Online Appendix to "Trade Flows and Fiscal Multipliers"

Matteo Cacciatore[*]
HEC Montréal, Bank of Canada, and NBER

Nora Traum[†]
HEC Montréal

July 27, 2020

Abstract

This Appendix gathers supplementary material to Cacciatore and Traum (2020).

[*]HEC Montréal, Institute of Applied Economics, 3000, chemin de la Côte-Sainte-Catherine, Montréal (Québec). E-mail: matteo.cacciatore@hec.ca. URL: http://www.hec.ca/en/profs/matteo.cacciatore.html.

[†]HEC Montréal, Institute of Applied Economics, 3000, chemin de la Côte-Sainte-Catherine, Montréal (Québec). E-mail: nora.traum@hec.ca. URL: https://sites.google.com/view/noratraum.

A Analytical Model Details

A.1 Equilibrium Log-Linearized System of Equations

We define $s_I \equiv I/Y$ and $s_G = G/Y$. Note that in steady state the following relationships hold: $s_{C_D} \equiv C_D/Y = (1-\alpha_X)(1-s_G-s_I)$; $s_{C_X} \equiv C_X/Y = (1-\alpha_X)(1-s_G-s_I)$; $s_{I_D} \equiv I_D/Y = (1-\alpha_X)s_I$; $s_{I_X} \equiv I_X/Y = (1-\alpha_X)s_I$; $s_{G_D} \equiv G_D/Y = (1-\alpha_X^g)s_G$; and $s_{G_X} \equiv G_X/Y = (1-\alpha_X^g)s_G$. The equilibrium conditions are given by:

$$\hat{C}_{D,t} = -\phi\hat{\rho}_{D,t} + \hat{C}_t$$

$$\hat{C}^*_{D,t} = -\phi\hat{\rho}^*_{D,t} + \hat{C}^*_t$$

$$\hat{I}_{D,t} = -\phi\hat{\rho}_{D,t} + \hat{I}_t$$

$$\hat{I}^*_{D,t} = -\phi\hat{\rho}^*_{D,t} + \hat{I}^*_t$$

$$\hat{G}_{D,t} = -\phi\hat{\rho}_{D,t} + \phi\hat{\rho}_{G,t} + \hat{G}_t$$

$$\hat{G}^*_{D,t} = -\phi\hat{\rho}^*_{D,t} + \phi\hat{\rho}^*_{G,t} + \hat{G}^*_t$$

$$\hat{C}_{X,t} = -\phi\hat{\rho}_{X,t} + \hat{C}^*_t$$

$$\hat{C}^*_{X,t} = -\phi\hat{\rho}^*_{X,t} + \hat{C}_t$$

$$\hat{I}_{X,t} = -\phi\hat{\rho}_{X,t} + \hat{I}^*_t$$

$$\hat{I}^*_{X,t} = -\phi\hat{\rho}^*_{X,t} + \hat{I}_t$$

$$\hat{G}_{X,t} = -\phi\hat{\rho}_{X,t} + \phi\hat{\rho}^*_{G,t} + \hat{G}^*_t$$

$$\hat{G}^*_{X,t} = -\phi\hat{\rho}^*_{X,t} + \phi\hat{\rho}_{G,t} + \hat{G}_t$$

$$\hat{L}_t = \hat{w}_t - \hat{C}_t$$

$$\hat{L}^*_t = \hat{w}^*_t - \hat{C}^*_t$$

$$\hat{Y}_t = \alpha\hat{K}_t + (1-\alpha)\hat{L}_t$$

$$\hat{Y}^*_t = \alpha\hat{K}^*_t + (1-\alpha)\hat{L}^*_t$$

$$\hat{w}_t = \hat{\rho}_{D,t} + \hat{Y}_t - \hat{L}_t$$

$$\hat{w}^*_t = \hat{\rho}^*_{D,t} + \hat{Y}^*_t - \hat{L}^*_t$$

$$\hat{r}_{K,t} = \hat{\rho}_{D,t} + \hat{Y}_t - \hat{K}_t$$

$$\hat{r}^*_{K,t} = \hat{\rho}^*_{D,t} + \hat{Y}^*_t - \hat{K}^*_t$$

$$
\begin{aligned}
&\hat{\rho}_{X,t} = \hat{\rho}_{D,t} - \hat{Q}_t \\
&\hat{\rho}^*_{X,t} = \hat{\rho}^*_{D,t} + \hat{Q}_t \\
&\widehat{TOT}_t = \hat{\rho}_{D,t} - \hat{\rho}^*_{D,t} - \hat{Q}_t \\
&\hat{r}_{K,t} = 0 \\
&\hat{r}^*_{K,t} = 0 \\
&0 = (1-\alpha_X)\hat{\rho}_{D,t} + \alpha_X \hat{\rho}^*_{X,t} \\
&0 = (1-\alpha_X)\hat{\rho}^*_{D,t} + \alpha_X \hat{\rho}_{X,t} \\
&0 = -\hat{\rho}_{G,t} + (1-\alpha^g_X)\hat{\rho}_{D,t} + \alpha^g_X \hat{\rho}^*_{X,t} \\
&0 = -\hat{\rho}^*_{G,t} + (1-\alpha^g_X)\hat{\rho}^*_{D,t} + \alpha^g_X \hat{\rho}_{X,t} \\
&\hat{Y}_t = s_{C_D}\hat{C}_{D,t} + s_{C_X}\hat{C}_{X,t} + s_{I_D}\hat{I}_{D,t} + s_{I_X}\hat{I}_{X,t} + s_{G_D}\hat{G}_{D,t} + s_{G_X}\hat{G}_{X,t} \\
&\hat{Y}^*_t = s_{C_D}\hat{C}^*_{D,t} + s_{C_X}\hat{C}^*_{X,t} + s_{I_D}\hat{I}^*_{D,t} + s_{I_X}\hat{I}^*_{X,t} + s_{G_D}\hat{G}^*_{D,t} + s_{G_X}\hat{G}^*_{X,t}.
\end{aligned}
$$

Under financial autarky, balanced trade implies:

$$
\begin{aligned}
\hat{Q}_t = -\hat{\rho}_{X,t} &- \frac{s_{C_X}}{s_{C_X}+s_{I_X}+s_{G_X}}\hat{C}_{X,t} - \frac{s_{I_X}}{s_{C_X}+s_{I_X}+s_{G_X}}\hat{I}_{X,t} - \frac{s_{G_X}}{s_{C_X}+s_{I_X}+s_{G_X}}\hat{G}_{X,t} \\
&+ \hat{\rho}^*_{X,t} + \frac{s_{C_X}}{s_{C_X}+s_{I_X}+s_{G_X}}\hat{C}^*_{X,t} + \frac{s_{I_X}}{s_{C_X}+s_{I_X}+s_{G_X}}\hat{I}^*_{X,t} + \frac{s_{G_X}}{s_{C_X}+s_{I_X}+s_{G_X}}\hat{G}^*_{X,t}.
\end{aligned}
$$

Under complete markets, cross-country risk sharing yields:

$$
\hat{Q}_t = \hat{C}_t - \hat{C}^*_t.
$$

A.2 Proof of Proposition 1

Following a shock to government spending, the response of the terms of trade is:

$$
\widehat{TOT}_t = \underbrace{\frac{s_G(1-s_G-2s_I)(1-\alpha)}{(1-s_G)(2-s_G-2s_I)(1-\alpha)+4(1-s_G-s_I)\alpha\alpha_X}}_{\Sigma_{G,TOT}}\hat{G}_t. \tag{1}
$$

Notice the GDP response can be written as a function of the terms-of-trade response and the closed-economy GDP response:

$$\hat{Y}_t = \frac{-(-1+s_G)s_G(-2+s_G+2s_I)(-1+\alpha)+2s_G(-1+s_G+s_I)(-3+s_G+2s_I)\alpha\alpha_X}{(-2+s_G+2s_I)((-1+s_G)(-2+s_G+2s_I)(-1+\alpha)+4(-1+s_G+s_I)\alpha\alpha_X)}\hat{G}_t$$

$$= \hat{Y}_t^{closed} + \frac{2(1-s_G-s_I)\alpha\alpha_X}{(2-s_G-2s_I)(1-\alpha)}\Sigma_{G,TOT}\hat{G}_t.$$

Likewise, all other variables can be written as a function of the terms-of-trade response and the variable's closed-economy response:

$$\hat{C}_t = \hat{C}_t^{closed} + \underbrace{\frac{\alpha_X(2-2s_I-s_G(1-\alpha))}{(2-s_G-2s_I)(1-\alpha)}}_{>0}\Sigma_{G,TOT}\hat{G}_t$$

$$\hat{K}_t = \hat{K}_t^{closed} + \underbrace{\frac{\alpha_X(2-s_G(1+\alpha)-2s_I)}{(2-s_G-2s_I)(1-\alpha)}}_{>0}\Sigma_{G,TOT}\hat{G}_t$$

$$\hat{L}_t = \hat{L}_t^{closed} - \underbrace{\frac{s_G\alpha\alpha_X}{(2-s_G-2s_I)(1-\alpha)}}_{>0}\Sigma_{G,TOT}\hat{G}_t$$

$$\hat{Y}_t^* = -\underbrace{\frac{2\alpha\alpha_X(1-s_G-s_I)}{(2-s_G-2s_I)(1-\alpha)}}_{>0}\Sigma_{G,TOT}\hat{G}_t$$

$$\hat{C}_t^* = -\underbrace{\frac{\alpha_x(2-s_G(1-\alpha)-2s_I)}{(2-s_G-2s_I)(1-\alpha)}}_{>0}\Sigma_{G,TOT}\hat{G}_t$$

$$\hat{K}_t^* = -\underbrace{\frac{\alpha_x(2-s_G(1-\alpha)-2s_I)}{(2-s_G-2s_I)(1-\alpha)}}_{>0}\Sigma_{G,TOT}\hat{G}_t$$

$$\hat{L}_t^* = \underbrace{\frac{s_G\alpha\alpha_X}{(2-s_G-2s_I)(1-\alpha)}}_{>0}\Sigma_{G,TOT}\hat{G}_t$$

$$\hat{Q}_t = -(1-2\alpha_X)\Sigma_{G,TOT}\hat{G}_t.$$

It follows whether domestic responses are higher or lower relative to the closed economy depends on the response of the terms of trade. Likewise, whether foreign spillovers are positive or negative depends on the response of the terms of trade. In contrast, the response of the real exchange rate depends on the response of the terms of trade, as well as whether $\alpha_X < 1/2$.

Following a shock to the income tax rate, the response of the terms of trade is given by:

$$\widehat{TOT}_t = -\underbrace{\frac{(s_I - \alpha)(1 - s_G - \alpha(1 - s_G - 2s_I))}{s_I(1 - s_G)(2 - s_G - 2s_I)(1 - \alpha) + 4s_I\alpha\alpha_X(1 - s_G - s_I)}}_{\Sigma_{\tau,TOT}}\hat{\tau}_t, \tag{2}$$

which is always negative following a tax cut given $s_I < \alpha$. In turn, all other variables' responses (except the real exchange rate) can be written as a function of the terms-of-trade response and each variable's closed economy response:

$$\hat{Y}_t = \hat{Y}_t^{closed} + \underbrace{\frac{2\alpha\alpha_X(1 - s_G - s_I)}{(2 - s_G - 2s_I)(1 - \alpha)}}_{>0}\Sigma_{\tau,TOT}\hat{\tau}_t$$

$$\hat{C}_t = \hat{C}_t^{closed} + \underbrace{\frac{\alpha_X(2 - 2s_I - s_G(1 - \alpha))}{(2 - s_G - 2s_I)(1 - \alpha)}}_{>0}\Sigma_{\tau,TOT}\hat{\tau}_t$$

$$\hat{K}_t = \hat{K}_t^{closed} + \underbrace{\frac{\alpha_X(2 - 2s_I - s_G(1 + \alpha))}{(2 - s_G - 2s_I)(1 - \alpha)}}_{>0}\Sigma_{\tau,TOT}\hat{\tau}_t$$

$$\hat{L}_t = \hat{L}_t^{closed} - \underbrace{\frac{s_G\alpha\alpha_X}{(2 - s_G - 2s_I)(1 - \alpha)}}_{>0}\Sigma_{\tau,TOT}\hat{\tau}_t$$

$$\hat{Y}_t^* = -\underbrace{\frac{\alpha_X(2 - 2s_I - s_G(1 + \alpha))}{(2 - s_G - 2s_I)(1 - \alpha)}}_{>0}\Sigma_{\tau,TOT}\hat{\tau}_t$$

$$\hat{C}_t^* = -\underbrace{\frac{\alpha_X(2 - 2s_I - s_G(1 - \alpha))}{(2 - s_G - 2s_I)(1 - \alpha)}}_{>0}\Sigma_{\tau,TOT}\hat{\tau}_t$$

$$\hat{K}_t^* = -\underbrace{\frac{\alpha_X(2 - 2s_I - s_G(1 + \alpha))}{(2 - s_G - 2s_I)(1 - \alpha)}}_{>0}\Sigma_{\tau,TOT}\hat{\tau}_t$$

$$\hat{L}_t^* = \underbrace{\frac{s_G\alpha\alpha_X}{(2 - s_G - 2s_I)(1 - \alpha)}}_{>0}\Sigma_{\tau,TOT}\hat{\tau}_t$$

$$\hat{Q}_t = (1 - 2\alpha_X)\Sigma_{\tau,TOT}\hat{\tau}_t.$$

It follows domestic responses are always lower than the closed economy responses following a decrease in income taxes, while foreign spillovers are always positive. In contrast, the real exchange rate can be positive or negative depending on whether or not $\alpha_X > 1/2$.

A.3 Tax Cut Under Financial Autarky

Figure A.1 repeats the numerical analysis of section 2 in the main text for a 1% cut in the income tax. The figure demonstrates that an income tax cut is less effective with stronger trade linkages. When the tax cut is financed by lump-sum transfers, as in figure A.1a, the terms of trade unambiguously deteriorates and Home GDP is lower relative to the closed economy for all parameterizations depicted, since there is no ν cut-off in this case and the ϕ-boundary lies below the values depicted. When a tax cut is financed by lower government expenditures, as in figure A.1b, the terms of trade are likely to substantially deteriorate, as both fiscal actions lead to a decline in the terms of trade. However, as discussed in the main text, a boundary for the ratio of public-to-private import demand, $\nu \equiv \alpha_X^g/\alpha_X$, exists for government spending, and once past the ν boundary, a decrease in government spending leads to an increase in the terms of trade, *ceteris paribus.* Thus, when an income tax cut is accompanied by a reduction in public expenditures, it is possible for the terms of trade to increase when ν is large enough. In turn, Home GDP can be higher than in the closed economy.

A.4 Complete Markets

The cutoff values for $\tilde{\alpha}_X$ and $\tilde{\phi}$ appearing in Proposition 3(1b) are given by:

$$\tilde{\alpha}_X = \frac{1 - s_G - \alpha}{(1 - s_G)(1 - \alpha) + 2\alpha^2},$$

$$\tilde{\phi} = \frac{(1 - s_G)[1 - \alpha_X(1 - \alpha)] - \alpha(1 + 2\alpha\alpha_X)}{(1 - s_G)(1 - \alpha)(1 - \alpha_X)}.$$

The cutoff values for $\bar{\alpha}_X$ and $\bar{\phi}$ in Proposition 3(1c) are given by:

$$\bar{\alpha}_X = \frac{1 - s_G - \alpha}{1 - s_G - \alpha + s_G\alpha + 2\alpha^2},$$

$$\bar{\phi} = \frac{1 - s_G - \alpha - \alpha_X + s_G\alpha_X + \alpha\alpha_X - s_G\alpha\alpha_X - 2\alpha^2\alpha_X}{1 - s_G - \alpha + s_G\alpha - \alpha_X + s_G\alpha_X + \alpha\alpha_X - s_G\alpha\alpha_X}.$$

The cutoff value for $\overline{\overline{\phi}}$ appearing in Proposition 3(2b) is given by:

$$\overline{\overline{\phi}} = \frac{(1-s_I)(1+4s_I\alpha\alpha_X) - (1-2s_I)\left[\alpha_X\left(1-\alpha^2\right) - \alpha\left(1-s_I\right)\right]}{\left(1-\alpha_X\right)\left(1-\alpha\right)\left(1+\alpha-2s_I\right)}.$$

Figure A.2 repeats the numerical analysis of section 2 of the main text under complete international asset markets. The figure relaxes the parametric restrictions assumed in Proposition 3 on the ratio of public-to-private import demand, $\nu \equiv \alpha_X^g/\alpha_X$, and the trade elasticity, ϕ. We consider a 1% increase in government spending and a 1% cut in the income tax.

A.5 Multiplier Probabilities in the Analytical Model

We compute the probability the domestic multiplier is larger in the open economy for both the financial-autarky and the complete-markets scenarios. To this end, we have to assign values to six parameters. We consider a grid of empirically-plausible values for the ratio of public-to-private-demand import shares: $\nu \equiv \alpha_X^g/\alpha_X \in [0, 0.75]$, the trade elasticity $\phi \in [0.5, 3]$, and the Frisch elasticity $1/\omega \in [0.25, 2.5]$. We then calibrate the share of government spending relative to GDP (s_G), the income tax rate (τ), and the capital production share (α) using standard values in the literature: $s_G = 0.2$, $\tau = 0.25$, and $\alpha = 0.3$. For each combination of parameters we re-calibrate α_X to keep the trade-to-GDP ratio constant and equal to 0.5. The unconditional probability that the output response is larger in the open-economy, $Pr\left(\hat{Y} > \hat{Y}^{\text{closed}}\right)$, following a public spending increase is 6% assuming complete markets and 48% under financial autarky. Following a decrease in income taxes, the same unconditional probability is 63% assuming complete markets, whereas the probability is zero under financial autarky.

These unconditional probabilities mask heterogeneity with respect to the role of individual parameters. To demonstrate this, Figure A.3 plots the probability that the output response is larger in the open economy conditional on specific parameter values under financial autarky. We summarize the results by plotting the probabilities by the quantile values of each parameter grid. Consistent with the analytical results, following an increase in public spending, $Pr\left(\hat{Y} > \hat{Y}^{\text{closed}}\right)$ is decreasing in the public-private demand import share ν, the trade elasticity ϕ, and the Frisch elasticity $1/\omega$. For low values of ν, ϕ, and $1/\omega$, the conditional probabilities are much larger than the unconditional probability.

A.6 Nominal Rigidities and The Role of International Pricing

We assume financial autarky and that prices are completely fixed. The representative agent in each country has access to domestic, private, risk-free, one-period nominal bonds. Home optimization implies the following Euler equation:

$$1 = (1 + i_t)\,\beta E_t \left\{ \frac{C_{t+1}^{-1}}{C_t^{-1}\,(1 + \pi_{C,t+1})} \right\},$$

where $1 + \pi_{C,t} \equiv P_t/P_{t-1}$ denotes consumer price inflation. The Home monetary authority sets the nominal interest rate i_t via a simple Taylor rule responding to inflation in domestic goods' prices:

$$\frac{1 + i_t}{1 + i} = \left(\frac{1 + \pi_{D,t}}{1 + \bar{\pi}_D} \right)^{\varrho_\pi},$$

where $1 + \pi_{D,t} = P_{D,t}/P_{D,t}$.

With complete exchange-rate pass through (i.e., with fully flexible prices or under producer currency pricing), TOT_t remain a sufficient statistic for cross-country wealth effects and the influence of trade linkages relative to the closed economy. In contrast, with incomplete exchange-rate pass through what matters for cross-country wealth effects is a markup-adjusted terms of trade, the terms of consumption: $TOC_t \equiv TOT_t \left(\mu_{D,t}/\mu_{D,t}^* \right) \left(\mu_{X,t}^*/\mu_{X,t} \right)$. We now present analytical results for the closed economy and the open economy under the three alternative scenarios for the invoicing of export prices.

