The Transmission of Foreign Demand Shocks: Online Appendix*

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This online appendix contains supplementary material about the data, the empirical methods, and the model-based analysis presented in the main paper. We also refer the reader to the replication package available online.

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A Empirical Appendix

This appendix contains various details about our empirical approach, data selection and transformation, and a battery of robustness checks of our empirical findings.

A.1 Data description

We begin by providing details about the data used for the empirical analysis.

A.1.1 List of countries

Table A.1 contains a complete list of the countries we consider in our baseline analysis, and the classification we apply. We consider the G7 countries as large economies, and the remaining 31 OECD members as small open economies.[1]

Table A.1: List of countries

Large countries	Canada, France, Germany, Italy, Japan, United Kingdom, United States of America.
Small countries	Australia, Austria, Belgium, Chile, Colombia, Costa Rica, Czech Republic, Denmark, Estonia, Finland, Greece, Hungary, Iceland, Ireland, Israel, Latvia, Lithuania, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, Slovenia, South Korea, Spain, Sweden, Switzerland, Turkey.

1. Some existing studies have considered Canada as a small open economy, e.g., Justiniano and Preston (2010). All our results are confirmed if we include Canada in the panel of small open economies.

A.1.2 Variable description

Symbol	Variable	Description	Measurement	Log
Y_{NT}	Non-tradable value added	Gross value added in services	Chained, SA	Yes
Y_T	Tradable value added	Gross value added in manufacturing	Chained, SA	Yes
C_{NT}	Consumption of non-tradables	Consumption of services	Chained, SA	Yes
C_T	Consumption of tradables	Cons. of non-durables + semidurables	Chained, SA	Yes
I	Investment	Gross capital formation	Chained, SA	Yes
X	Exports	Exports of goods and services	Chained, SA	Yes
M	Imports	Imports of goods and services	Chained, SA	Yes
N	Employment	Total employment	Hours, SA	Yes
Q	Real exchange rate	Real CPI effective exchange rate	Index	Yes
Y	Value added	$Y \equiv Y_T + Y_{NT}$	—	Yes
C	Consumption	$C \equiv C_T + C_{NT}$	—	Yes
wN	Real labor compensation	See text		Yes
w	Real wage rate	See text		Yes
π	Annual CPI inflation	See text		No
i	Nominal annual interest rate	See text		No
r	Real annual interest rate	See text		No
b^{cap}	Real credit (non-fin. sector)	See text		Yes

Table A.2: Variable description

Note: All data is quarterly and obtained from the OECD database (OECD, 2023a, 2023b, 2023c, 2023d, 2023e, 2023f, 2025i), except credit data (see below). All variables are detrended by a country-specific regression on $(1, t, t^2)$ after they have been transformed. "SA" indicates that a variable is seasonally adjusted. When constructing sums, we make sure to not simply add the underlying components, since these are chained, but to aggregate them appropriately.

Real labor compensation

Real labor compensation, $(wN)_t$, is computed as

$$(wN)_t = \frac{(WN)_t}{P_t^{\text{GDP}}},$$

where

- $(WN)_t$ is the total compensation of employees in current prices taken from OECD quarterly national accounts.
- P_t^{GDP} is computed as

$$P_t^{\text{GDP}} = \frac{\text{PGDP}_t}{\text{GDP}_t},$$

  where PGDP_t and GDP_t are nominal and chained volume estimates of GDP, respectively, taken from the OECD quarterly national accounts.

Real wage rate

The real wage rate, w_t, is computed as

$$w_t = \frac{(wN)_t}{N_t}.$$

Annual CPI inflation

Annual CPI inflation, π_t, is computed as

$$\pi_t = \frac{P_t}{P_{t-4}} - 1,$$

where P_t is the quarterly consumer price index taken from the OECD CPI database.

Nominal annual interest rate

The nominal annual interest rate, i_t, combines two short interest rate series, both taken from the OECD Monthly Monetary and Financial Statistics (MEI) database (OECD, 2023c):

- Immediate interest rates, Call Money, Interbank Rate.

- Short-term interest rate.

The two series are very closely correlated: Across country-years for which both are available, the correlation between them is 0.96. Thus, for each country, we simply use the longest series available.

