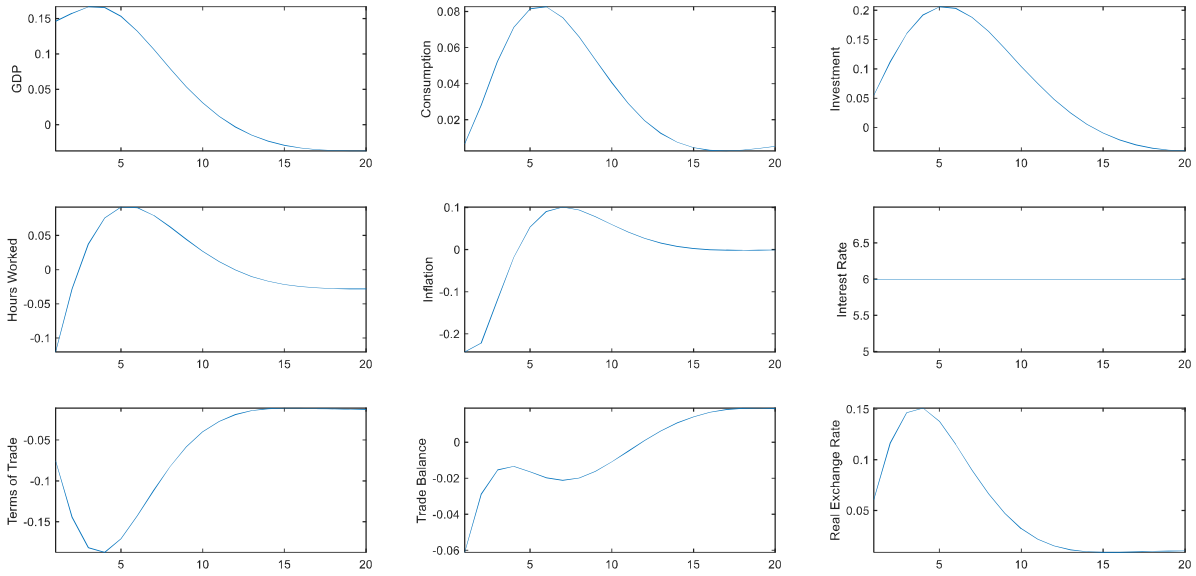


(b) Impulse response functions following an income tax cut after a risk premium shock

Figure 17: Impulse response functions following the two domestic fiscal shocks after a risk premium shock for the small open economy in the currency union. X-axis denotes quarters.