Closed Economy With fully rigid prices, the impact responses to a 1% increase in government spending for GDP, consumption, capital, and labor are given by

$$\hat{Y}_t^{closed} = \frac{s_G(1+\alpha)}{1 - 2s_I + \alpha}, \quad \hat{C}_t^{closed} = 0, \quad \hat{K}_t^{closed} = \frac{2s_G}{1 - 2s_I + \alpha}, \quad \hat{L}_t^{closed} = \frac{s_G}{1 - 2s_I + \alpha}.$$

Producer Currency Pricing. Under PCP, the Home export price is determined by $P_{X,t} = \epsilon_t P_D$ where P_D is the fixed price of domestic goods. The Foreign export price is given by $P_{X,t}^* = P_D^*/\epsilon_t$, where P_D^* is the fixed price of domestic goods in Foreign.

The impact responses to a 1% increase in government spending for the terms of trade and the terms of consumption are given by

$$\widehat{TOT}_t = \widehat{TOC}_t = \frac{s_G(2s_I\alpha_X + \alpha_X^g - 2s_I\alpha_X^g + \alpha\alpha_X^g)}{\Sigma_{TOC}^{PCP}},$$

where

$$\Sigma^{PCP}_{TOC} = 2\alpha_X^2[2s_I(1+\alpha-\phi)+(1-\phi)(s_G(1-2s_I+\alpha)-(1+\alpha))]+s_G\alpha_X^g(1-2s_I+\alpha)(1-2\phi(1-\alpha_X^g)) + \alpha_X[s_Gs_I(2+4\alpha_X^g-4\phi)+(1-2\phi)((1-2s_I+\alpha)-s_G(1+\alpha))].$$

In turn, the responses of other variables can be written as a function of the terms-of-consumption response and the variable's closed economy response:

$$\hat{Y}_t = \hat{Y}_t^{closed} - \frac{(2s_I\alpha\alpha_X + s_G\alpha_X^g(1+\alpha)}{1-2s_I+\alpha}\Sigma^{PCP}_{TOC}$$

$$\hat{C}_t = \hat{C}_t^{closed} + \alpha_X\Sigma^{PCP}_{TOC}$$

$$\hat{K}_t = \hat{K}_t^{closed} + \frac{\alpha_X(1-2s_I+\alpha)-2s_G\alpha_X^g}{1-2s_I+\alpha}\Sigma^{PCP}_{TOC}$$

$$\hat{L}_t = \hat{L}_t^{closed} - \frac{\alpha\alpha_X + s_G\alpha_X^g}{1-2s_I+\alpha}\Sigma^{PCP}_{TOC}$$

$$\hat{Y}_t^* = \frac{(2s_I\alpha\alpha_X + s_G\alpha_X^g(1+\alpha)}{1-2s_I+\alpha}\Sigma^{PCP}_{TOC}$$

$$\hat{C}_t^* = -\alpha_X\Sigma^{PCP}_{TOC}$$

$$\hat{K}_t^* = -\frac{\alpha_X(1-2s_I+\alpha)-2s_G\alpha_X^g}{1-2s_I+\alpha}\Sigma^{PCP}_{TOC}$$

$$\hat{L}_t^* = \frac{\alpha\alpha_X + s_G\alpha_X^g}{1-2s_I+\alpha}\Sigma^{PCP}_{TOC}$$

$$\hat{Q}_t = -(1-2\alpha_X)\Sigma^{PCP}_{TOC}.$$

Local Currency Pricing. Under LCP, the Home export price is fixed in Foreign currency, $P_{X,t} = P_X$, while the Foreign export price is fixed in Home currency, $P^*_{X,t} = P^*_X$.

The impact responses to a 1% increase in government spending for the terms of trade and the terms of consumption are given by

$$\widehat{TOC}_t = \underbrace{\frac{s_G(2s_I(\alpha_X-\alpha_X^g)+\alpha_X^g(1+\alpha))}{(1+\alpha-s_I(2-4\alpha_X))(s_G(\alpha_X-\alpha_X^g)-\alpha_X)}}_{\Sigma^{LCP}_{TOC}},$$

$$\widehat{TOT}_t = -\widehat{TOC}_t.$$

In turn, the responses of other variables can be written as a function of the terms-of-consumption response and the variable's closed economy response:

$$\hat{Y}_t = \hat{Y}_t^{closed} - \frac{(1+\alpha)(s_G(\alpha_X - \alpha_X^g) - \alpha_X)}{1 - 2s_I + \alpha}\Sigma_{TOC}^{LCP}$$

$$\hat{K}_t = \hat{K}_t^{closed} - \frac{2(s_G(\alpha_X - \alpha_X^g) - \alpha_X)}{1 - 2s_I + \alpha}\Sigma_{TOC}^{LCP}$$

$$\hat{L}_t = \hat{L}_t^{closed} - \frac{s_G(\alpha_X - \alpha_X^g) - \alpha_X}{1 - 2s_I + \alpha}\Sigma_{TOC}^{LCP}$$

$$\hat{Y}_t^* = \frac{2s_I(s_G(\alpha_X - \alpha_X^g) - \alpha_X)}{1 - 2s_I + \alpha}\Sigma_{TOC}^{LCP}$$

$$\hat{K}_t^* = \frac{2(s_G(\alpha_X - \alpha_X^g) - \alpha_X)}{1 - 2s_I + \alpha}\Sigma_{TOC}^{LCP}$$

$$\hat{L}_t^* = \frac{s_G(\alpha_X - \alpha_X^g) - \alpha_X}{1 - 2s_I + \alpha}\Sigma_{TOC}^{LCP}$$

$$\hat{Q}_t = -\Sigma_{TOC}^{LCP}.$$

with the exception of consumption, which always equals its closed economy response:

$$\hat{C}_t = \hat{C}_t^{closed}, \quad \hat{C}_t^* = 0.$$

Dominant Currency Pricing. Under DCP, the Home export price is fixed in Foreign currency, $P_{X,t} = P_X$, while the Foreign export price is given by $P_{X,t}^* = P_D^*/\epsilon_t$, where P_D^* is the fixed price of domestic goods in Foreign.

The impact responses to a 1% increase in government spending for the terms of trade and the terms of consumption are given by

$$\widehat{TOT}_t = 0,$$

$$\widehat{TOC}_t = \underbrace{\frac{-s_G(2s_I(\alpha_X - \alpha_X^g) + \alpha_X^g + \alpha\alpha_X^g)}{\alpha_X^2(1 - s_G + \alpha(1 - s_G - 2s_I)) + \phi(1 - 2s_I + \alpha)(\alpha_X(1 - s_G)(1 - \alpha_X) + s_G\alpha_X^g(1 - \alpha_X^g))}}_{\Sigma_{TOC}^{DCP}}.$$

In turn, the responses of domestic variables can be written as a function of the terms-of-consumption response and the variable's closed economy response:

$$\hat{Y}_t = \hat{Y}_t^{closed} + \frac{\alpha_X(1 - s_G + \alpha(1 - s_G - 2s_I))}{1 - 2s_I + \alpha}\Sigma_{TOC}^{DCP},$$

$$\hat{C}_t = \hat{C}_t^{closed} + \alpha_X \Sigma_{TOC}^{DCP},$$

$$\hat{K}_t = \hat{K}_t^{closed} + \frac{\alpha_X (3 - 2s_G - 2s_I - \alpha)}{1 - 2s_I + \alpha} \Sigma_{TOC}^{DCP},$$

$$\hat{L}_t = \hat{L}_t^{closed} + \frac{\alpha_X (1 - s_G - \alpha)}{1 - 2s_I + \alpha} \Sigma_{TOC}^{DCP}.$$

The foreign economy does not respond to the shock:

$$\hat{Y}_t^* = 0, \quad \hat{C}_t^* = 0,, \quad \hat{K}_t^* = 0, \quad \hat{L}_t^* = 0.$$

$$\hat{Q}_t = -(1 - \alpha_X) \Sigma_{TOC}^{DCP}.$$

B Alternative Specifications for the Analytical Model

In this section, we present additional sensitivity analysis for the analytical model of section 2.

B.1 Dynamic vs. Instantaneous Capital

Introducing capital (either assuming instantaneous adjustment or time to build) implies terms-of-trade dynamics no longer affect output solely through the wealth effect on labor supply, but also through investment dynamics. This channel is crucial to understand the response of output and operates regardless of the timing of capital accumulation.

Dynamic capital adjustment introduces two modifications to the model of section 2. First, there is a dynamic capital accumulation equation:

$$K_t = (1 - \delta_K) K_{t-1} + I_t. \tag{3}$$

Second, there is an Euler equation for investment:

$$1 = \beta E_t \left(\frac{C_{t+1}}{C_t} \right)^{-\gamma} \left[(1 - \tau_{t+1}) r_{K,t+1} + 1 - \delta_K \right]. \tag{4}$$

Figure A.4 illustrates this point by plotting the responses of output following a 1% increase in government spending for three alternative models: 1) labor as the only input, 2) the baseline model of the paper (instantaneous capital adjustment), and 3) standard dynamic capital accumulation. To generate the figure, we assume $\tau = 0.25$, $G/Y = 0.2$, $\omega = 1$, and a steady-state trade share equal to 0.5. When labor is the only input in production, we set $\alpha = 0$. For the models featuring capital in the production function, we set $\alpha = 0.3$. Additionally, in the model with dynamic capital adjustment, we set capital depreciation $\delta = 0.025$ and $\beta = 0.99$.

As shown in the figure, the relationship between the open- and closed-economy output responses is qualitatively different with or without capital. When there is no capital, a terms-of-trade appreciation leads output to decrease relative to the closed economy. The reverse is true when capital is present—regardless of the assumption on the timing of capital accumulation.

B.2 Proposition 1 with a Non-Unitary Frisch Elasticity

In Proposition 1 of the main paper, the terms of trade appreciate following a government spending shock only provided $s_I < s_C$. If one interprets the model with instantaneous capital adjustment as a model with intermediate inputs, the restriction $s_I < s_C$ is not empirically plausible. In this alternative interpretation of the model, s_I represents the share of materials relative to output. Here we show it is sufficient to relax the restriction of a unitary Frisch elasticity ($\omega = 1$) to ensure the open-economy output response can be larger than the closed-economy response even when $s_I > s_C$.

As in Proposition 1 of the main paper, we continue to assume $\phi = 1$, $\alpha_X^g = 0$, financial autarky, and lump-sum transfer financing. As in the baseline version, the terms of trade remain a sufficient statistic for the response of all variables relative to a closed economy. Following a shock to government spending, the response of the terms of trade is:

$$\widehat{TOT}_t = \underbrace{\frac{s_G(1-\alpha)(\omega s_C - s_I)}{[s_G^2\omega(1-\alpha) + (1-s_I)(1+\alpha(2\alpha_X - 1))(1+\omega) + s_G\{2\alpha\alpha_X(1+\omega) + (1-\alpha)[(1+2\omega) - s_I(1+\omega)]\}]}}_{\Sigma_{G,TOT}} \hat{G}_t.$$

As long as $\omega > s_I/s_C$, the response of the terms of trade is positive. In turn, all other responses can be written as a function of the terms-of-trade response and their closed-economy counterpart response:

$$\hat{Y}_t = \hat{Y}_t^{closed} + \underbrace{\frac{s_C\alpha\alpha_X(1+\omega)}{(1-\alpha)(1-s_I+s_C\omega)}}_{>0} \Sigma_{G,TOT}\hat{G}_t,$$

$$\hat{C}_t = \hat{C}_t^{closed} + \underbrace{\frac{\alpha_X[(1-s_I)(1+\omega) - (s_G\omega(1-\alpha))]}{(1-\alpha)(1-s_I+s_C\omega)}}_{>0} \Sigma_{G,TOT}\hat{G}_t,$$

$$\hat{K}_t = \hat{K}_t^{closed} + \underbrace{\frac{\alpha_X(1-s_G\alpha - s_I + s_C\omega)}{(1-\alpha)(1-s_I+s_C\omega)}}_{>0} \Sigma_{G,TOT}\hat{G}_t,$$

$$\hat{Y}_t^* = -\underbrace{\frac{s_C \alpha \alpha_X (1+\omega)}{(1-\alpha)(1-s_I+s_C\omega)}}_{>0} \Sigma_{G,TOT}\hat{G}_t,$$

$$\hat{C}_t^* = -\underbrace{\frac{\alpha_X[(1-s_I)(1+\omega)-(s_G\omega(1-\alpha))]}{(1-\alpha)(1-s_I+s_C\omega)}}_{>0} \Sigma_{G,TOT}\hat{G}_t$$

$$\hat{K}_t^* = -\underbrace{\frac{\alpha_X(1-s_G\alpha-s_I+s_C\omega)}{(1-\alpha)(1-s_I+s_C\omega)}}_{>0} \Sigma_{G,TOT}\hat{G}_t.$$

The derivations above show $\hat{Y}_t > \hat{Y}_t^{closed}$ can occur when $s_I > s_C$.

B.3 Analytical Model without Capital

When $\alpha = 0$ there is no capital in the model, and the responses of labor and output are identical. In this case, the terms of trade remain a sufficient statistic for the effects on output and consumption. In addition, an improvement in the terms of trade continue to crowd in private consumption relative to the closed economy. However, when labor is the only input, the wealth effect induced by a terms-of-trade movement only operates through the labor supply margin. In turn, this is crucial for shaping the output response. We now illustrate this point.

Proposition A below considers the same parameter restrictions of Proposition 1 in the main paper: full home bias in public spending ($\alpha_X^g = 0$) and a unitary trade elasticity ($\phi = 1$) together with $\alpha = 0$.

Proposition A *Let s_G denote the steady-state share of government spending relative to GDP and τ denote the income tax rate. Assume a unitary trade elasticity ($\phi = 1$), full home bias in government spending ($\alpha_X^g = 0$), a zero capital share ($\alpha = 0$), financial autarky, and lump-sum transfer financing. Following a fiscal expansion at Home:*

1. *The response of the terms of trade is given by:*

$$\widehat{TOT}_t = \frac{s_G}{2-s_G}\hat{G}_t + \frac{\tau}{(2-s_G)(1-\tau)}\hat{\tau}_t.$$

It follows that:

(a) For an increase in government spending, $\widehat{TOT}_t > 0$.

(b) For a decrease in income taxes, $\widehat{TOT}_t < 0$.

2. *Provided $\widehat{TOT}_t > 0$, it follows that*

   (a) *In the Home economy, $\hat{C}_t$ is increasing in openness (α_X); $\hat{Y}_t$ and $\hat{L}_t$ are equal to their closed economy responses.*

   (b) *In the Foreign economy, $\hat{C}_t^*$ is decreasing in openness (α_X); $\hat{Y}_t^* = \hat{L}_t^* = 0$.*

   (c) *The real exchange rate appreciates only when $\alpha_X < 0.5$.*

Proposition A shows a terms-of-trade appreciation crowds in domestic consumption relative to the closed economy, as in the model with physical capital. However, the response of domestic hours is identical in open and closed economies ($\hat{L}_t = \hat{L}_t^{closed}$), and foreign hours are constant ($\hat{L}_t^* = 0$). Both results depend on the assumption of logarithmic utility in consumption coupled with full home bias in government consumption ($\alpha_X^g = 0$). Domestic hours are not affected by trade openness because logarithmic utility implies that $\hat{L}_t$ is proportional to $\hat{G}_t$. Since $\hat{G}_t = \hat{G}_{D,t}$ when $\alpha_X^g = 0$, it follows that labor responds the same way in open and closed economies. By the same token, foreign hours are constant as income and substitution effects in foreign hours supply exactly offset each other in the absence of foreign fiscal shocks (i.e., $\hat{G}_t^* = 0$).

Next, we relax the assumption of full home bias in public spending and a unitary trade elasticity.

Proposition B *Assume a zero capital share ($\alpha = 0$), financial autarky, and lump-sum transfer financing. Following a Home fiscal expansion, provided $\widehat{TOT}_t > 0$, it follows that:*

1. *In the Home economy, $\hat{C}_t$ is increasing in openness (α_X); $\hat{Y}_t = \hat{L}_t$ is decreasing in openness (α_X).*

2. *In the Foreign economy, $\hat{C}_t^*$ is decreasing in openness (α_X); $\hat{Y}_t^* = \hat{L}_t^*$ is decreasing in openness (α_X).*

3. *The real exchange rate appreciates only when $\alpha_X < 0.5$.*

Proposition B shows when $\alpha_X^g > 0$, the wealth effect induced by a terms-of-trade appreciation leads to a decline in the labor supply relative to the closed economy since $G_t \neq G_{D,t}$. As a result, output declines following an increase in public spending. See the end of this subsection for the proof.

We now show absent the wealth effect on the labor supply, the response of output fully realigns with Proposition 1 in the paper: a terms-of-trade appreciation crowds in domestic output relative to the closed economy, even when labor is the only production input. We illustrate this point by considering an alternative preference structure that features non-separability in consumption and labor as in Greenwood et al. (1988). We modify the household's utility function by assuming $E_0 \left\{ \sum_{t=0}^{\infty} \beta^t \left[\log \left(C_t - \frac{L_t^{1+\omega}}{1+\omega} \right) \right] \right\}$. This alternative preference structure affects the first-order condition for hours supply, which is now given by $L_t^{\omega} = (1 - \tau_t)\, \rho_{D,t}$, since $w_t = \rho_{D,t}$. As in the baseline model, we assume a unitary Frisch elasticity.

Proposition C *Assume a zero capital share ($\alpha = 0$), financial autarky, and lump-sum transfer financing. Following a Home fiscal expansion, provided $\widehat{TOT}_t > 0$ and zero wealth effect on the labor supply, it follows that:*

1. *In the Home economy, $\hat{Y}_t$, $\hat{L}_t$ and $\hat{C}_t$ are increasing in openness (α_X).*
2. *In the Foreign economy, $\hat{Y}_t^*$, $\hat{L}_t^*$ and $\hat{C}_t^*$ are decreasing in openness (α_X).*
3. *The real exchange rate appreciates only when $\alpha_X < 0.5$.*

Proposition C—proved at the end of this subsection—shows when the wealth effect on the labor supply is eliminated, the output response is reversed: a terms-of-trade appreciation crowds in domestic output relative to the closed economy. In this case, following an increase in public spending, the labor supply responds only to the relative price of the Home good, $\rho_{D,t}$. When this relative price increases, the Home terms of trade improve and households supply more labor. Following a tax cut, the reduction in $\hat{\tau}_t$ directly increases the labor supply. Whether $\hat{L}_t > \hat{L}_t^{closed}$ depends on whether $\hat{\rho}_{D,t}$ (and thus the terms of trade) declines in equilibrium.