Real annual interest rate

The real annual interest rate, r_t, is computed as

$$r_t = \frac{1 + i_t}{1 + \pi_{t+4}} - 1.$$

Real credit

As our measure of credit, we use credit to the private non-financial sector from the BIS database (see Bank for International Settlements, 2025). This series is available for most of the OECD countries. We convert the series to real terms in the same way as described above for labor compensation.

Measures of global economic activity

We employ the following measures of global economic activity:

- Index of Industrial Production in the OECD + Six Major Economies (Brazil, China, India, Indonesia, Russia, South Africa): The index was developed by Baumeister and Hamilton (2019), and an updated version is available from Christiane Baumeister's personal website.
- Index of Global Real Economic Activity: The index was developed by Kilian (2009). An updated version with the corrections described in Kilian (2019) is available from the FRED database (see Federal Reserve Bank of Dallas).
- CPB World Industrial Production Index: The index is developed and maintained by the CPB Netherlands Bureau for Economic Policy Analysis for the European Commission. The data is available from the CPB's World Trade Monitor webpage (see CPB Netherlands Bureau for Economic Policy Analysis, 2025).

- OECD-wide GDP is obtained directly from the OECD database as described above.
- Oil Price: We use the West Texas Intermediate Spot Crude Oil Price. The series is available from the FRED database (see Federal Reserve Bank of St. Louis).
- Commodity Price Index: We use the U.S. Producer Price Index for all commodities. The series is available from the FRED database (see U.S. Bureau of Labor Statistics).

Trade linkages

We calculate trade linkages based on data for "Gross exports" from the OECD Trade in Value-Added (TiVA) database (OECD, 2021b). Data is available from 1995 and we use data until and including 2019.

A.1.3 Construction of foreign variables

We compute a country-specific foreign variable for country j at time t, $z^*_{j,t}$, based on data for all 38 OECD countries over time, $z_{j,t}$, as follows (for example, $z_{j,t}$ could denote detrended log output):

1. **Compute raw weights.** Compute the raw weights based on exports:

$$w^{\text{raw}}_{j,p} = \frac{X_{j,p}}{\sum_{p=1}^{38} X_{j,p}} \quad \text{for } j, p = 1, \ldots, 38,$$

   where $X_{j,p}$ denotes country j's exports to country p. We use a simple time-average over 1995-2019.

2. **Adjust weights for interdependencies between small open economies.** To make sure that our "small open economy assumption" remains valid, we exclude from the construction of $z^*_{j,t}$ those countries for which country j represents a significant trading partner. Formally, if country p's exports to country j exceeds some cutoff ε, we set country p's weight in $z^*_{j,t}$ to 0:

$$\tilde{w}_{j,p} = \begin{cases} 0 & \text{if} \quad w^{\text{raw}}_{p,j} > \varepsilon \\ w^{\text{raw}}_{j,p} & \text{otherwise} \end{cases},$$

and re-scale the resulting weights to add up to 1 for each country:

$$w_{i,j} = \frac{\tilde{w}_{i,j}}{\sum_{j=1}^{38} \tilde{w}_{i,j}}.$$

In practice, we use a cutoff of $\varepsilon = 0.03$. To understand this step, consider Sweden as an example: Both Germany and Finland are important trading partners for Sweden. From the viewpoint of Germany, however, Sweden is not a quantitatively important trading partner, so we can safely assume that the German business cycle is exogenous to the Swedish economy. From the viewpoint of Finland, instead, Sweden is a significant trading partner, and the exogeneity assumption is violated. Hence, we include Germany in the computation of $z^*_{j,t}$ for Sweden, but exclude Finland.

To make sure our results are not too sensitive to this approach, we consider two alternatives. The first is to use only the G7 countries (appropriately weighted) in the construction of the country-specific foreign variables. The second is to use the same foreign economy for all countries, i.e., $z^*_{j,t} = z^*_t, \forall j$. The results from these exercises—which are reported in Figures A.17 and A.18—are very similar to those obtained with our baseline specification.