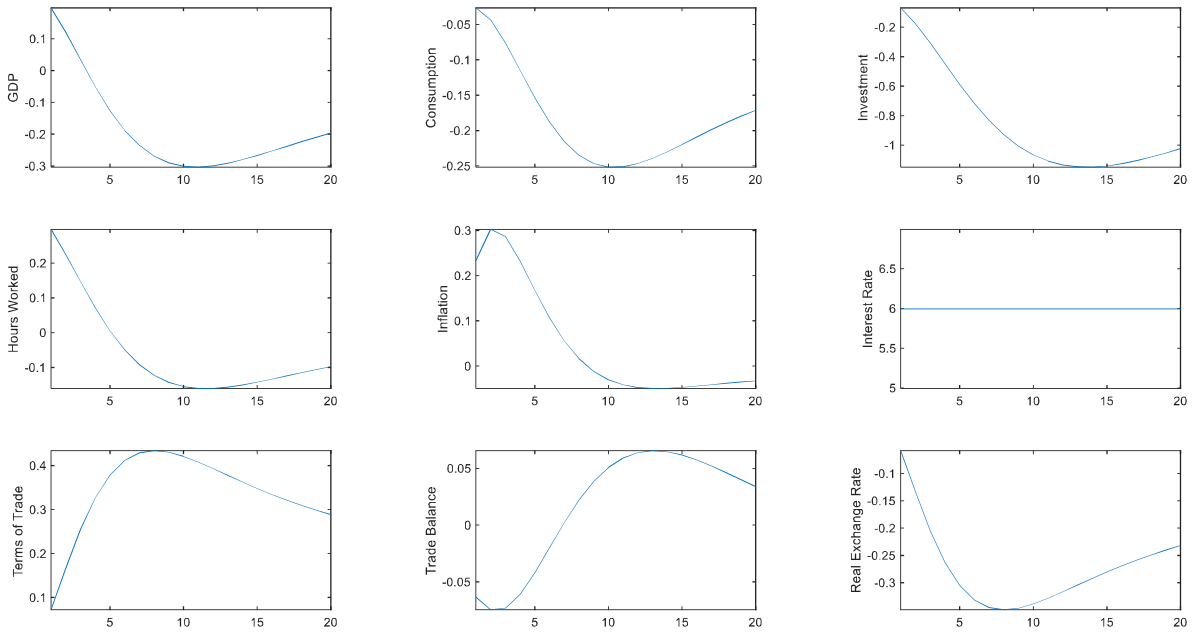


(a) Impulse response functions following a public spending increase

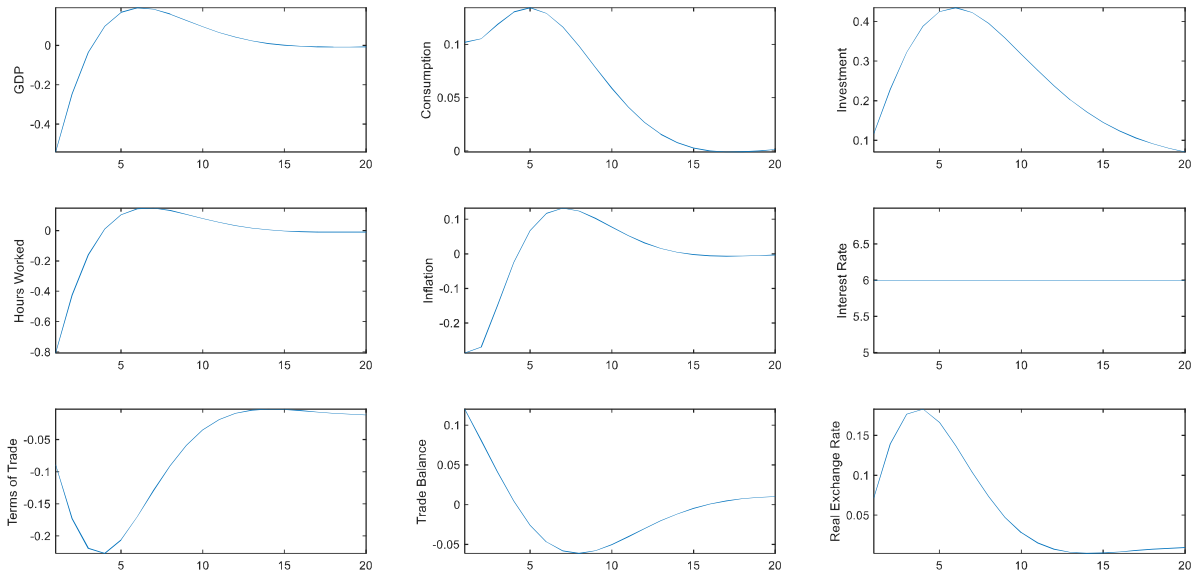


(b) Impulse response functions following an income tax cut

Figure 18: Impulse response functions following the two domestic fiscal shocks for the small open economy with a full home bias in government spending in the currency union. X-axis denotes quarters.