Proof. Proof of Propositions A, B, and C

Separable Preferences (as in the Main Paper). The closed-economy responses are given by:

$$\hat{Y}_t^{closed} = \frac{s_G}{2 - s_G} \hat{G}_t + \frac{\tau(1 - s_G)}{(2 - s_G)(\tau - 1)} \hat{\tau}_t, \quad \hat{C}_t^{closed} = \frac{-s_G}{2 - s_G} \hat{G}_t + \frac{\tau}{(2 - s_G)(\tau - 1)} \hat{\tau}_t.$$

Following a shock to government spending, the response of the terms of trade is:

$$\widehat{TOT}_t = \underbrace{\frac{s_G(\alpha_X(s_G - 1) + \alpha_X^g(s_G - 2))}{2\alpha_X^2(s_G - 2)(s_G - 1)(\phi - 1) + \alpha_X(s_G - 1)(s_G(1 + 2\alpha_X^g) - 2 + 2\phi(2 - s_G)) - s_G\alpha_X^g(s_G - 2)(1 + 2\phi(\alpha_X^g - 1))}}_{\Sigma_{G,TOT}} \hat{G}_t.$$

When $\alpha_X^g = 0$ and $\phi = 1$, the above expression reduces to the one in Proposition A. In turn, each variable's response can be written as a function of the terms-of-trade response and its closed-economy counterpart:

$$\hat{Y}_t = \hat{Y}_t^{closed} + \underbrace{\frac{s_G \alpha_X^g}{s_G - 2}}_{<0} \Sigma_{G,TOT} \hat{G}_t, \quad \hat{C}_t = \hat{C}_t^{closed} + \underbrace{\alpha_X - \frac{s_G \alpha_X^g}{s_G - 2}}_{>0} \Sigma_{G,TOT} \hat{G}_t,$$

$$\hat{Y}_t^* = -\underbrace{\frac{s_G \alpha_X^g}{s_G - 2}}_{<0} \Sigma_{G,TOT} \hat{G}_t, \quad \hat{C}_t^* = -\underbrace{\alpha_X - \frac{s_G \alpha_X^g}{s_G - 2}}_{>0} \Sigma_{G,TOT} \hat{G}_t.$$

It follows that whether domestic responses are higher or lower relative to the closed economy responses depends on the response of the terms of trade. Likewise, whether foreign spillovers are positive or negative depends on the response of the terms of trade. In contrast, the response of the real exchange rate is given by:

$$\hat{Q}_t = -(1 - 2\alpha_X) \Sigma_{G,TOT} \hat{G}_t,$$

whose sign depends on the response of the terms of trade, as well as whether $\alpha_X < 1/2$.

Following a shock to the income tax rate, the response of the terms of trade is given by:

$$\widehat{TOT}_t = -\underbrace{\frac{\alpha_X \tau (1 - s_G)}{(1-\tau)(2\alpha_X^2 (s_G - 2)(s_G - 1)(\phi - 1) + \alpha_X (s_G - 1)(s_G(1 + 2\alpha_X^g) - 2 + 2\phi(2 - s_G)) - s_G \alpha_X^g (s_G - 2)(1 + 2\phi(\alpha_X^g - 1)))}}_{\Sigma_{\tau,TOT}} \hat{\tau}_t.$$

In turn, all other variables' responses can be written as a function of the terms-of-trade response and each variable's closed economy response:

$$\hat{Y}_t = \hat{Y}_t^{closed} + \underbrace{\frac{s_G \alpha_X^g}{s_G - 2}}_{<0} \Sigma_{\tau,TOT} \hat{\tau}_t, \quad \hat{C}_t = \hat{C}_t^{closed} + \underbrace{\alpha_X - \frac{s_G \alpha_X^g}{s_G - 2}}_{>0} \Sigma_{\tau,TOT} \hat{\tau}_t,$$

$$\hat{Y}_t^* = -\underbrace{\frac{s_G \alpha_X^g}{s_G - 2}}_{<0} \Sigma_{\tau,TOT} \hat{\tau}_t, \quad \hat{C}_t^* = -\underbrace{\alpha_X - \frac{s_G \alpha_X^g}{s_G - 2}}_{>0} \Sigma_{\tau,TOT} \hat{\tau}_t,$$

$$\hat{Q}_t = -(1 - 2\alpha_X) \Sigma_{\tau,TOT} \hat{\tau}_t.$$

GHH Preferences. With GHH preferences, the closed economy responses are given by:

$$\hat{Y}_t^{closed} = \frac{\tau}{\tau - 1} \hat{\tau}_t, \quad \hat{C}_t^{closed} = \frac{s_G}{s_G - 1} \hat{G}_t + \frac{\tau}{(\tau - 1)(1 - s_G)} \hat{\tau}_t.$$

Following a shock to government spending, the response of the terms of trade is:

$$\widehat{TOT}_t = \underbrace{\frac{s_G(\alpha_X - \alpha_X^g)}{2\alpha_X^2(2 + s_G(\phi - 1) - \phi) + \alpha_X(s_G(1 + 2\alpha_X^g) - 1 + 2\phi(1 - s_G)) - s_G\alpha_X^g(1 + 2\phi(\alpha_X^g - 1))}}_{\Sigma_{G,TOT}} \hat{G}_t.$$

In turn, each variable's response can be written as a function of the terms-of-trade response and its closed-economy counterpart:

$$\hat{Y}_t = \hat{Y}_t^{closed} + \underbrace{\alpha_X}_{>0} \Sigma_{G,TOT}\hat{G}_t,$$

$$\hat{C}_t = \hat{C}_t^{closed} + \underbrace{\frac{\alpha_X(2 - s_G) + s_G\alpha_X^g}{1 - s_G}}_{>0} \Sigma_{G,TOT}\hat{G}_t,$$

$$\hat{Y}_t^* = -\underbrace{\alpha_X}_{>0} \Sigma_{G,TOT}\hat{G}_t,$$

$$\hat{C}_t^* = -\underbrace{\frac{\alpha_X(2 - s_G) + s_G\alpha_X^g}{1 - s_G}}_{>0} \Sigma_{G,TOT}\hat{G}_t,$$

$$\hat{Q}_t = -(1 - 2\alpha_X)\Sigma_{G,TOT}\hat{G}_t.$$

Similarly, following a shock to the income tax rate, the response of the terms of trade is given by:

$$\widehat{TOT}_t = -\underbrace{\frac{\alpha_X\tau}{(\tau - 1)(2\alpha_X^2(2 + s_G(\phi - 1) - \phi) + \alpha_X(s_g(1 + 2\alpha_X^g) - 1 + 2\phi(1 - s_G)) - s_G\alpha_X^g(1 + 2\phi(\alpha_X^g - 1)))}}_{\Sigma_{\tau,TOT}} \hat{\tau}_t.$$

In turn, all other variables' responses can be written as a function of the terms of trade response and each variable's closed economy response:

$$\hat{Y}_t = \hat{Y}_t^{closed} + \underbrace{\alpha_X}_{>0} \Sigma_{\tau,TOT}\hat{\tau}_t,$$

$$\hat{C}_t = \hat{C}_t^{closed} + \underbrace{\frac{\alpha_X(2 - s_G) + s_G\alpha_X^g}{1 - s_G}}_{>0} \Sigma_{\tau,TOT}\hat{\tau}_t,$$

$$\hat{Y}_t^* = -\underbrace{\alpha_X}_{>0} \Sigma_{\tau,TOT}\hat{\tau}_t,$$

$$\hat{C}_t^* = -\underbrace{\frac{\alpha_X(2-s_G)+s_G\alpha_X^g}{1-s_G}}_{>0}\Sigma_{\tau,TOT}\hat{\tau}_t,$$

$$\hat{Q}_t = -(1-2\alpha_X)\Sigma_{\tau,TOT}\hat{\tau}_t.$$

■

C Quantitative International Business Cycle Model

Household's First-Order Conditions

In the symmetric equilibrium, the real wage, $w_t \equiv w_t^n/P_t$, is a time-varying markup, $\mu_{w,t}$, over the marginal rate of substitution between hours and consumption: $w_t = \mu_{w,t}\bar{\beta}_t\bar{h}_t L_t^{\omega}/u_{C,t}(1-\tau_t^I)$, where $u_{C,t} \equiv (\bar{\beta}_t/(1+\tau_t^C))(\tilde{C}_t - h_c\tilde{C}_{t-1})^{-1}$. The household's wage markup is:

$$\mu_{w,t} \equiv \frac{\eta}{(\eta-1)\left(1-\frac{\nu_w}{2}\Delta_{W,t}^2\right)+\nu_w\left\{\begin{array}{c}\pi_{w,t}\Delta_{W,t}\left(1+\pi_{C,t-1}\right)^{-\iota_w}\\ -E_t\left[\beta_{t,t+1}\frac{(1+\pi_{w,t+1})^2}{1+\pi_{C,t+1}}\Delta_{W,t+1}\left(1+\pi_{C,t}\right)^{-\iota_w}\frac{L_{t+1}}{L_t}\right]\end{array}\right\}},$$

where $\pi_{w,t} \equiv w_t^n/w_{t-1}^n - 1$, $\Delta_{W,t} \equiv \frac{1}{\bar{z}}\frac{w_t^n}{w_{t-1}^n}\left(1+\pi_{C,t-1}\right)^{-\iota_w} - 1$, and $\beta_{t,t+1} \equiv \beta u_{C,t+1}/u_{C,t}$. Intuitively, the wage markup changes over time in order to smooth wage changes across periods.

The Euler equation for capital accumulation requires

$$\zeta_{K,t} = E_t\left\{\beta_{t,t+1}\left[r_{K,t+1}u_{K,t+1}\left(1-\tau_{t+1}^I\right) - \Psi(u_{K,t+1}^j) + \left(1-\delta_{t+1}\right)\zeta_{K,t+1}\right]\right\},$$

where $\zeta_{K,t}$ denotes the shadow value of capital (in units of consumption), defined by the first-order condition for investment I_t:

$$\rho_{I,t}\zeta_{K,t}^{-1} = \left[1-\frac{\nu_K}{2}\left(\frac{I_t}{I_{t-1}}-1\right)^2 - \nu_K\left(\frac{I_t}{I_{t-1}}-1\right)\left(\frac{I_t}{I_{t-1}}\right)\right]$$
$$+\nu_K\beta_{t,t+1}E_t\left[\frac{\zeta_{K,t+1}}{\zeta_{K,t}}\left(\frac{I_{t+1}}{I_t}-1\right)\left(\frac{I_{t+1}}{I_t}\right)^2\right].$$

The optimal condition for capital utilization implies: $\left(1-\tau_t^I\right)r_{K,t} = \Psi'(u_{K,t}^j)$.

The Euler equations for bond holdings are:

$$1 = (1 + i_t) E_t \left(\frac{\beta_{t,t+1}}{1 + \pi_{C,t+1}} \right), \quad 1 = (1 + i_t^*) \Gamma_t E_t \left(\frac{\beta_{t,t+1}}{1 + \pi_{C,t+1}^*} \frac{Q_{t+1}}{Q_t} \right),$$

where $a_{*,t} \equiv A_t / P_t^*$ denotes Home real holdings of Foreign bonds (in units of Foreign consumption).

C.1 Intermediate-Input Producers

Let φ_t be the real price (in units of final consumption) of the intermediate input. The Home firm chooses L_t and K_t to maximize the value of per-period profit: $\varphi_t Y_t^I - (w_t^n / P_t) L_t - r_{K,t} K_t$, where $w_t^n \equiv \left[\int_0^1 \left(w_{jt}^n \right)^{1-\eta} dj \right]^{1/(1-\eta)}$ is the nominal wage bill, and $r_{K,t}$ is the real rental rate of capital. The first-order condition for L_t 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 yields $\alpha \varphi_t Y_t^I / K_t = r_{K,t}$.

Final-Sector Producers

The representative producer chooses $P_{D,t}^i$ and $P_{X,t}^i$ in order to maximize the expected present discounted value of the stream of real profits $E_t \sum_{s=t}^{\infty} \beta_{s,t} d_s^i$, where

$$d_t^i = \begin{array}{l} \left\{ \left[1 - \frac{\nu_T}{2} \left(\frac{P_{D,t}^i}{P_{D,t-1}^i} (1 + \pi_{C,t-1})^{-\iota_p} - 1 \right)^2 \right] \frac{P_{D,t}^i}{P_t} - \varphi_t \right\} Y_{D,t}^i \\ + \left\{ \left[1 - \frac{\nu_T}{2} \left(\frac{P_{X,t}^i}{P_{X,t-1}^i} \left(1 + \pi_{C,t-1}^* \right)^{-\iota_p} - 1 \right)^2 \right] \frac{\varepsilon_t P_{X,t}^i}{P_t} - \varphi_t \right\} Y_{X,t}^i \end{array}.$$

In the symmetric equilibrium, the real price of Home output for domestic sales, $\rho_{D,t} \equiv P_{D,t} / P_t$, is a time-varying markup $\mu_{D,t}$ over the marginal cost φ_t: $\rho_{D,t} = \mu_{D,t} \varphi_t$. The time-varying domestic markup, $\mu_{D,t}$, is given by:

$$\mu_{D,t} = \frac{\bar{\theta}_t}{\left(\bar{\theta}_t - 1 \right) \left(1 - \frac{\nu_T}{2} \Delta_{D,t}^2 \right) + \nu_T \left\{ \begin{array}{c} (1 + \pi_{D,t}) \Delta_{D,t} (1 + \pi_{C,t-1})^{-\iota_p} \\ -E_t \left[\beta_{t,t+1} \frac{(1+\pi_{D,t+1})^2}{1+\pi_{C,t+1}} \Delta_{D,t+1} (1 + \pi_{C,t})^{-\iota_p} \frac{Y_{D,t+1}}{Y_{D,t}} \right] \end{array} \right\}}, \quad (5)$$

where $\pi_{D,t} = P_{D,t} / P_{D,t-1} - 1$ and $\Delta_{D,t} \equiv (1 + \pi_{D,t}) (1 + \pi_{C,t-1})^{-\iota_p} - 1$. The real price of Home output for export sales $\rho_{X,t} \equiv P_{X,t} / P_t^*$ (in units of Foreign consumption) is a time-varying markup $\mu_{X,t}$ over the marginal cost of the export bundle φ_t: $\rho_{X,t} = \mu_{X,t} \varphi_t / Q_t$, where Q_t denotes the real exchange rate (units of Home consumption per unit of Foreign consumption). The time-varying export markup, $\mu_{X,t}$, is given by:

$$\mu_{X,t} = \frac{\bar{\theta}}{\left(\bar{\theta}-1\right)\left[1-\frac{\nu_T}{2}\Delta^2_{X,t}\right]+\nu_T\left\{\begin{array}{c}\left(1+\pi_{X,t}\right)\Delta_{X,t}\left(1+\pi^*_{C,t-1}\right)^{-\iota_p} \\ -E_t\left[\beta_{t,t+1}\frac{\left(1+\pi_{X,t+1}\right)^2}{1+\pi_{C,t+1}}\Delta_{X,t+1}\left(1+\pi^*_{C,t}\right)^{-\iota_p}\frac{Y_{X,t+1}}{Y_{X,t}}\right]\end{array}\right\}}, \quad (6)$$

where $\pi_{X,t} = P_{X,t}/P_{X,t-1}-1$ and $\Delta_{X,t} \equiv (1+\pi_{X,t})\left(1+\pi^*_{C,t-1}\right)^{-\iota_p}-1$. Price stickiness introduces endogenous markup variations both in the domestic and export markets.

Symmetric Equilibrium and Foreign Variables

Total domestic demand for the Home output basket, $Y_{D,t}$, is the sum of private-sector and government demand:

$$Y_{D,t} = \left[1-\frac{\nu}{2}\left(\Delta_{D,t}\right)^2\right]^{-1}\left[\left(1-\alpha_X\right)\rho_{D,t}^{-\bar{\phi}_t}C_t + \left(1-\alpha_X^{I_K}\right)\left(\frac{\rho_{D,t}}{\rho_{I_K,t}}\right)^{-\bar{\phi}_t} I_{K,t} + \left(1-\alpha_X^g\right)\left(\frac{\rho_{D,t}}{\rho_{G,t}}\right)^{-\bar{\phi}_t} G_t\right].$$

Similarly, total export demand is the sum of private-sector and government Foreign demand:

$$Y_{X,t} = \left[1-\frac{\nu}{2}\left(\Delta_{X,t}\right)^2\right]^{-1}\left[\alpha_X\rho_{X,t}^{-\bar{\phi}^*_t}C^*_t + \alpha_X^{I_K}\left(\frac{\rho_{X,t}}{\rho^*_{I_K,t}}\right)^{-\bar{\phi}^*_t} I^*_{K,t} + \alpha_X^g\left(\frac{\rho_{X,t}}{\rho^*_{G,t}}\right)^{-\bar{\phi}^*_t} G^*_t\right].$$

Goods market clearing requires $K_t^\alpha\left(\bar{Z}_tL_t\right)^{1-\alpha} = Y_{D,t}+Y_{X,t}$. The price index of private consumption implies: $1 = (1-\alpha_X)\rho_{D,t}^{1-\bar{\phi}_t} + \alpha_X\rho_{X,t}^{1-\bar{\phi}_t}$. Similarly, the price index of the investment good satisfies $\rho_{I_K,t}^{1-\bar{\phi}_t} = (1-\alpha_X^{I_K})\rho_{D,t}^{1-\bar{\phi}_t} + \alpha_X^{I_K}\rho_{X,t}^{1-\bar{\phi}_t}$, while the price index of government consumption satisfies $\rho_{G,t}^{1-\bar{\phi}_t} = (1-\alpha_X^g)\rho_{D,t}^{1-\bar{\phi}_t} + \alpha_X^g\rho_{X,t}^{1-\bar{\phi}_t}$.

Eight Foreign variables directly affect macroeconomic dynamics in the small open economy: C^*_t, i^*_t, $\pi^*_{C,t}$, $I^*_{K,t}$ G^*_t, $\rho^*_{X,t}$, $Y^*_{X,t}$. Foreign consumption, C^*_t, government consumption G^*_t, the nominal interest rate, i^*_t, and inflation, $\pi_t^{C^*}$, are determined by treating the rest of the world (Foreign) as a closed economy that features the same production structure, technology, and frictions that characterize the small open economy. To determine prices and quantities related to Foreign exports and imports, we assume that Foreign producers solve a profit maximization problem that is equivalent to that faced by Home producers.

D Prior-Predictive Analysis

Table A.1 lists our priors. We choose conventional prior distributions for all parameters that are standard in the Bayesian estimation literature (e.g. Lubik and Schorfheide, 2005, Forni et al., 2009, Justiniano and Preston, 2010, Leeper et al., 2010, and Drautzburg and Uhlig, 2015). We set the price and wage stickiness parameters, ν and ν_w, to reproduce a given frequency of price adjustment in a log-linearized Phillips curve using a Calvo parameter ξ.[1] Likewise, we set the wage stickiness parameter, ν_w, to reproduce the slope of the log-linearized wage Phillips curve derived using a Calvo parameter ξ_w and estimate ξ_w.[2]

Our prior means for the AR(1) coefficients for government spending, income and consumption tax processes are centered at 0.8, reflecting the high persistence in fiscal measures. For all other shocks, the priors for the AR(1) coefficients are fairly diffuse with a mean of 0.5 and standard deviation of 0.2.

Figure A.5 compares the difference in open- and closed-economy GDP present-value multipliers expressed at constant prices (top row), CPI units (middle row), and production units (bottom row). Quantitatively, the resulting range of multipliers are virtually identical across the three cases.

D.1 Two-Country Model

The two-country model consists of two large economies that feature symmetric preferences and technologies. Aside from modeling two large countries, the only difference relative to the baseline model is each country issues non-contingent bonds denominated in domestic currency that are traded internationally. All remaining model features are the same. In particular, we assume (i) the same prior distributions as in table A.1 and (ii) dominant currency (i.e., Foreign currency) pricing of exports.

Figure A.6 displays the difference in open- and closed-economy present-value multipliers and select impulse responses from the prior-predictive analysis in the two-large country framework. The size and sign of the responses are similar to the baseline model.

[1] The parameter ξ is related to ν via the mapping $\nu = \left[\left(\bar{\theta}-1\right)/\bar{\theta}\right]\xi/(1-\xi)(1-\xi\beta)$.