3. **Compute time-varying weights.** For each point in time, denote the set of countries for which data is available by $\mu(t)$. Define the weight at time t as the weight over these countries:

$$w_{j,p,t} = \begin{cases} \frac{w_{j,p}}{\sum_{p \in \mu(t)} w_{j,p}} & \text{if} \quad p \in \mu(t) \\ 0 & \text{otherwise.} \end{cases}$$

4. **Construct the foreign variable.**

   (a) Set the initial value of $z^*_{j,t}$ to the weighted average of the variable in question across the trading partners for which data is available in the first period:

   $$z^*_{j,0} = \sum_{p=1}^{38} w_{j,p,0} z_{p,0}.$$

   (b) Update $z^*_{j,t}$ at time $t = 1, \ldots, T$ using the weighted average of the

difference in the variable in question across trading partners:

$$z^*_{j,t} = z^*_{j,t-1} + \sum_{p=1}^{38} w_{j,p,t} \Delta z_{p,t}$$

When we consider a balanced panel of countries, step 3 becomes irrelevant, as the weights will be constant over time ($w_{j,p,t} = w_{j,p}$ for all t), so that $z^*_{j,t}$ is simply a weighted average of the relevant variable across trading partners at all points in time:

$$z^*_{j,t} = \sum_{p=1}^{38} w_{j,p} z_{p,t}.$$

As shown in Figure A.16, our empirical findings are largely unaltered when we use a balanced panel of countries (starting in 1996).

A.1.4 Data for analysis of fiscal consolidations

For the study of fiscal consolidations in Section 2.7, we rely on annual instead of quarterly data, since the shock series itself is available at the annual frequency. For most variables, we simply rely on the annual versions of the quarterly data series described in Appendix A.1.2.[2] We use data from the OECD (OECD, 2025a, 2025b, 2025c, 2025d, 2025e, 2025g, 2025h).

The fiscal consolidations shock series developed by Guajardo et al. (2014) and updated by Adler et al. (2024) covers the following 21 OECD countries for the sample period 1978-2019: Australia, Austria, Belgium, Canada, Chile, Colombia, Costa Rica, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Mexico, Netherlands, Portugal, Spain, Sweden, United Kingdom, United States.

A.2 Sign restrictions

We continue with additional details about our identification strategy.

2. The response of the real interest rate is computed by subtracting the response of the inflation rate (leaded by one period) from that of the nominal interest rate.

A.2.1 Method

We define the 4×4 matrix of horizon-h (reduced form) impulse responses as:

$$C_h \equiv \begin{pmatrix} \beta_{1,h} & \beta^{Y}_{1,h} & \beta^{\pi}_{1,h} & \beta^{i}_{1,h} \\ \beta_{2,h} & \beta^{Y}_{2,h} & \beta^{\pi}_{2,h} & \beta^{i}_{2,h} \\ \beta_{3,h} & \beta^{Y}_{3,h} & \beta^{\pi}_{3,h} & \beta^{i}_{3,h} \\ \beta_{4,h} & \beta^{Y}_{4,h} & \beta^{\pi}_{4,h} & \beta^{i}_{4,h} \end{pmatrix},$$

for $h = 1, \ldots, H$ and $C_0 = I$. As in Rubio-Ramírez et al. (2010), the structural horizon-h impulse-response matrix is

$$\Theta_h = C_h B Q,$$

where Q is a 4×4 orthogonal matrix, and BB' is the Cholesky decomposition of the covariance matrix of the Wold innovation $\varepsilon_{t,h} = (\varepsilon_{t,1}, \varepsilon^{y}_{t,1}, \varepsilon^{\pi}_{t,1}, \varepsilon^{i}_{t,1})'$, such that B has strictly positive diagonal elements, c.f. Plagborg-Møller and Wolf (2021). Sign restrictions can then be imposed as follows, for each $n = 1, 2, ..., N$:

1. Draw $Q^{(n)}$ from the subspace of a uniform distribution of 4×4 orthogonal matrices consistent with the relevant zero restrictions (i.e., the "small open economy assumption"), following Arias et al. (2018).

2. Draw $C^{(n)}_h$ from a normal distribution with mean C_h and standard deviation given by the estimated standard errors of C_h, for all h.

3. Compute $\Theta^{(n)}_h = C^{(n)}_h B Q^{(n)}$, for all h.

4. If the following condition is satisfied, keep the draw of $Q^{(n)}$:

$$S_m \Theta^{(n)} e_m \geq 0, \quad m = 1, 2, 3, 4,$$

   where $\Theta^{(n)} \equiv (\Theta^{(n)'}_0, \Theta^{(n)'}_1, \ldots, \Theta^{(n)'}_H)'$, and S_m is a matrix set to impose the sign restrictions (see details below), as in Rubio-Ramírez et al. (2010). e_m denotes column m of a 4×4 unit matrix.