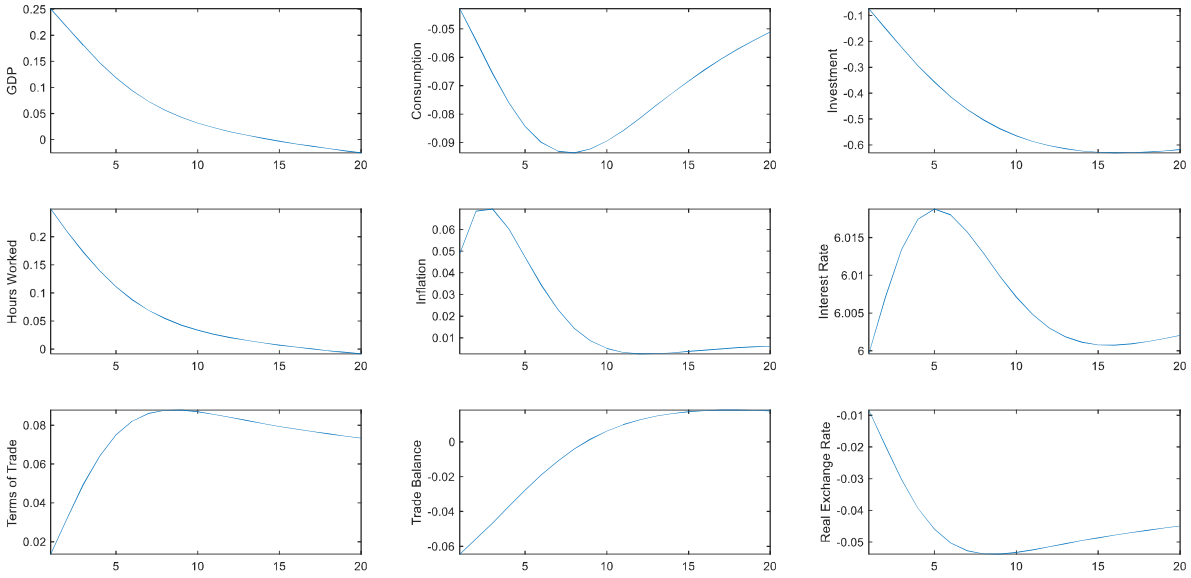


(a) Impulse response functions following a public spending increase

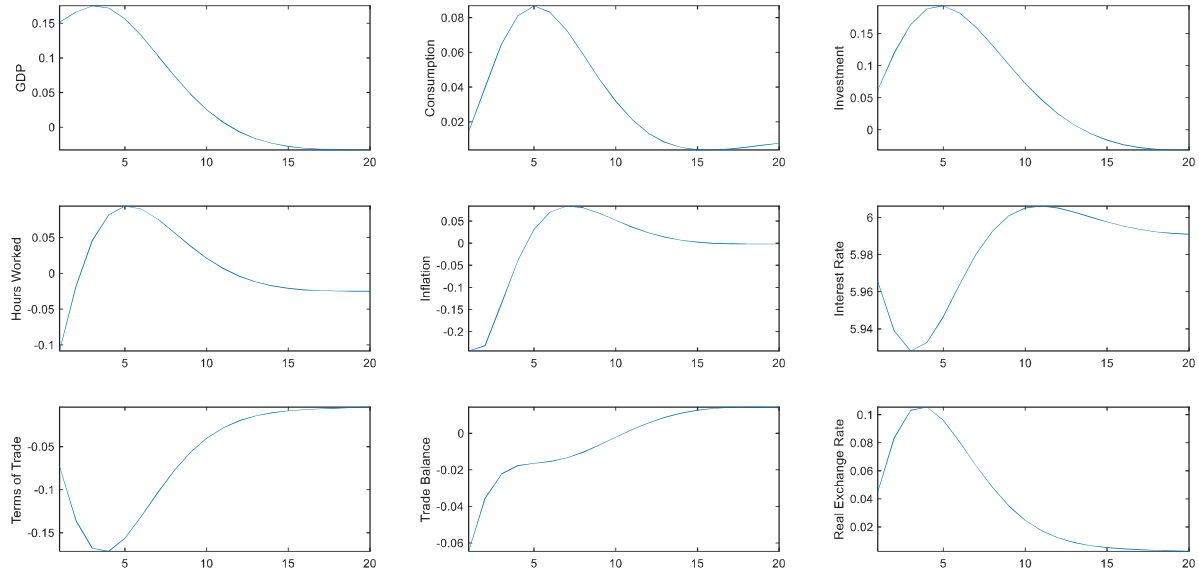


(b) Impulse response functions following an income tax cut

Figure 19: Impulse response functions following the two domestic fiscal shocks for the small open economy with a balanced government budget in the currency union. X-axis denotes quarters.