[2] The parameter ξ_w is related to ν_w via the mapping $\nu_w = \xi_w(\eta_w - 1)(1+\eta_w\omega)/\left[(1-\xi_w)(1-\xi_w\beta)\right]$.

E Estimation Details for Canada and U.S.

E.1 Data Description

The following data series are taken from the Federal Reserve Economic Data (FRED), U.S. Bureau of Economic Analysis (BEA), and Statistics Canada CANSIM database. Exact sources are listed below.

1. **CPI**

   Canada: Core CPI (CANSIM Table 176-0003), log transformed and first differenced to get domestic consumer inflation.

   U.S.: Core CPI (FRED Series CPILFESL), log transformed and first differenced to get domestic consumer inflation.

2. **Population**

   Canada: total population (CANSIM Table 051-0005).[3]

   U.S.: total civilian non-institutional population (series CNP16OV from FRED database).

3. **GDP**

   Canada: Gross domestic product at market prices (CANSIM Table 380-0064), deflated with CPI, divided by population, and log transformed.

   U.S.: Gross domestic product (BEA Table 1.1.5), deflated with CPI, divided by population, and log transformed.

4. **Consumption**

   Canada: Household final consumption expenditure at market prices on nondurables and services (CANSIM Table 380-0064), deflated with CPI, divided by population, and log transformed.

   U.S.: Personal consumption expenditures on nondurables and services (BEA Table 1.1.5, lines 5 and 6), deflated with CPI, divided by population, and log transformed.

5. **Investment**

   Canada: The sum of business gross fixed capital formation, investment in inventories, and

[3] A quarterly data series for working age population (15-64) is available from the OECD only starting in 1994. These two series correlation is above 0.99. Population by age groups is available at annual frequency in CANSIM.

household final consumption expenditure on durables and semidurables (CANSIM Table 380-0064), deflated with CPI, divided by population, and log transformed.

U.S.: Gross private domestic investment and personal consumption expenditures on durables (BEA Table 1.1.5, lines 4 and 7), deflated with CPI, divided by population, and log transformed.

6. **Government Spending**

   Canada: General governments final consumption expenditure plus gross fixed capital formation (CANSIM Table 380-0064), deflated with CPI, divided by population, and log transformed. Our observable takes the difference in log of this series and GDP.

   U.S.: Government consumption expenditures and gross investment (BEA Table 1.1.5, line 22), deflated with CPI, divided by population, and log transformed. Our observable takes the difference in log of this series and GDP.

7. **Income Tax Revenue**

   Canada: The sum of general government revenue on taxes on income, contributions to social insurance plans, and the sum of other current transfers (CANSIM Table 380-0080), deflated with CPI, divided by population, and log transformed. Our observable takes the difference in log of this series and GDP.

   U.S.: Taxes on production and imports (BEA Table 3.1), deflated with CPI, divided by population, and log transformed. Our observable takes the difference in log of this series and GDP.

8. **Consumption Tax Revenue**

   Canada: General government tax revenue on production and imports (CANSIM Table 380-0080), deflated with CPI, divided by population, and log transformed. Our observable takes the difference in log of this series and GDP.

   U.S.: The sum of personal current taxes, taxes on corporate income, contributions for government social insurance, and taxes from the rest of the world (BEA Table 3.1), deflated with CPI, divided by population, and log transformed. Our observable takes the difference in log of this series and GDP.

9. **Government Debt**

   Canada: General government market value of net financial assets (CANSIM Table 378-0121), multiplied by a minus sign, deflated with CPI, divided by population, and log transformed. Our observable takes the difference in log of this series and GDP.

U.S.: The end of period value of market debt (FRED series MVGFD027MNFRBDAL), deflated with CPI, divided by population, and log transformed. Our observable takes the difference in log of this series and GDP.

10. **Hours Worked**

    Canada: Hours worked for total economy (CANSIM Table 383-0012), divided by population and log transformed.

    U.S.: Economy-wide total hours (BLS, www.bls.gov/lpc/special_requests/us_total_hrs_emp.xlsx), divided by population and log transformed.

11. **Interest Rate**

    Canada: The quarterly average of interest rates on Treasury Bills for Canada divided by 4 (FRED series INTGSTCAM193N).

    U.S.: The quarterly average of daily figures of the Federal Funds Rate (from the Board of Governors of the Federal Reserve System) divided by 4.

12. **Real Exchange Rate (Can/U.S.$)**

    Nominal bilateral exchange rate (series DEXCAUS from FRED database) multiplied by U.S. CPI and divided by Canadian CPI. The series is log transformed.

13. **U.S. Exports to Canada**

    We seasonally adjust the monthly figures of U.S. trade in goods with Canada reported by the Census Bureau and take quarterly averages. The series is then deflated with CPI, divided by population, and log transformed.

14. **U.S. Imports from Canada**

    We seasonally adjust the monthly figures of U.S. trade in goods with Canada reported by the Census Bureau and take quarterly averages. The series is then deflated with CPI, divided by population, and log transformed.

E.2 Dogmatic Priors

For the estimation, we fix some steady-state values to match sample averages for the U.S. and Canada. We set the steady-state total trade to GDP ratio to 35 percent, consistent with bilateral trade data between the U.S. and Canada. In addition, we set the import intensity of public consumption to be 1/3 that of private consumption, and the import intensity of investment to be 4/3 that of private consumption, consistent with historical measures of Canadian import shares from Dion et al. (2005) and the World Bank.

Steady-state fiscal variables are calibrated to the mean values from Canadian and U.S. data for the general government over the estimation sample. Government consumption as a share of GDP is set to 0.22 in Canada and 0.18 in the U.S. The annualized market-value of government debt to GDP ratio is set to 0.73 in Canada and 0.61 in the U.S. Consumption and income tax rates are set to match average consumption and income tax rates, 0.14 and 0.25 respectively for Canada and 0.12 and 0.27 respectively for the U.S.

Finally, as is common practice in the literature, we normalize the shocks to investment, hours, lump-sum transfers, and the elasticity of substitution between home and foreign goods to enter with a unitary coefficient in the log-linearized equations that determine investment, wages, and government debt, as well as the equation that defines exports.

E.3 Estimation Details & Posterior Parameter Estimates

We use Bayesian methods, whereby the data are used to update our priors through the likelihood function, calculated using the Kalman filter. These updates give us draws from the posterior distribution. We take 1.5 million draws from the posterior distribution using the random walk Metropolis-Hastings algorithm. For inference, we discard the first 500,000 draws and keep one out of 100 draws to obtain a sample of 10,000, equivalent to our prior-predictive sample.[4]

Table A.2 displays the posterior mean and 90 percent credible sets for parameters. Posterior credible sets are tighter than the priors, and in line with estimates from the literature. Public and private goods in the U.S. are complements, as in Bouakez and Rebei (2007) and Fève et al. (2013). For Canada, the 90-percent posterior interval includes zero, suggesting public and private goods are neither substitutes nor complements. The elasticity of substitution between Home and Foreign goods is tightly estimated to be around one. Lubik and Schorfheide (2005) show estimates of this parameter are sensitive to its prior when bilateral exports and imports are not included as observables. In contrast, we find the data to be informative about this parameter once including imports and exports as observables.

[4]Our step size implies an acceptance rate of 28 percent. Diagnostics to determine chain convergence include cumulative sum of the draws (CUMSUM) statistics and Geweke's Separated Partial Means (GSPM) test.

E.4 Estimation Fit

Figure A.7 plots correlograms for cross-country correlations from the data (solid lines) and the 90-percent posterior intervals for the estimated model (shaded areas).[5] The figure demonstrates the model is able to account for the international comovement. Figure A.8 plots correlograms from the data (solid lines) and the 90-percent posterior intervals (shaded areas) implied by the estimated model for Canadian series, while figure A.9 plots the same series for the U.S. Both figures demonstrate the model is also able to account for a wide range of correlations of macroeconomic time series in Canada and the U.S. Table A.3 reports standard deviations from the data and 90 percent posterior intervals for the estimated model. The data counterparts lie within the model's posterior bands for almost all reported series.

Finally, table A.4 reports the forecast error variance decompositions at the posterior mean estimates for the observables, as well as the growth rate of the nominal exchange rate and GDP. We report the forecast error variance decompositions after 10 quarters, capturing business cycle frequency dynamics. Given the assumption that Canada is a small open economy relative to the U.S., the latter is not influenced by Canadian and international shocks by construction (with the exception of U.S. imports and exports).

E.5 Additional Posterior Results

Figure A.10 plots the levels of present-value multipliers in Canada and the U.S. implied by the posterior estimates. The shaded regions denote the 90 percent confidence intervals. Figures A.11 and A.12 present the responses of Canadian variables to a 1% increase in government spending and a 1% decrease in income taxes, respectively.

Finally, we present an alternative approach to comparing open vs. closed economy multipliers. Since the Foreign economy is modeled as a closed-economy, one can directly compare Home and Foreign multipliers if the two countries have a symmetric parametrization. Thus, we take our posterior parameter estimates for Canada and force a symmetric parametrization for Home (e.g., Canada) and Foreign (e.g., Canada counterfactually closed). Next, we calculate the multipliers following a 1% shock to government spending or taxes at Home and, separately, the same shocks in Foreign. Figure A.13 presents the posterior 90 percentile intervals of the difference in the Home

[5] We sample 5,000 draws from the posterior. For each draw, we simulate 100 samples from the model with the same length as our dataset, after first discarding 100 initial observations. We compute statistics for each of these samples.

and Foreign present-value GDP multipliers (calculated in consumption units and constant-price units). The differences are similar to those from our original calculation, demonstrating that the results are not driven by the asymmetries in parameter estimates between Canada and the U.S.

F Robustness of Estimation Results

F.1 Longer Sample

To examine the sensitivity of the results to the sample size, we re-estimate the model using data from 1992-2017.[6] The last columns of table A.2 list the parameter estimates in this case; most parameter estimates are comparable to the shorter sample, in particular the trade elasticity ϕ. Figure A.14 presents the 90-percent posterior intervals for present-value multipliers and select impulse responses for this case. The figure shows the results of the paper are robust to using the longer sample (and even strengthened).

F.2 Terms of Consumption as an Observable

In this section, we consider the sensitivity of the results to including a measure of the terms of consumption among the observables. In the model, $TOC_t = P_{D,t}/P^*_{X,t}$. For $P_{D,t}$ we use the producer price index for Canada excluding energy. For $P^*_{X,t}$, we use the model linkage $P^*_{X,t} = (P^*_{D,t}\varepsilon_t)$. For $P^*_{D,t}$, we use the U.S. producer price index for total manufacturing industries (St. Louis Fed FRED database ID: PCUOMFGOMFG), and ε_t is the quarterly average nominal exchange rate between Canada and the U.S. (St. Louis Fed FRED database ID: DEXCAUS). We normalize the Canadian and U.S. producer price series so that 2002Q1 = 100. We allow for measurement error for the terms of consumption, since the U.S. producer price series in the data is not perfectly aligned with the model—a specific U.S. price index for exports to Canada is not available.

Table A.5 lists the posterior parameter estimates in this case, while figure A.15 displays 90-percent posterior probability bands for select differences in open- and closed-economy present-value multipliers and impulse responses. While posterior estimates of many shock processes change (for instance, the standard deviations of the risk premium shock and price markup shocks), the estimates of the structural parameters are similar to the baseline estimation. This in turn explains

[6] We note that the sample starts in 1992 because 1) some of the Canadian fiscal data are only available since 1990 and 2) Canada changed its monetary policy framework in 1991, adopting an inflation targeting regime.

why the present-value multipliers and impulse responses are robust to the inclusion of the terms-of-consumption observable.

F.3 U.S.-Euro Area Estimation

To examine the robustness of the results to a different country pair, we estimate the model for the U.S. and the Euro Area (E.A.). To do so, we make a few modifications to the model to make it in-line with the E.A.-U.S. data: we assume export prices are set in the producer's currency in each country.

We target steady-state values using data for the E.A. and U.S. We set the steady-state trade-to-GDP ratio to 12 percent, consistent with the average bilateral trade data between the U.S. and E.A. In addition, we set the import intensity of public consumption to be 0.2 that of private consumption, and the import intensity of investment to be 4/3 that of private consumption, consistent with historical measures of U.S. import shares (we calibrate the same values for the E.A. and the U.S.).

Steady-state fiscal variables are calibrated to the mean values from the E.A. and U.S. data for the general government over the estimation sample. See below for more details on the data sources. Government consumption as a share of GDP is set to 0.23 in the E.A. and 0.18 in the U.S. The annualized market-value of government debt to GDP ratio is set to 0.69 in the E.A. and 0.61 in the U.S. Consumption and income tax rates are set to match average consumption and income tax rates, 0.28 and 0.30 respectively for the E.A. and 0.12 and 0.27 respectively for the U.S. We estimate the model using the same priors and procedure as outlined in section E.

F.3.1 Data

We use the following data series to construct observable variables. U.S. series are defined the same as in the estimation for Canada-U.S. (see section E.1). Sources for the Euro Area variables include Fagan et al. (2001) (henceforth AWM database) and Paredes et al. (2009) (henceforth fiscal database).

1. **CPI**

   E.A.: consumer deflator (AWM series ID PCD), log transformed and first differenced to get domestic consumer inflation.

2. **Population**

E.A.: total population (series SPPOPTOTLEMU from FRED database); linearly interpolated annual series to get quarterly values).

3. **GDP**

   E.A.: Gross domestic product at market prices chained linked 1995 (AWM series ID YER), divided by population, and log transformed.

4. **Consumption**

   E.A.: Individual consumption expenditure at market prices chained linked 1995 (AWM series ID PCR), divided by population, and log transformed.

5. **Investment**

   E.A.: Gross fixed capital formation at market prices chained linked 1995 (AWM series ID ITR), divided by population, and log transformed.

6. **Government Spending**

   E.A.: General government consumption and investment (fiscal series IDs GCN and GIN), deflated with CPI, divided by population, and log transformed. Our observable takes the difference in log of this series and GDP.

7. **Income Tax Revenue**

   E.A.: Direct taxes and social security contributions (fiscal series IDs DTX and SCT), deflated with CPI, divided by population, and log transformed. Our observable takes the difference in log of this series and GDP.

8. **Consumption Tax Revenue**

   E.A.: Indirect taxes (fiscal series ID TIN), deflated with CPI, divided by population, and log transformed. Our observable takes the difference in log of this series and GDP.

9. **Government Debt**

   E.A.: General government debt (fiscal series ID MAL), deflated with CPI, divided by population, and log transformed. Our observable takes the difference in log of this series and GDP.

10. **Hours Worked**

    E.A.: Total employment (AWM series ID LNN), divided by population and log transformed.

11. **Real Wages**

    E.A.: Wages per head (AWM series ID WRN), divided by CPI and log differenced.

12. **Interest Rate**

    E.A.: nominal short-term interest rate, Euribor 3 month, divided by 4 (AWM series ID STN).

13. **Real Exchange Rate (E.A./U.S.$)**

    Nominal bilateral exchange rate (AWM series ID EXR) multiplied by U.S. CPI and divided by E.A. CPI. The series is log transformed.

14. **U.S. Exports to E.A.**

    We seasonally adjust the monthly figures of U.S. trade in goods with E.A. reported by the Census Bureau and take quarterly averages. The series is then deflated with CPI, divided by population, and log transformed.

15. **U.S. Imports from E.A.**

    We seasonally adjust the monthly figures of U.S. trade in goods with E.A. reported by the Census Bureau and take quarterly averages. The series is then deflated with CPI, divided by population, and log transformed.

F.3.2 Posterior Results

Table A.6 lists the posterior parameter estimates while figures A.16 and A.17 display 90-percent posterior probability bands for difference in open- and closed-economy present-value multipliers for the E.A. and U.S., respectively. Qualitatively, the results are similar to the U.S.-Canada application: government spending multipliers are higher than in a counterfactually closed economy (formally defined as $\alpha_X = \alpha_X^g = \alpha_X^I = \alpha_X^* = \alpha_X^{g^*} = \alpha_X^{I^*} = 0$) for both the E.A. and U.S., while the reverse is true for income tax multipliers. Quantitatively, the difference between open- and closed-economy multipliers is smaller relative to the estimates for Canada. This difference is mainly due to the lower bilateral trade share between the E.A. and U.S.—weaker trade linkages dampen the wealth effect associated with terms-of-consumption fluctuations—and the assumption of producer currency pricing. A caveat to interpreting these results is that the E.A.-U.S. analysis holds trade with the rest of the world constant. We note this is a lesser important issue when studying Canada and the U.S., since the U.S. is a good approximation of the rest of the world for Canada.

References

BOUAKEZ, H. AND N. REBEI (2007): "Why Does Private Consumption Rise After a Government Spending Shock?" *Canadian Journal of Economics*, 40, 954–979.

DION, R., M. LAURENCE, AND Y. ZHENG (2005): "Exports, Imports, and the Appreciation of the Canadian Dollar," *Bank of Canada Review*, Autumn, 5–18.

DRAUTZBURG, T. AND H. UHLIG (2015): "Fiscal Stimulus and Distortionary Taxes," *Review of Economic Dynamics*, 18, 894–920.

FAGAN, G., J. HENRY, AND R. MESTRE (2001): "An Area-wide Model (AWM) for the Euro Area," European central bank working paper no. 42.

FÈVE, P., J. MATHERON, AND J.-G. SAHUC (2013): "A Pitfall with Estimated DSGE-Based Government Spending Multipliers," *American Economic Journal: Macroeconomics*, 5, 141–178.

FORNI, L., L. MONTEFORTE, AND L. SESSA (2009): "The General Equilibrium Effects of Fiscal Policy: Estimates for the Euro Area," *Journal of Public Economics*, 93, 559–585.

GREENWOOD, J., Z. HERCOWITZ, AND G. W. HUFFMAN (1988): "Investment, Capacity Utilization, and the Real Business Cycle," *American Economic Review*, 78, 402–17.

JUSTINIANO, A. AND B. PRESTON (2010): "Can Structural Small Open-Economy Models Account for the Influence of Foreign Disturbances?" *Journal of International Economics*, 81, 61–74.

LEEPER, E. M., M. PLANTE, AND N. TRAUM (2010): "Dynamics of Fiscal Financing in the United States," *Journal of Econometrics*, 156, 304–321.

LUBIK, T. AND F. SCHORFHEIDE (2005): "A Bayesian Look at the New Open Economy Macroeconomics," in *NBER Macroeconomics Annual*, ed. by M. Gertler and K. Rogoff, The University of Chicago Press, vol. 20, 313–366.

PAREDES, J., D. J. PEDREGAL, AND J. PEREZ (2009): "A Quarterly Fiscal Database for the Euro Area Based on Intra-Annual Fiscal Information," European central bank working paper no. 1132.

ZELLNER, A. (1971): *An Introduction to Bayesian Inference in Econometrics*, New York: John Wiley and Sons, Inc.

Table A.1: Prior distributions for structural parameters.