5. If the number of accepted draws of Q exceeds a given threshold (which we set to 1000), stop. Otherwise set $n = n + 1$, and return to step 1.

The impulse responses reported in the paper (as well as those in the robustness

checks below) represent the median of the accepted impulse responses, while the confidence bands reflect the percentiles of the distribution of these.

Table A.3 presents a complete summary of the sign and zero restrictions we impose. All of these are imposed only on impact. We have checked that our findings are robust when we impose the restrictions for several quarters after the shock. As discussed in the main text, all of these assumptions are in line with existing work.

Table A.3: Structural restrictions

	Domestic	Foreign demand	Foreign supply	Foreign mon. pol.
Z	+	*	*	*
Y^*	0	+	+	+
π^*	0	+	-	+
i^*	0	+	-	-

Note: Rows indicate variables, and columns indicate structural shocks. "+" indicates a positive sign restriction (i.e., a positive response of a given variable to a *positive* shock of a given type), and "-" a negative one. "0" indicates a zero restriction, while "*" indicates that the response is not restricted.

Implementing the restrictions in Table A.3 requires setting the matrices S_m as:[3]

$$S_1 = \begin{pmatrix} 1 & 0 & 0 & 0 \end{pmatrix}, \qquad S_2 = \begin{pmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix},$$

$$S_3 = \begin{pmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{pmatrix}, \qquad S_4 = \begin{pmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 \end{pmatrix}.$$

The entire procedure can also be carried out using a structural VAR model instead of local projections. To do this, we simply replace the 4×4 matrix of horizon-h impulse responses C_h by the equivalent SVAR impulse responses.

A.3 Implied shock series from LP regressions

In this appendix, we report the implied shocks obtained from our baseline empirical approach based on sign restrictions, as outlined in Section 2.1. We also compute correlations with identified shock series from the existing literature, so as to

3. For simplicity, we omit the zero columns here since the restrictions are only imposed on impact.

validate that our shocks are capturing demand, supply, and monetary policy disturbances, respectively. Since our baseline approach is to construct country-specific foreign variables ($Y^*_{j,t}$, $\pi^*_{j,t}$, $i^*_{j,t}$) for each country j, our estimation procedure produces country-specific shock series for each of the foreign shocks, rather than one common shock series for, e.g., foreign demand shocks. We then report the implied shocks for each of the small open economies (obtained as the average across the draws in the sign-restriction procedure).[4]