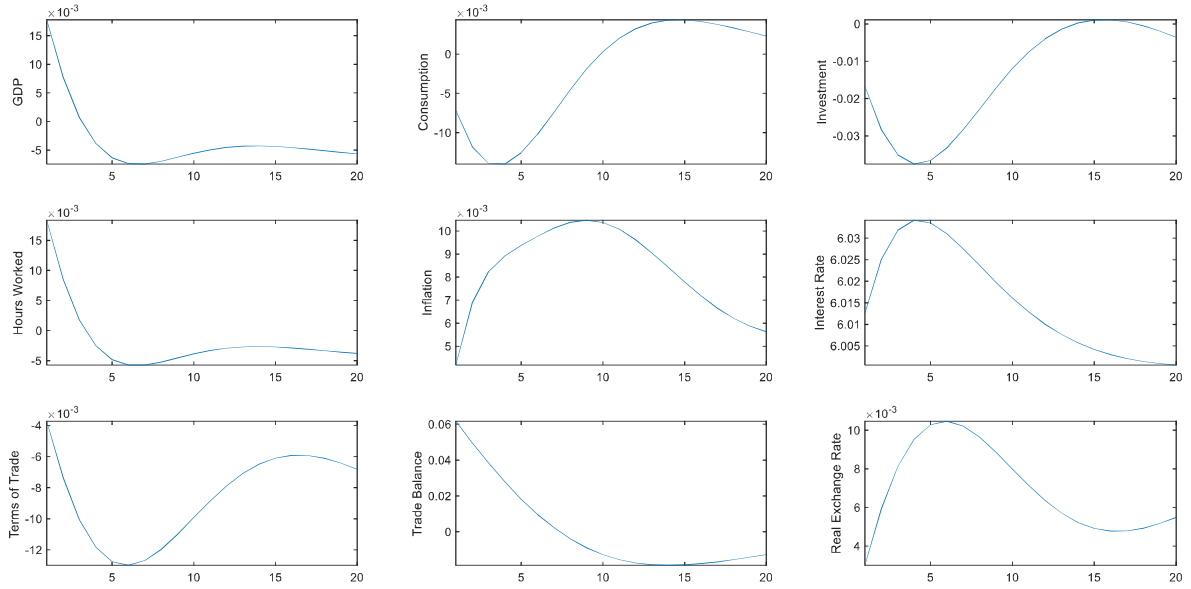


(a) Impulse response functions following a public spending increase

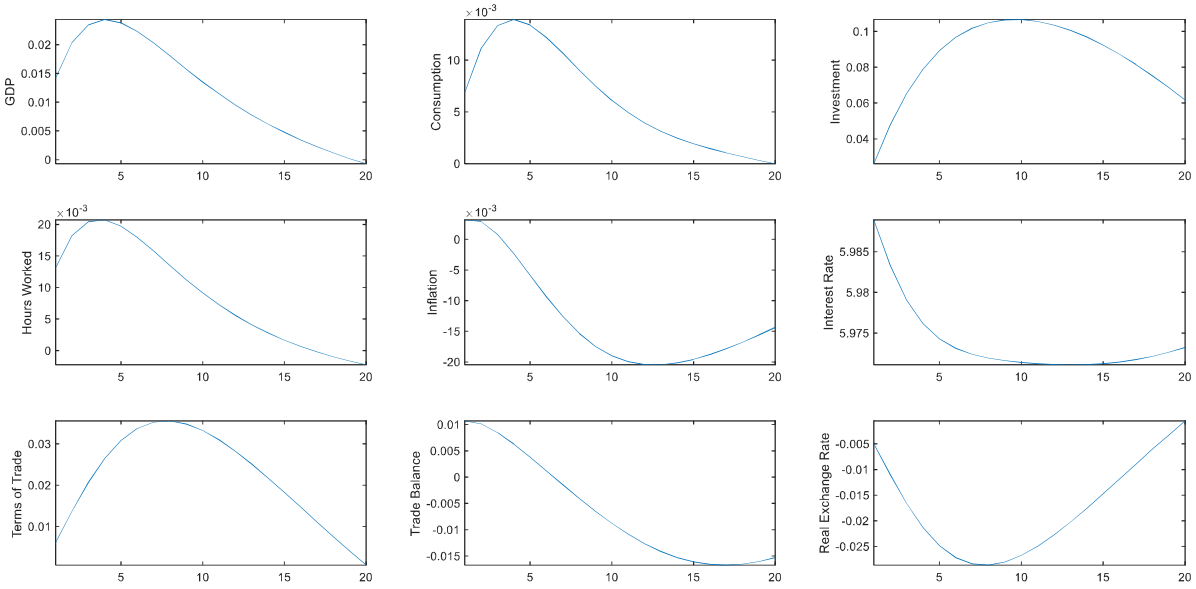


(b) Impulse response functions following an income tax cut

Figure 20: Impulse response functions following the two domestic fiscal shocks for the large open economy in the currency union. X-axis denotes quarters.



(a) Impulse response functions following a public spending increase



(b) Impulse response functions following an income tax cut

Figure 21: Impulse response functions following the two foreign fiscal shocks for the small open economy in the currency union.