Parameter	Prior		
	Dist.*	Mean	Std.
Preferences			
h_C, habit formation	B	0.7	0.1
ω, inverse Frisch	G	2	0.5
ω_G, substitutability of private/public cons.	U	0	1.01
ϕ, substitutability of home/foreign	U	3.03	1.59
α_X^g/α_X, public-private imports	U	0.25	0.09
α_X^I/α_X, inv.-cons. imports	U	1.08	0.19
Frictions and Production			
$100 \log \bar{z}$, growth rate	N	0.45	0.03
10γ, endog. risk premium	IG	0.75	1.5
ν_K, investment adj. cost	N	4	1.5
ς, capital utilization	B	0.5	0.2
ξ, Calvo price stickiness	B	0.66	0.1
ξ_w, Calvo wage stickiness	B	0.66	0.1
ι_p, price partial indexation	B	0.5	0.15
ι_w, wage partial indexation	B	0.5	0.15
steady-state trade-to-GDP ratio	U	0.5	0.14
Monetary Policy			
ϱ_i, resp. to lagged interest rate	B	0.75	0.1
ϱ_π, interest resp. to inflation	N	1.7	0.3
ϱ_Y, interest resp. to Y	G	0.15	0.1
Fiscal Policy			
γ_G, debt response for G	N	0.3	0.1
γ_{τ^I}, debt response for τ^I	N	0.3	0.1
γ_{τ^C}, debt response for τ^C	N	0.3	0.1
ϱ_G, lagged response for G	B	0.8	0.1
ϱ_{τ^I}, lagged response for τ^I	B	0.8	0.1
ϱ_{τ^C}, lagged response for τ^C	B	0.8	0.1
ϱ_{T_G}, lagged response for T_G	B	0.5	0.2
steady-state G/Y	U	0.23	0.07
steady-state annualized B/Y	U	0.6	0.12
steady-state income tax rate	U	0.25	0.06
steady-state cons. tax rate	U	0.13	0.04
Shock Processes			
$\rho_{\bar{\Lambda}_a}$, risk premium	B	0.5	0.2
$\rho_{\bar{\beta}}$, preference	B	0.5	0.2
ρ_ϕ, subst home/foreign	B	0.5	0.2
$\rho_{\bar{\zeta}}$, tfp growth	B	0.5	0.2
$\rho_{\bar{P}_K}$, investment	B	0.5	0.2
$\rho_{\bar{\theta}}$, price mark-up	B	0.3	0.1
$\rho_{\bar{h}}$, hours supply	B	0.3	0.1
$100\sigma_{\bar{\Lambda}_a}$, risk premium	IG	1	1
$100\sigma_{\bar{\beta}}$, preference	IG	1	1
$100\sigma_\phi$, subst home/foreign	IG	1	1
$100\sigma_{\bar{\zeta}}$, tfp growth	IG	0.5	1
$100\sigma_{\bar{P}_K}$, investment	IG	1	1
$100\sigma_{\bar{\theta}}$, price mark-up	IG	1	1
$100\sigma_{\bar{h}}$, hours supply	IG	1	1
$100\sigma_i$, monetary policy	IG	1	1
$100\sigma_G$, gov spending	IG	1	1
$100\sigma_{\tau^I}$, income tax	IG	1	1
$100\sigma_{\tau^C}$, income tax	IG	1	1
$100\sigma_{T_G}$, transfer	IG	1	1

*Distributions: N: Normal; G: Gamma; B: Beta; U: Uniform; IG: Inverse Gamma with distribution as in Zellner (1971): $p(y|\gamma,\alpha) = 2/(\Gamma(\alpha)\gamma^\alpha y^{2\alpha+1}) \exp^{-1/\gamma y^2}$.

Table A.2: Posterior distributions for structural parameters with different sample periods.

Parameter	Posterior							
	1992-2007 (baseline)				1992-2017			
	Canada		U.S.		Canada		U.S.	
	Mean	90% Int	Mean	90% Int	Mean	90% Int	Mean	90% Int
Preferences								
h_C, habit formation	0.72	[0.65, 0.79]	0.84	[0.76, 0.91]	0.76	[0.70, 0.83]	0.79	[0.73, 0.85]
ω, inverse Frisch	1.96	[1.28, 2.79]	1.72	[1.08, 2.52]	2.76	[2.07, 3.51]	1.58	[1.05, 2.17]
ω_G, substitutability of private/public cons.	0.10	[-0.14, 0.34]	-0.53	[-0.83, -0.23]	0.14	[-0.03, 0.32]	-0.68	[-0.95, -0.39]
ϕ, substitutability of home/foreign	1.06	[0.91, 1.23]		1.01	[0.90, 1.13]			
Frictions and Production								
$100 \log \bar{z}$, growth rate	0.45	[0.40, 0.50]		0.44	[0.39, 0.49]			
10γ, endog. risk premium	0.39	[0.23, 0.64]		0.36	[0.22, 0.54]			
ν_K, investment adj. cost	4.82	[3.06, 6.78]	6.58	[5.58, 7.75]	5.22	[3.46, 7.13]	4.41	[2.66, 6.70]
ς, capital utilization	0.12	[0.02, 0.28]	0.87	[0.75, 0.96]	0.39	[0.19, 0.63]	0.79	[0.65, 0.92]
ξ, Calvo price stickiness	0.65	[0.52, 0.75]	0.91	[0.89, 0.93]	0.49	[0.38, 0.61]	0.94	[0.92, 0.96]
ξ_w, Calvo wage stickiness	0.46	[0.35, 0.57]	0.65	[0.56, 0.72]	0.57	[0.48, 0.65]	0.74	[0.68, 0.80]
ι_p, price partial indexation	0.69	[0.47, 0.87]	0.34	[0.17, 0.52]	0.80	[0.64, 0.92]	0.29	[0.14, 0.46]
ι_w, wage partial indexation	0.47	[0.24, 0.70]	0.51	[0.28, 0.75]	0.48	[0.24, 0.73]	0.47	[0.23, 0.72]
Monetary Policy								
ϱ_i, resp. to lagged interest rate	0.82	[0.77, 0.87]	0.77	[0.69, 0.83]	0.84	[0.80, 0.87]	0.78	[0.73, 0.83]
ϱ_π, interest resp. to inflation	2.12	[1.73, 2.51]	1.87	[1.52, 2.25]	2.60	[2.23, 2.98]	2.08	[1.56, 2.48]
ϱ_Y, interest resp. to Y	0.04	[0.01, 0.09]	0.05	[0.02, 0.09]	0.04	[0.01, 0.08]	0.03	[0.01, 0.05]
Fiscal Policy								
γ_G, debt response for G	0.38	[0.25, 0.51]	0.34	[0.20, 0.46]	0.39	[0.28, 0.50]	0.36	[0.28, 0.46]
γ_{τ^I}, debt response for τ^I	0.15	[0.08, 0.23]	0.36	[0.20, 0.52]	0.13	[0.07, 0.19]	0.28	[0.15, 0.43]
γ_{τ^C}, debt response for τ^C	0.22	[0.07, 0.39]	0.32	[0.15, 0.48]	0.24	[0.10, 0.39]	0.18	[-0.5, 0.38]
ϱ_G, lagged response for G	0.95	[0.93, 0.97]	0.83	[0.74, 0.92]	0.94	[0.92, 0.96]	0.93	[0.90, 0.95]
ϱ_{τ^I}, lagged response for τ^I	0.70	[0.55, 0.83]	0.86	[0.80, 0.91]	0.74	[0.64, 0.84]	0.90	[0.85, 0.94]
ϱ_{τ^C}, lagged response for τ^C	0.96	[0.92, 0.99]	0.94	[0.89, 0.98]	0.97	[0.93, 0.99]	0.98	[0.95, 0.99]
ϱ_{T_G}, lagged response for T_G	0.29	[0.13, 0.46]	0.18	[0.06, 0.33]	0.22	[0.10, 0.35]	0.19	[0.07, 0.32]
Shock Processes								
$\rho_{\bar{\Lambda}_a}$, risk premium	0.95	[0.90, 0.98]		0.97	[0.95, 0.99]			
$\rho_{\bar{\beta}}$, preference	0.77	[0.65, 0.87]	0.73	[0.57, 0.84]	0.70	[0.56, 0.82]	0.86	[0.79, 0.93]
ρ_ϕ, subst home/foreign	0.98	[0.96, 0.99]	0.92	[0.87, 0.96]	0.97	[0.96, 0.99]	0.93	[0.90, 0.95]
$\rho_{\bar{\zeta}}$, tfp growth	0.98	[0.96, 0.99]	0.35	[0.22, 0.47]	0.98	[0.97, 0.99]	0.39	[0.30, 0.48]
$\rho_{\bar{P}_K}$, investment	0.34	[0.16, 0.52]	0.73	[0.62, 0.83]	0.53	[0.39, 0.66]	0.87	[0.78, 0.94]
$\rho_{\bar{\theta}}$, price mark-up	0.59	[0.39, 0.78]	0.31	[0.16, 0.49]	0.73	[0.60, 0.83]	0.25	[0.12, 0.40]
$\rho_{\bar{h}}$, hours supply	0.24	[0.13, 0.36]	0.22	[0.12, 0.33]	0.22	[0.12, 0.33]	0.12	[0.05, 0.20]
$100\sigma_{\bar{\Lambda}_a}$, risk premium	0.29	[0.23, 0.36]		0.25	[0.21, 0.30]			
$100\sigma_{\bar{\beta}}$, preference	2.08	[1.58, 2.73]	2.90	[1.91, 4.43]	2.06	[1.59, 2.63]	2.95	[2.28, 3.86]
$100\sigma_\phi$, subst home/foreign	3.42	[2.89, 4.04]	2.83	[2.45, 3.27]	3.36	[2.96, 3.81]	4.89	[4.33, 5.52]
$100\sigma_{\bar{\zeta}}$, tfp growth	1.26	[1.08, 1.46]	0.71	[0.61, 0.82]	1.28	[1.13, 1.44]	0.77	[0.68, 0.86]
$100\sigma_{\bar{P}_K}$, investment	0.96	[0.74, 1.20]	0.37	[0.29, 0.47]	0.78	[0.62, 0.97]	0.30	[0.25, 0.37]
$100\sigma_{\bar{\theta}}$, price mark-up	3.36	[1.51, 6.31]	9.17	[5.58, 13.70]	1.95	[1.26, 3.14]	22.14	[11.11, 44.61]
$100\sigma_{\bar{h}}$, hours supply	0.32	[0.28, 0.39]	0.42	[0.35, 0.50]	0.30	[0.25, 0.34]	0.47	[0.41, 0.53]
$100\sigma_i$, monetary policy	0.24	[0.20, 0.28]	0.19	[0.16, 0.22]	0.21	[0.18, 0.25]	0.16	[0.14, 0.18]
$100\sigma_G$, gov spending	1.17	[1.00, 1.37]	0.74	[0.64, 0.87]	1.21	[1.07, 1.37]	0.83	[0.73, 0.94]
$100\sigma_{\tau^I}$, income tax	2.58	[2.22, 3.01]	2.00	[1.72, 2.32]	2.43	[2.16, 2.74]	2.26	[2.00, 2.55]
$100\sigma_{\tau^C}$, income tax	1.04	[0.90, 1.22]	0.61	[0.52, 0.71]	1.11	[0.98, 1.25]	0.66	[0.59, 0.75]
$100\sigma_{T_G}$, transfer	2.29	[1.97, 2.66]	1.71	[1.47, 1.99]	2.31	[2.05, 2.58]	1.99	[1.78, 2.22]

Table A.3: Standard deviations from the data and 90 percent posterior intervals [in brackets] implied from the estimated model.

	Series	Data	Model
International			
	Real Exchange Rate, Growth Rate	2.78	[2.25 - 3.27]
	Nominal Exchange Rate, Growth Rate	2.68	[2.46 - 3.64]
	U.S. Imports Growth Rate	3.09	[2.37 - 3.55]
	U.S. Exports Growth Rate	2.71	[2.43 - 3.48]
Fiscal			
	Canadian Gov. Spending-GDP Ratio	7.09	[2.38 - 7.76]
	Canadian Income Tax Revenue-GDP Ratio	4.31	[3.00 - 6.66]
	Canadian Vat Tax Revenue-GDP Ratio	6.03	[1.94 - 7.31]
	Canadian Gov. Debt-GDP Ratio	26.66	[5.18 - 25.81]
	U.S. Gov. Spending-GDP Ratio	3.85	[1.31 - 4.11]
	U.S. Income Tax Revenue-GDP Ratio	6.02	[2.78 - 6.80]
	U.S. Vat Tax Revenue-GDP Ratio	2.36	[1.20 - 4.75]
	U.S. Gov. Debt-GDP Ratio	5.02	[3.59 - 13.78]
Macroaggregates (relative to GDP Growth)			
	Canadian Cons. Growth	0.56	[0.54 - 0.82]
	Canadian Inv. Growth	2.63	[1.68 - 2.76]
	Canadian Hours	3.99	[1.15 - 2.38]
	Canadian Real Wage Growth	0.76	[0.64 - 0.95]
	Canadian Nominal Interest Rate	0.40	[0.30 - 0.59]
	Canadian CPI Inflation Rate	0.32	[0.40 - 0.68]
	U.S. Cons. Growth	0.71	[0.63 - 0.96]
	U.S. Inv. Growth	3.01	[2.64 - 4.42]
	U.S. Hours	5.38	[2.06 - 4.97]
	U.S. Real Wage Growth	1.54	[0.98 - 1.83]
	U.S. Nominal Interest Rate	0.78	[0.31 - 0.78]
	U.S. CPI Inflation Rate	0.27	[0.18 - 0.49]

Table A.4: Forecast error variance decompositions after 10 quarters.

Variable	**Shock**								
	Risk Prem.	ϕ	ϕ^*	U.S. Growth	TFP Cointeg.	Canadian Fiscal	U.S. Fiscal	Canadian Other	U.S. Other
Canadian Output Growth	2.03	16.21	13.47	17.37	16.19	3.87	0.04	29.76	1.06
Canadian Cons Growth	6.09	6.51	2.49	21.13	9.48	1.00	0.0	52.39	0.90
Canadian Inv Growth	5.33	5.90	3.03	3.66	6.84	0.75	0.01	73.74	0.73
Canadian Hours	1.06	13.03	9.11	7.55	9.13	3.27	0.03	55.44	1.38
Canadian Wage Growth	6.48	9.91	5.10	12.86	7.54	0.12	0.0	56.49	1.50
Canadian Inflation	14.24	8.83	4.79	3.14	3.44	0.83	0.0	62.10	2.63
Canadian Int Rate	13.77	6.85	3.67	5.30	6.78	1.00	0.01	60.80	1.82
Canadian Gov Spending-GDP	1.15	11.90	7.11	0.99	2.88	44.14	0.02	30.60	1.21
Canadian Gov Debt-GDP	1.23	6.35	3.08	7.55	3.43	62.64	0.0	15.11	0.58
Canadian Vat Rev-GDP	0.73	8.47	6.54	5.21	10.85	53.92	0.03	12.95	1.28
Canadian Inc Tax-GDP	0.25	0.65	0.27	1.47	3.84	79.24	0.0	14.21	0.05
U.S. Output Growth	0.0	0.0	0.0	44.12	0.0	0.0	10.42	0.0	45.46
U.S. Cons Growth	0.0	0.0	0.0	35.12	0.0	0.0	3.78	0.0	61.10
U.S. Inv Growth	0.0	0.0	0.0	10.31	0.0	0.0	0.37	0.0	89.32
U.S. Hours	0.0	0.0	0.0	9.47	0.0	0.0	6.11	0.0	84.41
U.S. Wage Growth	0.0	0.0	0.0	7.10	0.0	0.0	0.05	0.0	92.86
U.S. Inflation	0.0	0.0	0.0	2.06	0.0	0.0	0.77	0.0	97.16
U.S. Int Rate	0.0	0.0	0.0	1.55	0.0	0.0	0.82	0.0	97.62
U.S. Gov Spending-GDP	0.0	0.0	0.0	13.38	0.0	0.0	36.61	0.0	50.01
U.S. Gov Debt-GDP	0.0	0.0	0.0	4.76	0.0	0.0	70.18	0.0	25.06
U.S. Vat Rev-GDP	0.0	0.0	0.0	11.52	0.0	0.0	47.56	0.0	40.90
U.S. Inc Tax-GDP	0.0	0.0	0.0	5.43	0.0	0.0	77.85	0.0	16.72
U.S. Export Growth	28.21	23.46	17.85	2.61	5.97	0.46	0.01	15.64	5.79
U.S. Import Growth	0.01	0.04	93.19	2.43	0.02	0.0	0.24	0.04	4.03
Real Exchange Rate Growth	20.26	32.61	9.89	0.78	10.04	0.38	0.01	21.71	4.32
Nominal Exchange Rate Growth	25.00	36.20	11.94	0.46	8.21	0.25	0.01	13.00	4.91

Table A.5: Prior and posterior distributions for structural parameters when the terms of consumption are included in the estimation.

Parameter	Prior			Posterior			
				Canada		U.S.	
	Dist.*	Mean	Std.	Mean	90% Int	Mean	90% Int
Preferences							
h_C, habit formation	B	0.7	0.1	0.73	[0.65, 0.80]	0.83	[0.75, 0.90]
ω, inverse Frisch	G	2	0.5	1.96	[1.30, 2.75]	1.78	[1.11, 2.61]
ω_G, substitutability of private/public cons.	U	0	1.01	0.09	[-0.15, 0.33]	-0.52	[-0.83, -0.22]
ϕ, substitutability of home/foreign	U	3.03	1.59	1.06	[0.90, 1.23]		
Frictions and Production							
$100 \log \bar{z}$, growth rate	N	0.45	0.03	0.45	[0.40, 0.50]		
10γ, endog. risk premium	IG	0.75	1.5	0.40	[0.23, 0.64]		
ν_K, investment adj. cost	N	4	1.5	4.97	[3.20, 6.96]	5.10	[3.14, 7.14]
ς, capital utilization	B	0.5	0.2	0.11	[0.02, 0.26]	0.86	[0.73, 0.96]
ξ, Calvo price stickiness	B	0.66	0.1	0.68	[0.55, 0.79]	0.92	[0.90, 0.94]
ξ_w, Calvo wage stickiness	B	0.66	0.1	0.47	[0.36, 0.57]	0.64	[0.56, 0.72]
ι_p, price partial indexation	B	0.5	0.15	0.70	[0.50, 0.87]	0.36	[0.18, 0.55]
ι_w, wage partial indexation	B	0.5	0.15	0.47	[0.24, 0.70]	0.51	[0.26, 0.76]
Monetary Policy							
ϱ_i, resp. to lagged interest rate	B	0.75	0.1	0.82	[0.77, 0.87]	0.76	[0.69, 0.83]
ϱ_π, interest resp. to inflation	N	1.7	0.3	2.11	[1.72, 2.50]	1.89	[1.54, 2.27]
ϱ_Y, interest resp. to Y	G	0.15	0.1	0.04	[0.01, 0.09]	0.06	[0.03, 0.09]
Fiscal Policy							
γ_G, debt response for G	N	0.3	0.1	0.38	[0.25, 0.52]	0.33	[0.19, 0.46]
γ_{τ^I}, debt response for τ^I	N	0.3	0.1	0.15	[0.08, 0.25]	0.36	[0.20, 0.52]
γ_{τ^C}, debt response for τ^C	N	0.3	0.1	0.22	[0.07, 0.38]	0.32	[0.15, 0.48]
ϱ_G, lagged response for G	B	0.8	0.1	0.95	[0.93, 0.97]	0.83	[0.74, 0.92]
ϱ_{τ^I}, lagged response for τ^I	B	0.8	0.1	0.70	[0.56, 0.84]	0.86	[0.80, 0.91]
ϱ_{τ^C}, lagged response for τ^C	B	0.8	0.1	0.96	[0.91, 0.99]	0.94	[0.89, 0.98]
ϱ_{T_G}, lagged response for T_G	B	0.5	0.2	0.29	[0.12, 0.47]	0.18	[0.06, 0.34]
Shock Processes							
$\rho_{\bar{\Lambda}_a}$, risk premium	B	0.5	0.2	0.95	[0.90, 0.99]		
$\rho_{\bar{\beta}}$, preference	B	0.5	0.2	0.77	[0.65, 0.87]	0.74	[0.59, 0.85]
ρ_ϕ, subst home/foreign	B	0.5	0.2	0.98	[0.96, 0.99]	0.92	[0.87, 0.96]
$\rho_{\bar{\zeta}}$, tfp growth	B	0.5	0.2	0.98	[0.96, 0.99]	0.35	[0.22, 0.47]
$\rho_{\bar{P}_K}$, investment	B	0.5	0.2	0.34	[0.17, 0.51]	0.77	[0.65, 0.88]
$\rho_{\bar{\theta}}$, price mark-up	B	0.3	0.1	0.54	[0.35, 0.75]	0.28	[0.13, 0.45]
$\rho_{\bar{h}}$, hours supply	B	0.3	0.1	0.24	[0.13, 0.36]	0.22	[0.12, 0.33]
$100\sigma_{\bar{\Lambda}_a}$, risk premium	IG	1	1	0.29	[0.23, 0.37]		
$100\sigma_{\bar{\beta}}$, preference	IG	1	1	2.10	[1.60, 2.74]	2.78	[1.83, 4.44]
$100\sigma_\phi$, subst home/foreign	IG	1	1	3.41	[2.86, 4.04]	2.83	[2.46, 3.27]
$100\sigma_{\bar{\zeta}}$, tfp growth	IG	0.5	1	1.26	[1.08, 1.46]	0.71	[0.61, 0.82]
$100\sigma_{\bar{P}_K}$, investment	IG	1	1	0.95	[0.74, 1.19]	0.36	[0.29, 0.46]
$100\sigma_{\bar{\theta}}$, price mark-up	IG	1	1	4.33	[1.68, 9.17]	11.01	[6.24, 18.04]
$100\sigma_{\bar{h}}$, hours supply	IG	1	1	0.32	[0.28, 0.39]	0.42	[0.35, 0.50]
$100\sigma_i$, monetary policy	IG	1	1	0.24	[0.20, 0.28]	0.19	[0.16, 0.22]
$100\sigma_G$, gov spending	IG	1	1	1.18	[1.01, 1.38]	0.75	[0.64, 0.87]
$100\sigma_{\tau^I}$, income tax	IG	1	1	2.59	[2.23, 3.01]	2.00	[1.73, 2.31]
$100\sigma_{\tau^C}$, income tax	IG	1	1	1.04	[0.89, 1.22]	0.61	[0.52, 0.71]
$100\sigma_{T_G}$, transfer	IG	1	1	2.28	[1.97, 2.64]	1.71	[1.47, 2.00]
TOC meas. err, transfer	IG	1	1	1.73	[1.50, 2.00]		