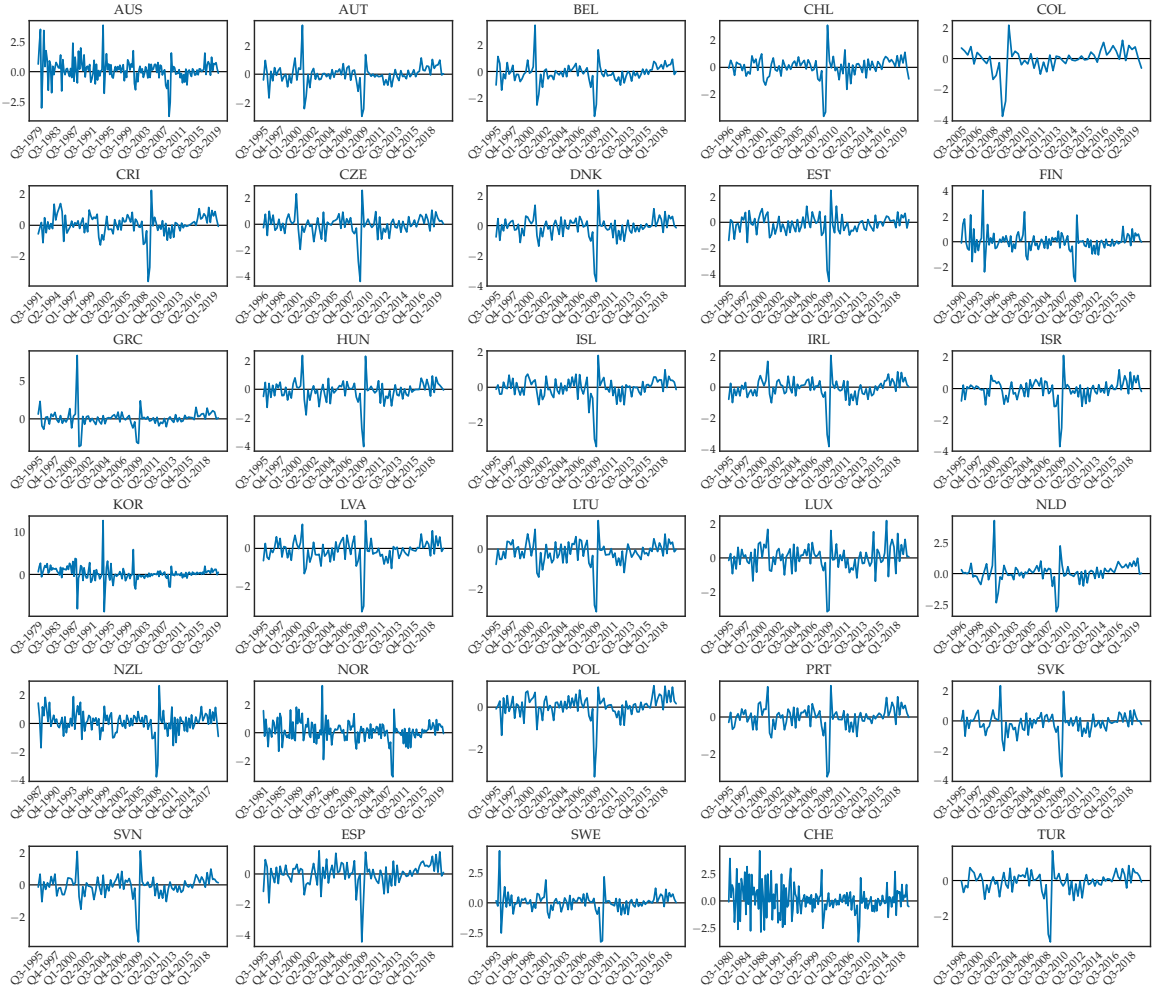


Figure A.1: Foreign demand shocks

Note: Estimated foreign demand shocks. The reported shocks are the average across draws, and obtained from regressions with exports on the left-hand side.

4. Our empirical approach implies that we estimate the entire system of equations, (2.1)-(2.4), for each domestic variable. As a result, we obtain "variable-specific" series for each of the foreign shocks. In practice, the implied foreign shock series from the different regressions display a very high correlation (typically > 0.95). Thus, while Figures A.1-A.3 report implied shocks from regressions with domestic exports on the left-hand side, this choice makes virtually no difference.

The implied shocks to foreign demand, supply, and monetary policy are reported in Figures A.1-A.3.[5] For each type of shock, the series display a high degree of cross-country correlation, with the median country-pair correlation (excluding self-correlations) equal to 0.83 for both demand and supply shocks, and slightly higher for monetary policy shocks. This is consistent with our finding that using a common foreign economy for all countries (that is, $Y^*_{j,t} = Y^*_t, \forall j$, and similar for $\pi^*_{j,t}$ and $i^*_{j,t}$) yields results very similar to our baseline (see Appendix Figure A.18).