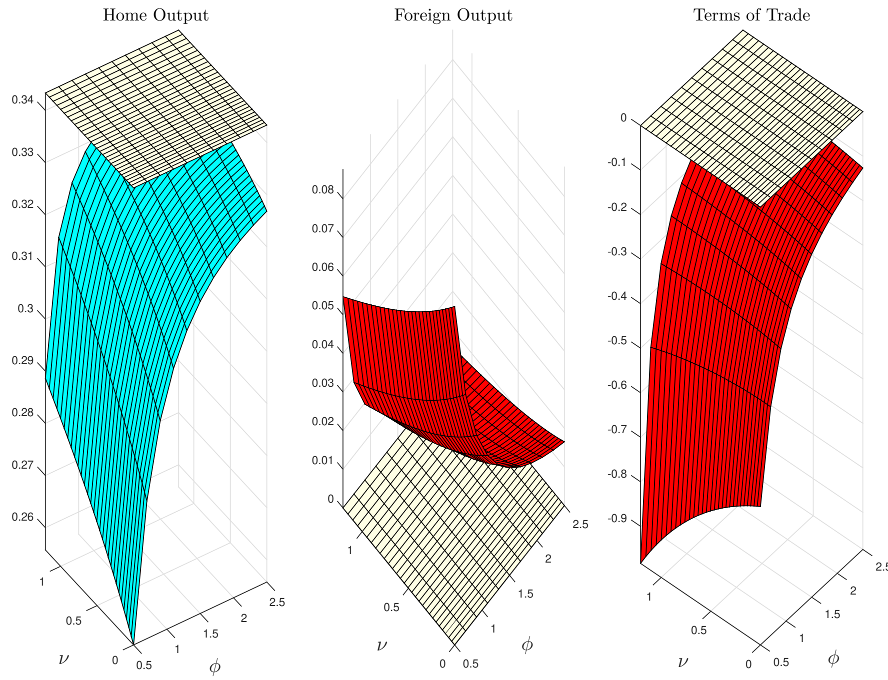
*Distributions: N: Normal; G: Gamma; B: Beta; U: Uniform;

IG: Inverse Gamma with distribution as in Zellner (1971): $p(y|\gamma,\alpha) = 2/(\Gamma(\alpha)\gamma^\alpha y^{2\alpha+1}) \exp^{-1/\gamma y^2}$.

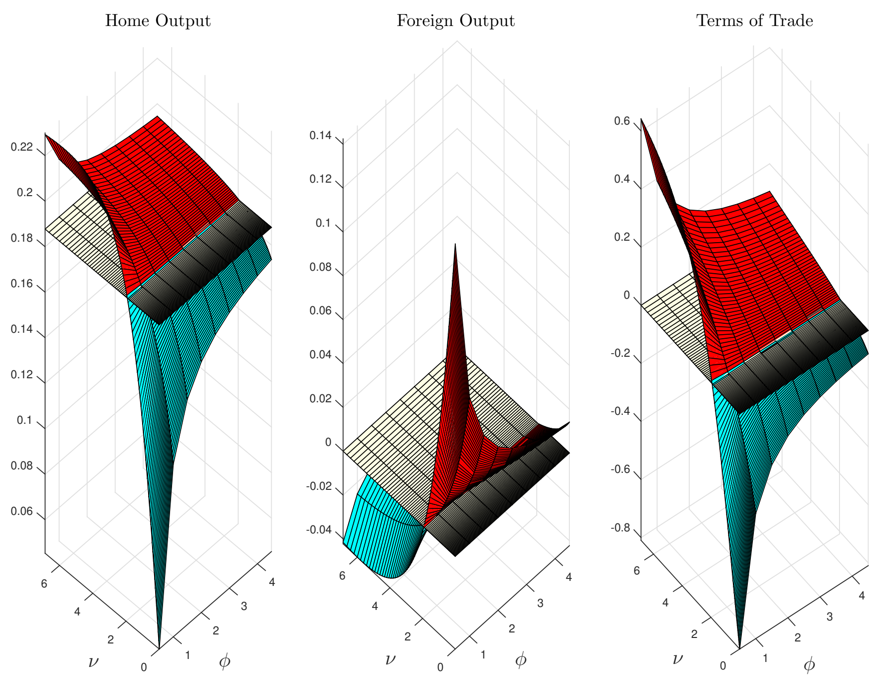
Table A.6: Prior and posterior distributions for structural parameters when estimating using the U.S. and E.A. data.

Parameter	**Prior**			**Posterior**			
				European Area		**U.S.**	
	Dist.*	Mean	Std.	Mean	90% Int	Mean	90% Int
Preferences							
h_C, habit formation	B	0.7	0.1	0.63	[0.51, 0.75]	0.85	[0.77, 0.91]
ω, inverse Frisch	G	2	0.5	2.25	[1.47, 3.17]	1.69	[1.07, 2.44]
ω_G, substitutability of private/public cons.	U	0	1.01	0.15	[-0.15, 0.46]	-0.67	[-1.01, -0.32]
ϕ, substitutability of home/foreign	U	3.03	1.59	0.86	[0.73, 0.97]		
Frictions and Production							
$100 \log \bar{z}$, growth rate	N	0.45	0.03	0.45	[0.40, 0.50]		
10γ, endog. risk premium	IG	0.75	1.5	0.58	[0.27, 1.20]		
ν_K, investment adj. cost	N	4	1.5	5.57	[3.87, 7.40]	5.38	[3.56, 7.33]
ς, capital utilization	B	0.5	0.2	0.65	[0.38, 0.88]	0.66	[0.45, 0.86]
ξ, Calvo price stickiness	B	0.66	0.1	0.58	[0.50, 0.66]	0.86	[0.82, 0.90]
ξ_w, Calvo wage stickiness	B	0.66	0.1	0.57	[0.45, 0.70]	0.62	[0.51, 0.73]
ι_p, price partial indexation	B	0.5	0.15	0.56	[0.33, 0.77]	0.77	[0.57, 0.91]
ι_w, wage partial indexation	B	0.5	0.15	0.43	[0.22, 0.66]	0.48	[0.24, 0.73]
Monetary Policy							
ϱ_i, resp. to lagged interest rate	B	0.75	0.1	0.75	[0.67, 0.81]	0.81	[0.73, 0.87]
ϱ_π, interest resp. to inflation	N	1.7	0.3	1.90	[1.52, 2.31]	2.17	[1.79, 2.56]
ϱ_Y, interest resp. to Y	G	0.15	0.1	0.18	[0.06, 0.32]	0.05	[0.01, 0.11]
Fiscal Policy							
γ_G, debt response for G	N	0.3	0.1	0.34	[0.18, 0.49]	0.38	[0.23, 0.51]
γ_{τ^I}, debt response for τ^I	N	0.3	0.1	0.33	[0.17, 0.49]	0.38	[0.22, 0.54]
γ_{τ^C}, debt response for τ^C	N	0.3	0.1	0.31	[0.15, 0.46]	0.27	[0.13, 0.42]
ϱ_G, lagged response for G	B	0.8	0.1	0.92	[0.86, 0.97]	0.89	[0.82, 0.95]
ϱ_{τ^I}, lagged response for τ^I	B	0.8	0.1	0.84	[0.75, 0.92]	0.85	[0.79, 0.91]
ϱ_{τ^C}, lagged response for τ^C	B	0.8	0.1	0.90	[0.84, 0.95]	0.92	[0.85, 0.97]
ϱ_{T_G}, lagged response for T_G	B	0.5	0.2	0.53	[0.35, 0.70]	0.14	[0.04, 0.28]
Shock Processes							
$\rho_{\bar{\Lambda}_a}$, risk premium	B	0.5	0.2	0.96	[0.94, 0.98]		
$\rho_{\bar{\beta}}$, preference	B	0.5	0.2	0.67	[0.46, 0.81]	0.61	[0.39, 0.81]
ρ_ϕ, subst home/foreign	B	0.5	0.2	0.98	[0.97, 0.99]	0.84	[0.74, 0.92]
$\rho_{\bar{\zeta}}$, tfp growth	B	0.5	0.2	0.995	[0.99, 0.998]	0.13	[0.05, 0.22]
$\rho_{\bar{P}_K}$, investment	B	0.5	0.2	0.24	[0.08, 0.44]	0.51	[0.30, 0.71]
$\rho_{\bar{\theta}}$, price mark-up	B	0.3	0.1	0.34	[0.20, 0.50]	0.27	[0.14, 0.41]
$\rho_{\bar{h}}$, hours supply	B	0.3	0.1	0.13	[0.06, 0.23]	0.20	[0.10, 0.32]
$100\sigma_{\bar{\Lambda}_a}$, risk premium	IG	1	1	0.92	[0.53, 1.59]		
$100\sigma_{\bar{\beta}}$, preference	IG	1	1	1.01	[0.72, 1.41]	3.04	[1.92, 4.67]
$100\sigma_\phi$, subst home/foreign	IG	1	1	4.63	[3.88, 5.51]	1.92	[1.63, 2.29]
$100\sigma_{\bar{\zeta}}$, tfp growth	IG	0.5	1	1.37	[1.17, 1.60]	0.84	[0.71, 0.99]
$100\sigma_{\bar{P}_K}$, investment	IG	1	1	0.46	[0.37, 0.56]	0.51	[0.38, 0.68]
$100\sigma_{\bar{\theta}}$, price mark-up	IG	1	1	1.14	[0.74, 1.75]	11.19	[5.51, 21.27]
$100\sigma_{\bar{h}}$, hours supply	IG	1	1	0.21	[0.17, 0.25]	0.41	[0.34, 0.50]
$100\sigma_i$, monetary policy	IG	1	1	0.19	[0.16, 0.23]	0.19	[0.16, 0.23]
$100\sigma_G$, gov spending	IG	1	1	0.69	[0.58, 0.81]	0.72	[0.61, 0.85]
$100\sigma_{\tau^I}$, income tax	IG	1	1	1.13	[0.96, 1.34]	2.16	[1.83, 2.54]
$100\sigma_{\tau^C}$, income tax	IG	1	1	0.79	[0.67, 0.93]	0.55	[0.46, 0.65]
$100\sigma_{T_G}$, transfer	IG	1	1	0.68	[0.57, 0.79]	1.62	[1.38, 1.91]

*Distributions: N: Normal; G: Gamma; B: Beta; U: Uniform;
IG: Inverse Gamma with distribution as in Zellner (1971): $p(y|\gamma, \alpha) = 2/(\Gamma(\alpha)\gamma^\alpha y^{2\alpha+1}) \exp^{-1/\gamma y^2}$.

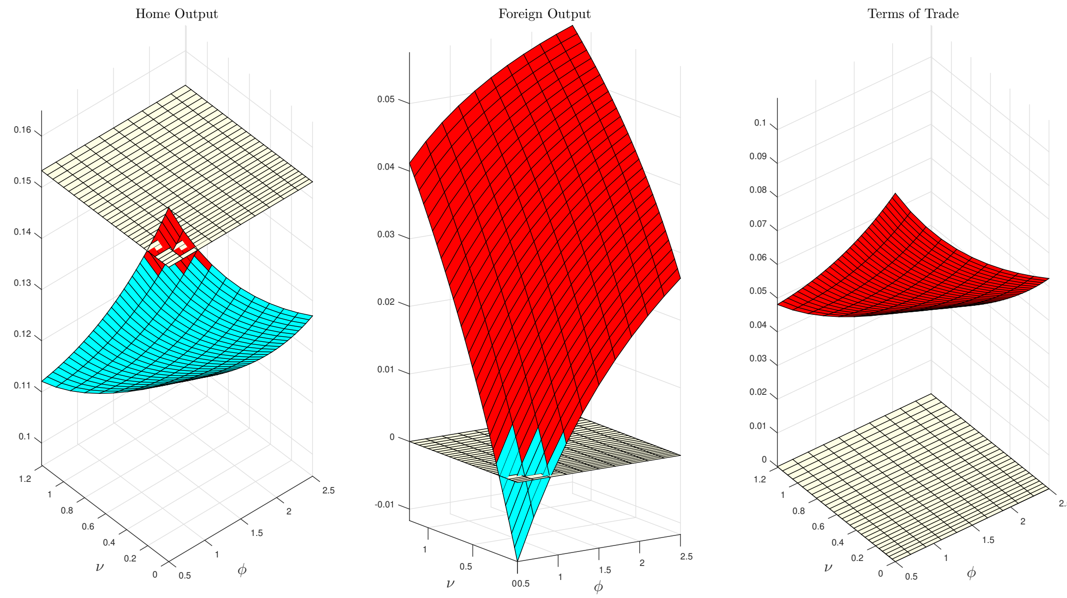


(a) Income Tax Cut Financed with Lump-Sum Transfers

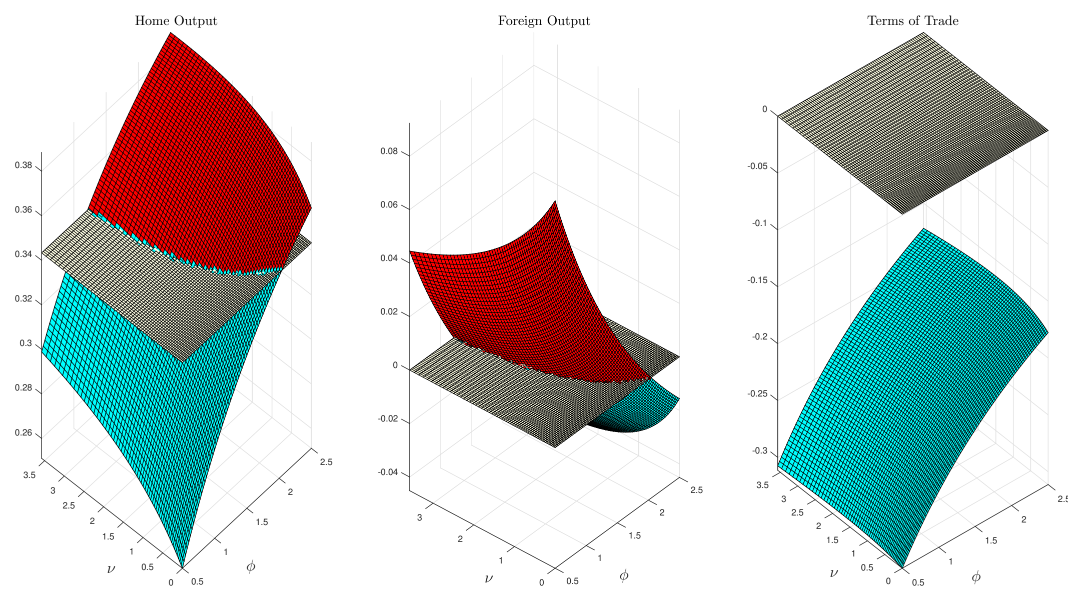


(b) Income Tax Cut Financed with Government Spending

Figure A.1: Impact response of GDP (Home and Foreign) and the terms of trade following a 1% cut in the income tax under financial autarky for different combinations of ν and ϕ. The plane in each panel denotes the response in the closed economy. In all cases, $\alpha = 0.33$, $s_G = 0.2$, $\tau = 0.25$, and the trade share $= 0.5$.



(a) Government Spending Increase with Complete Markets



(b) Income Tax with Complete Markets

Figure A.2: Impact response of GDP (Home and Foreign) and the terms of trade with complete international financial assets for different combinations of ν and ϕ. The plane in each panel denotes the response in the closed economy. In all cases, $\alpha = 0.33$, $s_G = 0.2$, $\tau = 0.25$, and the trade share $= 0.5$.

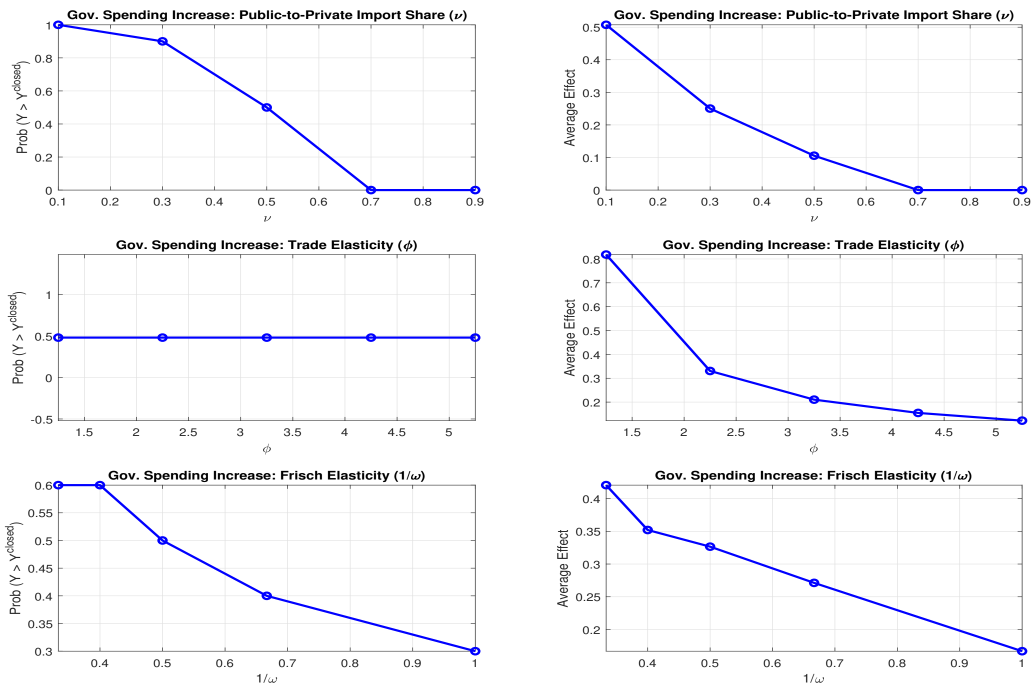


Figure A.3: Probability that the output response is larger in the open economy under financial autarky, i.e. $Pr(\hat{Y}_t > \hat{Y}_t^{\text{closed}})$. In all cases, $s_G = 0.2$, $\tau = 0.25$, $\alpha = 0.3$, and the trade share equal to 0.5. Horizontal axis displays quantiles of the parameter range.