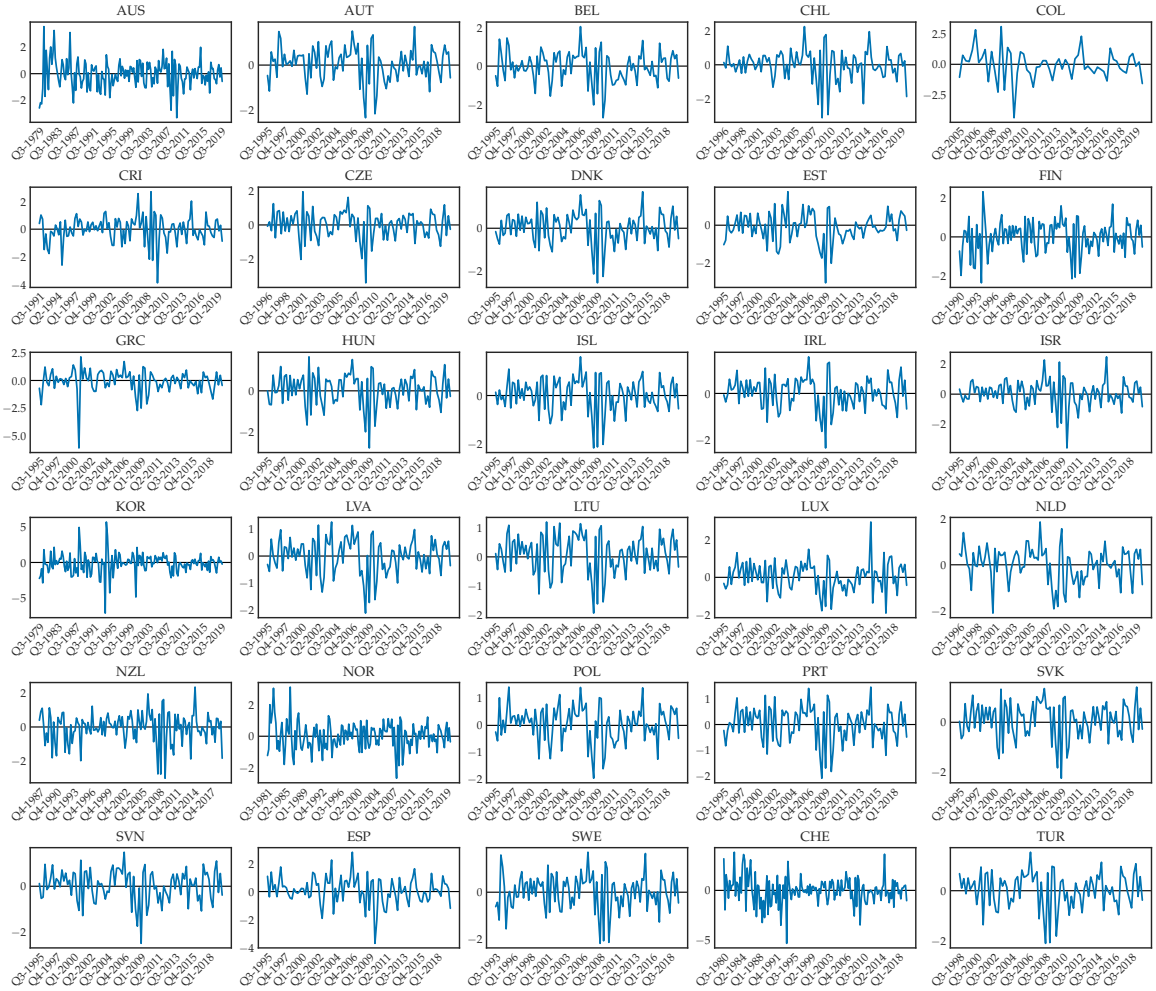


Figure A.2: Foreign supply shocks

Note: Estimated foreign supply shocks. The reported shocks are the average across draws, and obtained from regressions with exports on the left-hand side.

Next, we consider the correlation between the implied foreign shocks and other

5. While there are 31 countries in our sample, the OECD database does not have data on exports for Mexico, which is therefore not included in these figures.

identified shock series from the existing literature. For a range of relevant identified shock series, we compute their correlation (and the associated p-values) with each of the 30 country-specific foreign shocks reported in Figures A.1-A.3. We summarize these results by reporting the median correlation across countries and the number of country-level correlations that are statistically significant at the 5 percent level. For foreign demand shocks, Table A.4 shows that our shocks display some correlation (0.16) with the U.S. military spending shocks of Ramey (2011), though this relationship is significant only in two of the 30 countries. We observe no correlation with other fiscal shocks. We also find some (negative) correlation with the uncertainty measure of Bloom (2009), but not with other uncertainty shocks. Finally, we find evidence of a negative correlation with the financial shocks of Gilchrist and Zakrajšek (2012). In sum, our shocks are correlated with some existing series with the expected sign, but the magnitude of the correlations is modest.