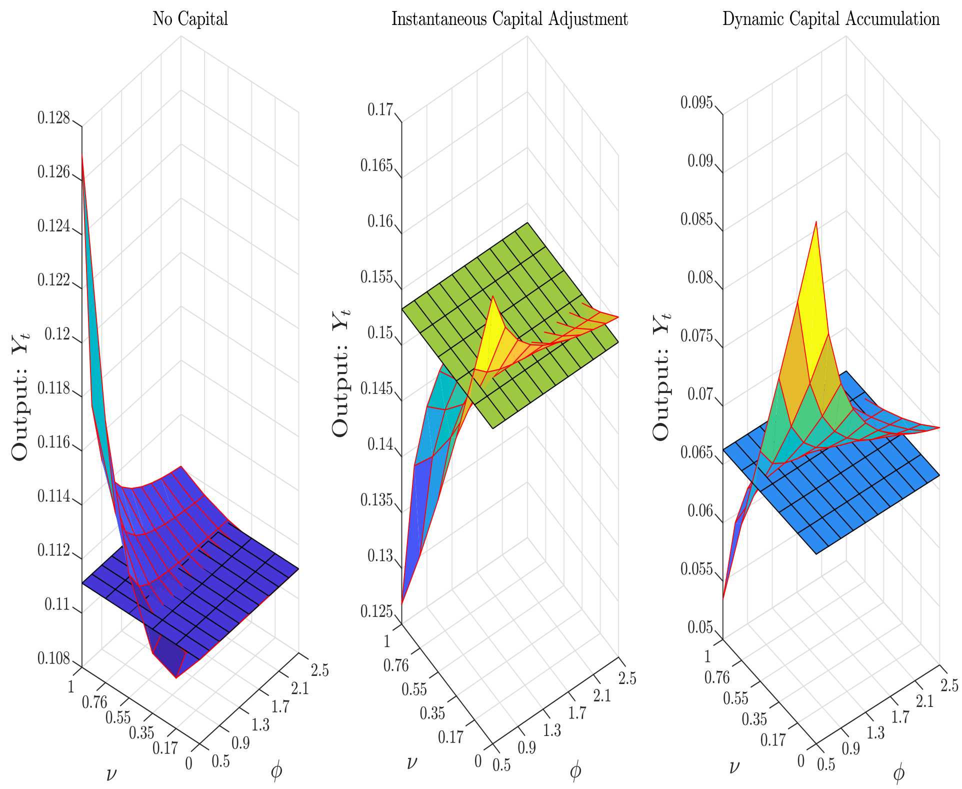


Figure A.4: Response of output to a 1% increase in government spending for three models. *First column:* labor as the only input of production. *Second column:* baseline model of Section 2: instantaneous capital adjustment and no capital depreciation (second column). *Third column:* time to build in capital adjustment and capital depreciation ($\delta = 0.025$).

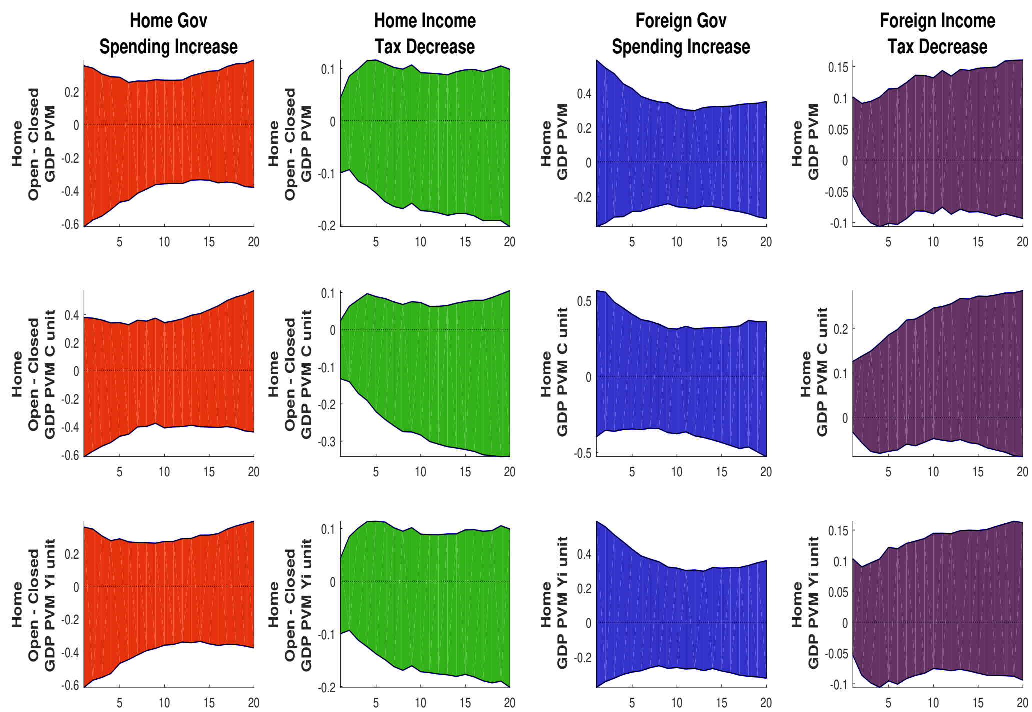
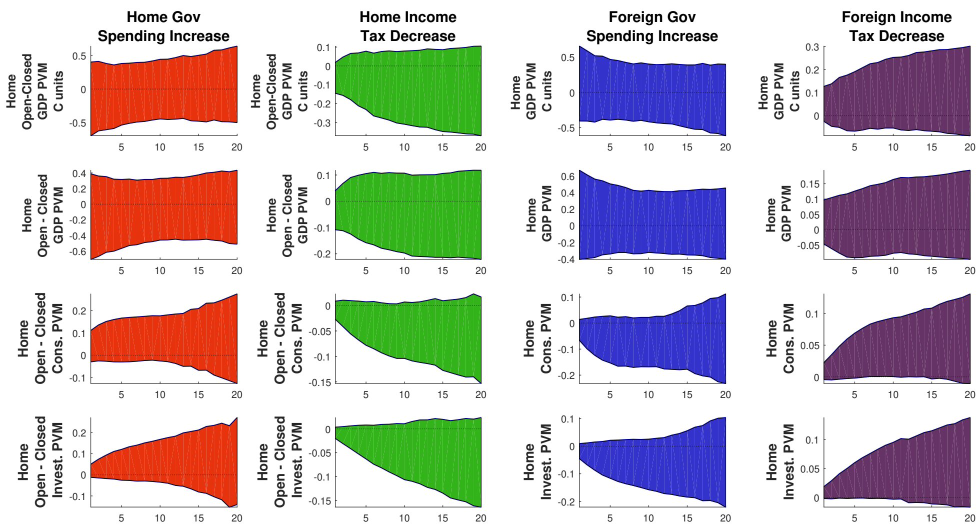
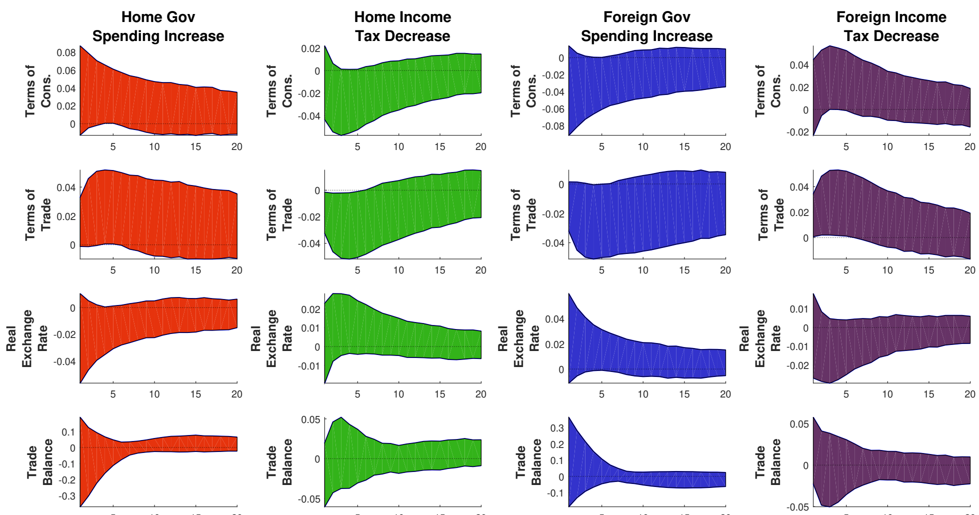


Figure A.5: Differences in open- and closed-economy multipliers from the prior-predictive analysis, using alternative deflators. *Top row:* constant-price units; *middle row:* CPI units; *bottom row:* production units.



(a) Present-Value Multipliers



(b) Select Impulse Responses

Figure A.6: 90-percentile intervals implied by the prior-predictive analysis, using the two-large country model.

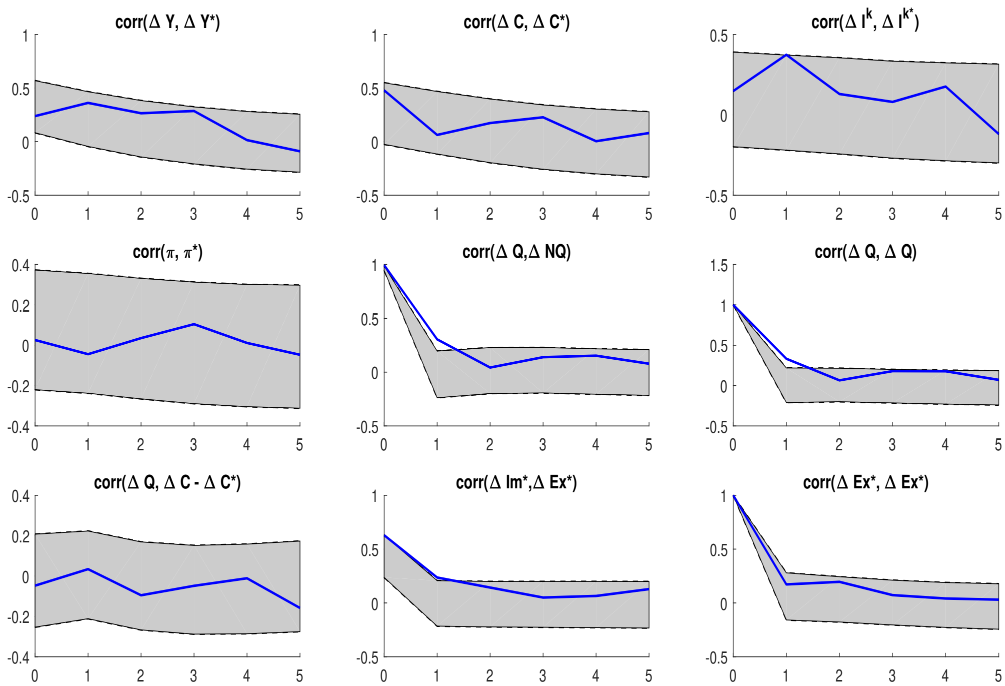


Figure A.7: Select correlograms from the data (solid lines) and 90 percent posterior intervals (shaded areas) implied from the estimated model.

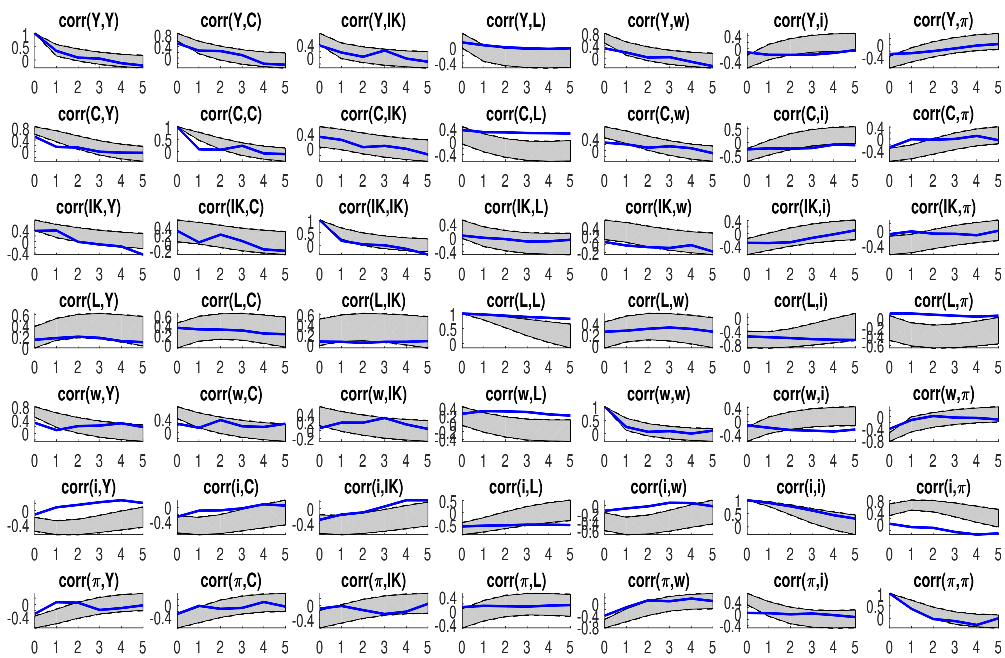


Figure A.8: Select correlograms from the data (solid lines) and 90 percent posterior intervals (shaded areas) implied from the estimated model for Canadian Series.

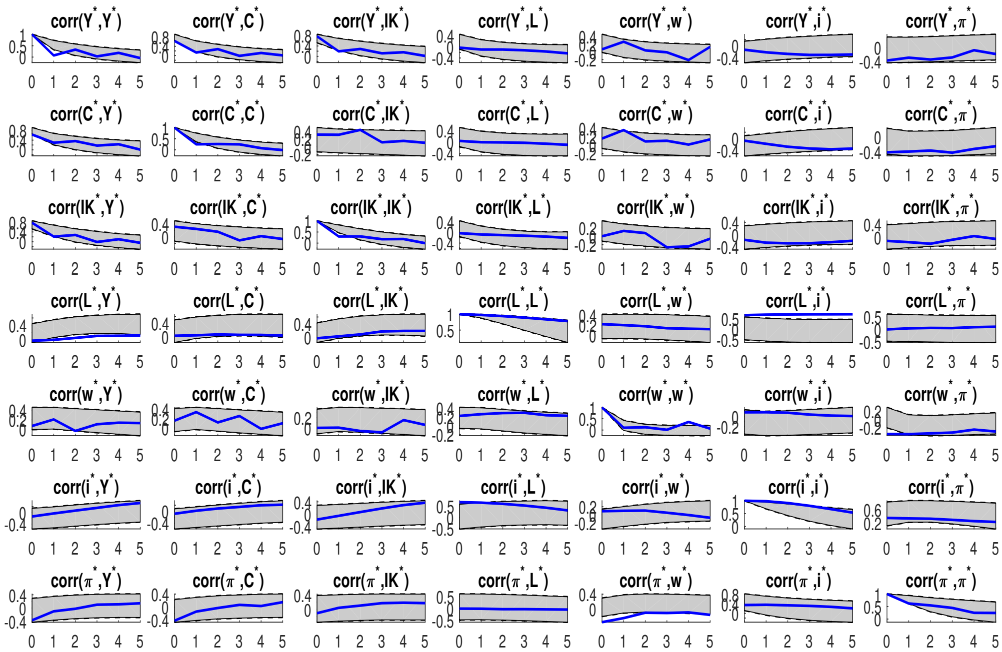


Figure A.9: Select correlograms from the data (solid lines) and 90 percent posterior intervals (shaded areas) implied from the estimated model for U.S. Series.

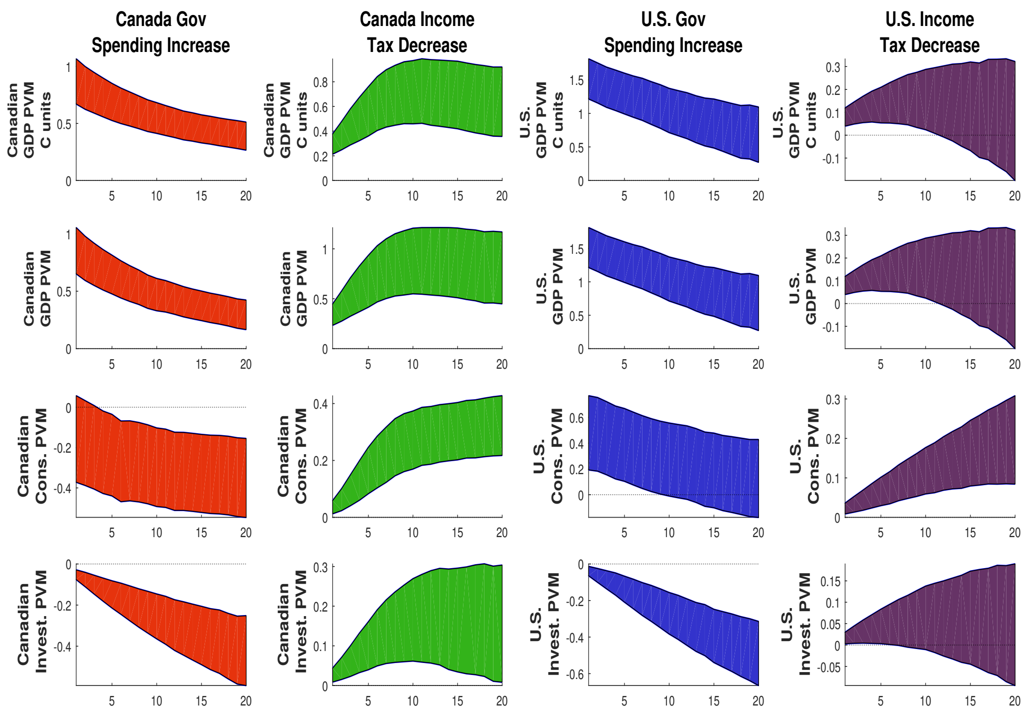


Figure A.10: 90 percent posterior intervals of the levels of Canadian and U.S. present-value multipliers.

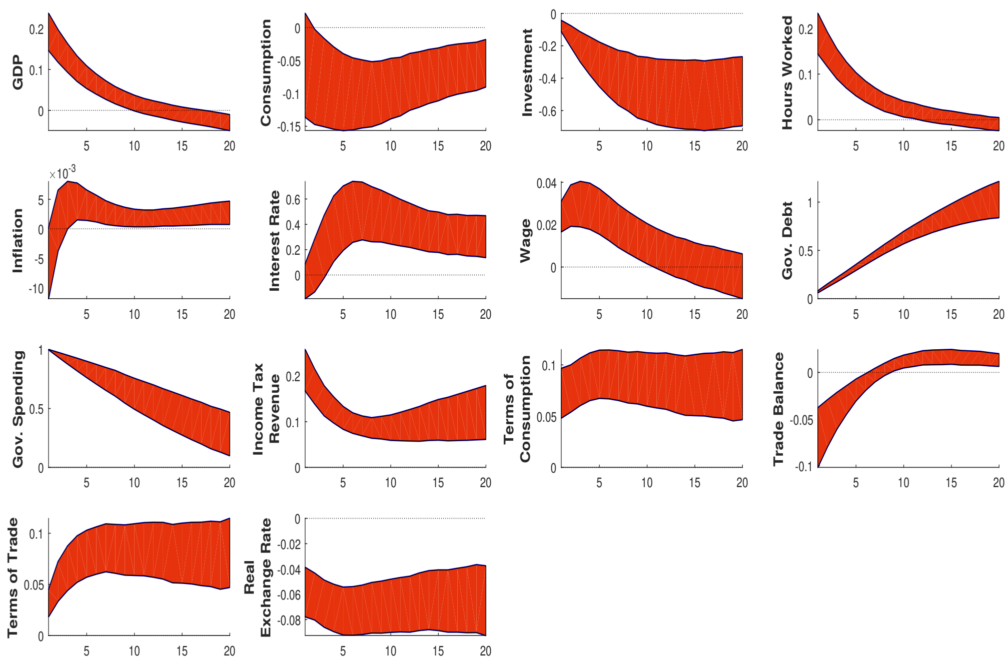


Figure A.11: 90 percent posterior intervals of the responses of Canadian variables following a 1% increase in Canadian government spending.

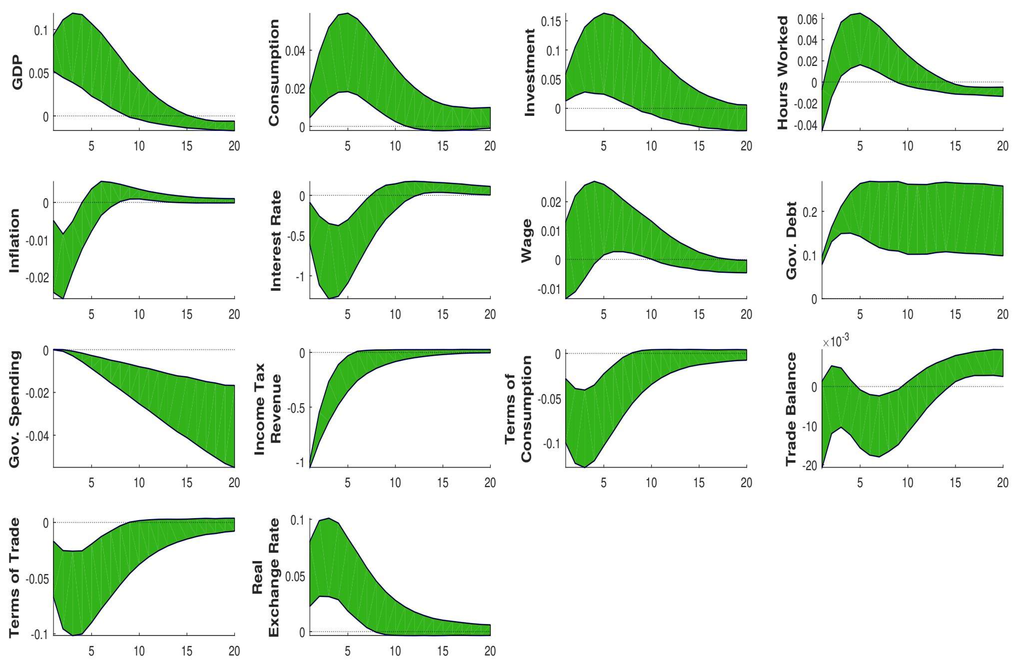


Figure A.12: 90 percent posterior intervals of the responses of Canadian variables following a 1% decrease in Canadian income taxes.

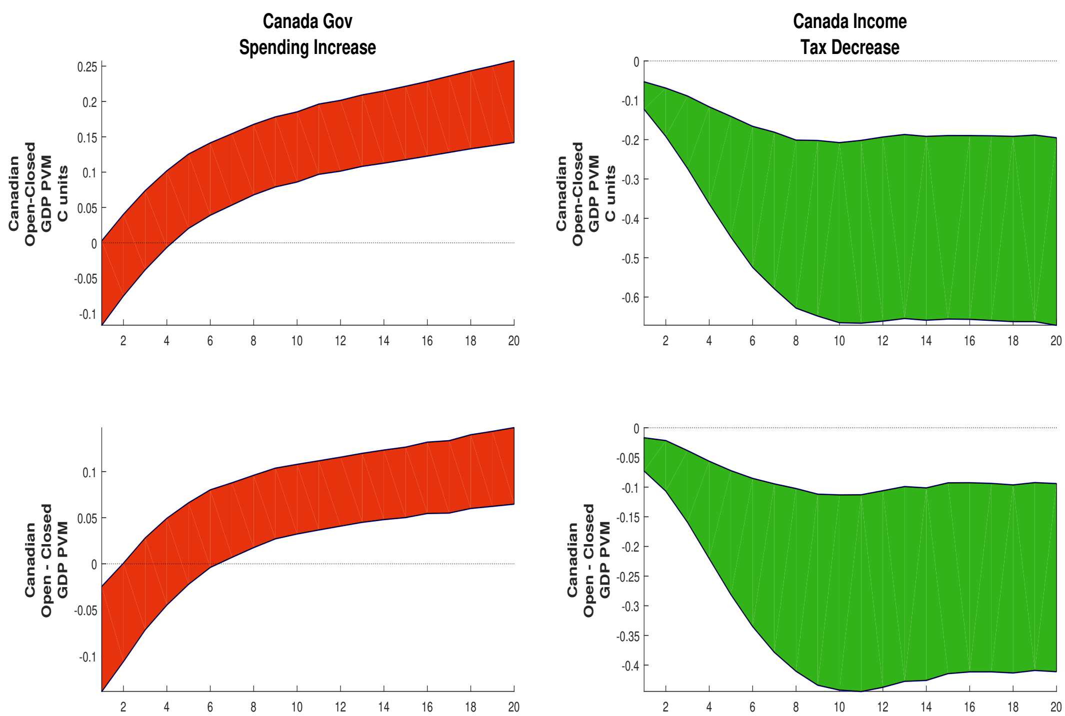
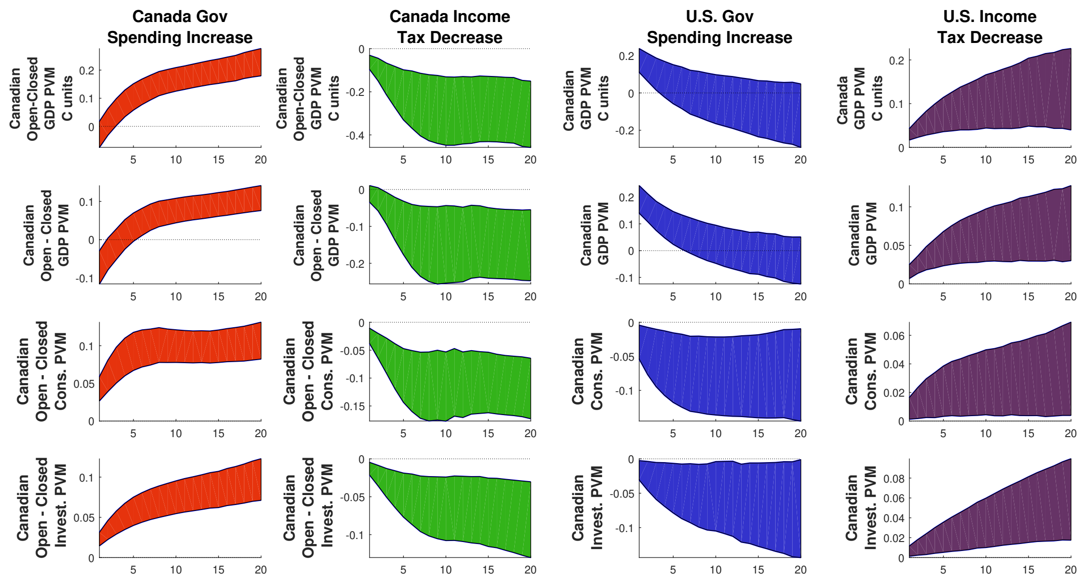
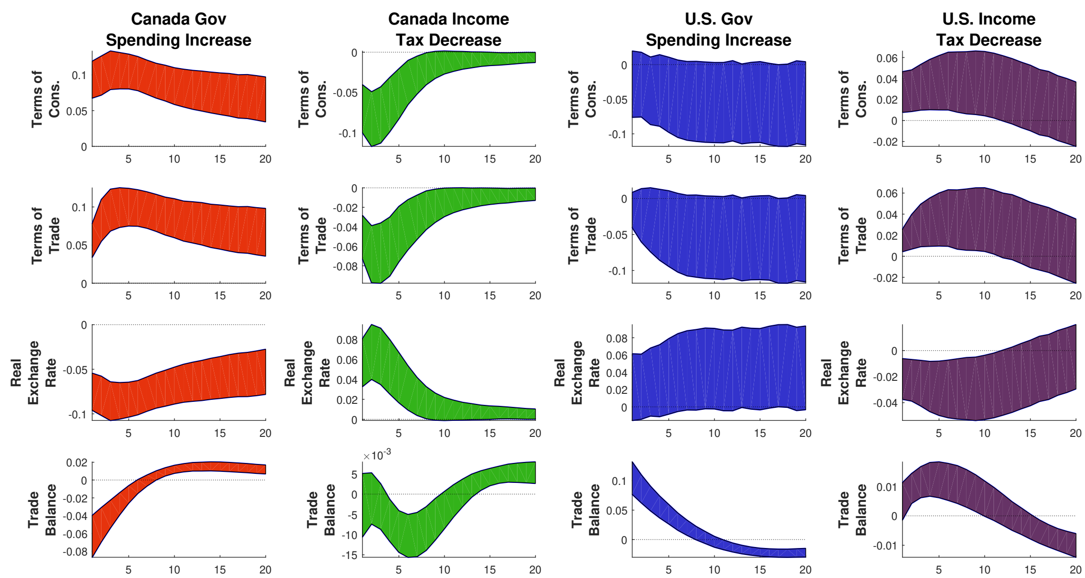


Figure A.13: 90-percent posterior probability bands for the difference in open- and closed-economy present-value Canadian GDP multipliers, using Canadian posterior estimates for both Home and Foreign.

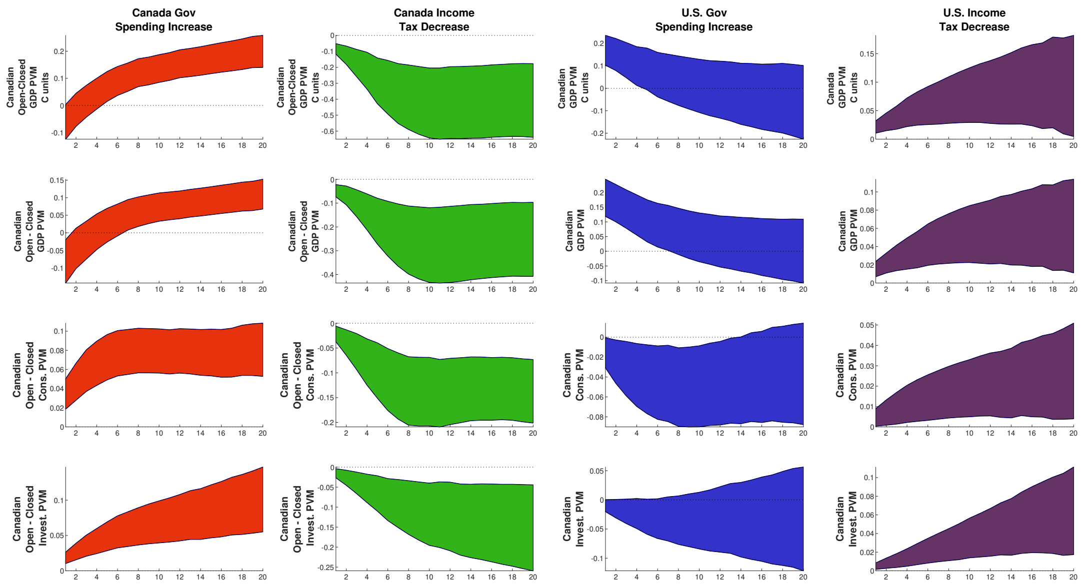


(a) Present-Value Multipliers

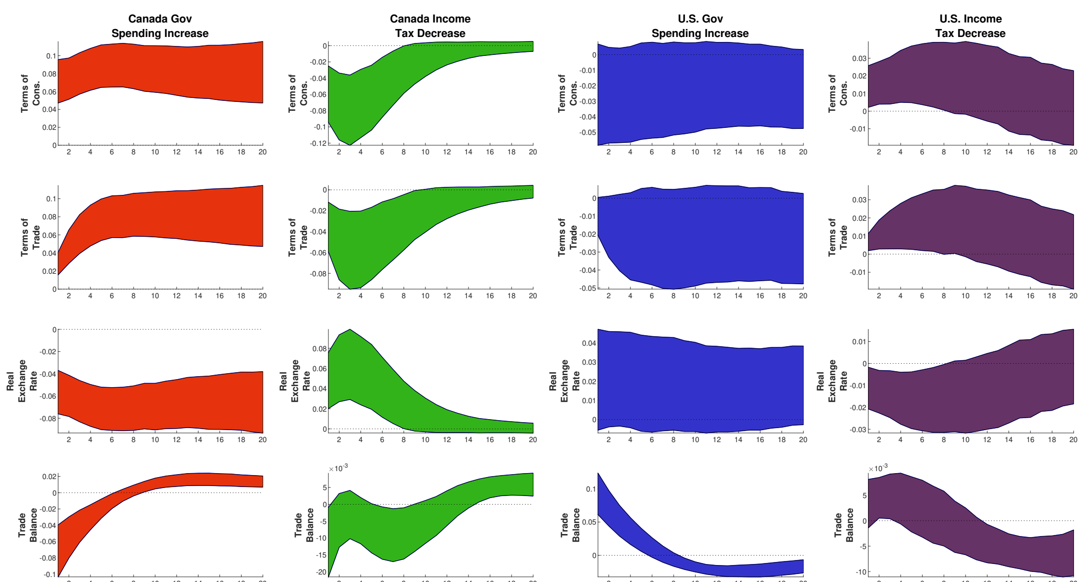


(b) Select Impulse Responses

Figure A.14: 90-percentile intervals implied by the posterior estimates over the sample period 1992-2017.



(a) Present-Value Multipliers



(b) Select Impulse Responses

Figure A.15: 90-percentile intervals implied by the posterior estimates when the terms of consumption are included as an observable.

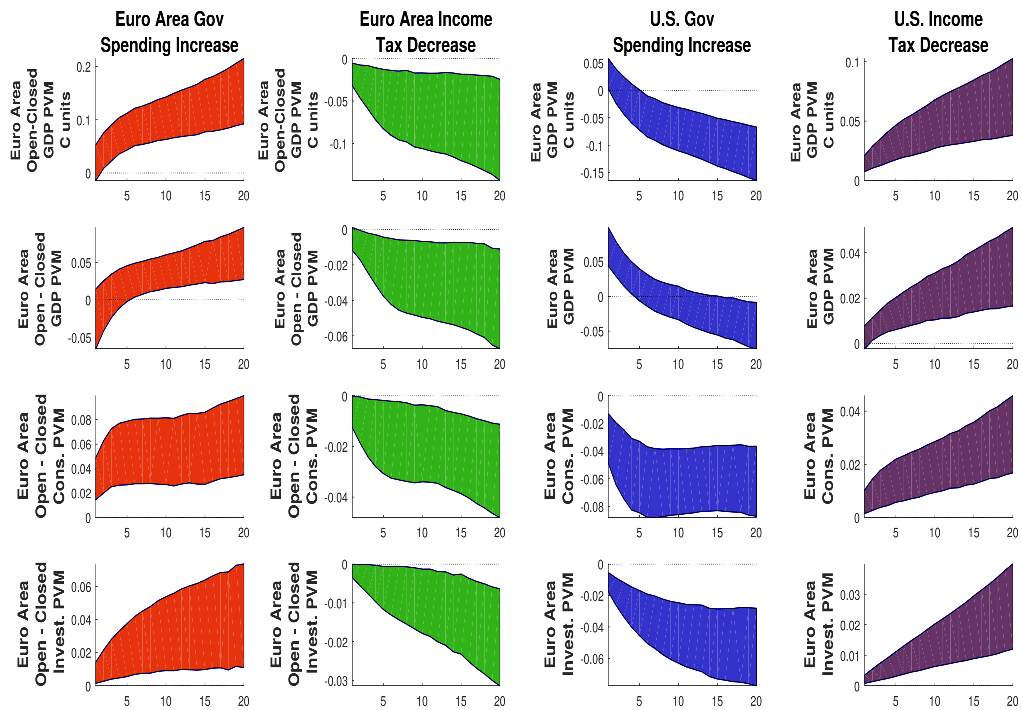


Figure A.16: 90 percent posterior intervals of Euro Area present-value multipliers relative to a counterfactually closed Euro Area.

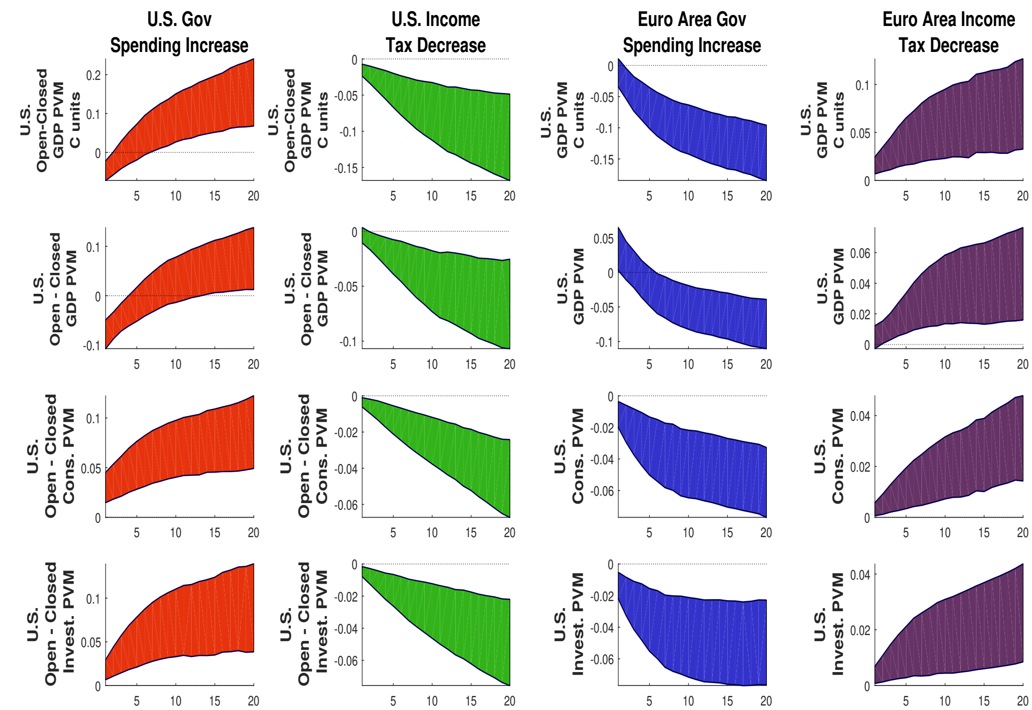


Figure A.17: 90 percent posterior intervals of U.S. present-value multipliers relative to a counterfactually closed U.S.