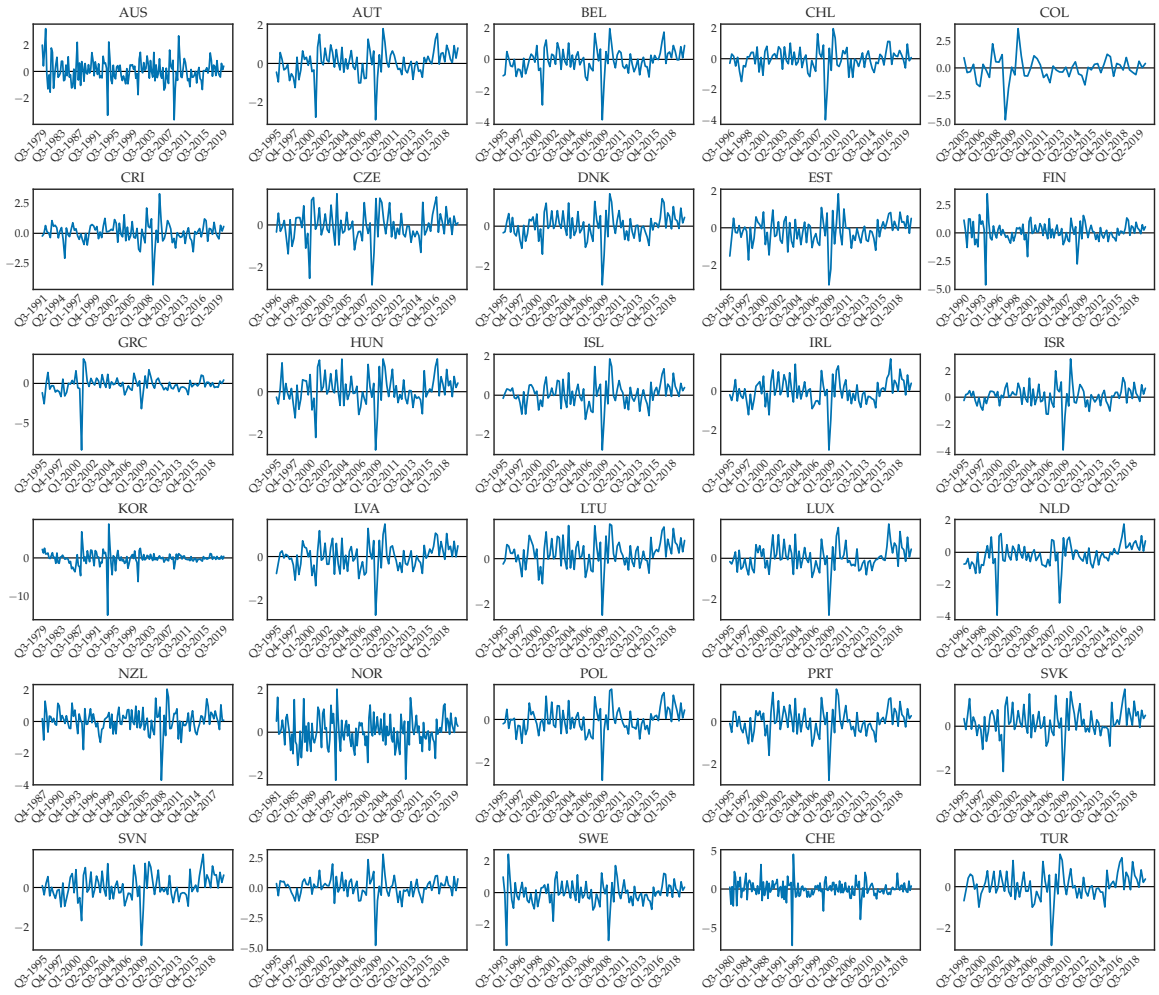


Figure A.3: Foreign monetary policy shocks

Note: Estimated foreign monetary policy shocks. The reported shocks are the average across draws, and obtained from regressions with exports on the left-hand side.

Turning to foreign supply shocks, Table A.5 shows that our shocks correlate with some other supply-side shocks in the form of the oil supply news shocks of Känzig (2021) as well as the oil supply shocks of Caldara et al. (2019), with weaker evidence of a correlation with some of the other oil supply shocks. The correlations have the expected signs, as a positive realization of our shocks implies a positive supply shock, in line with Caldara et al. (2019), while the opposite is true for the measure of Känzig (2021). This suggests that our shocks are indeed capturing supply disturbances.

Finally, as seen from Table A.6, our monetary policy shocks display some correlation with existing monetary policy shocks. In particular, they are correlated with the Euro area shocks of Jarociński and Karadi (2020) as well as the U.S. monetary policy

shocks from Romer and Romer (2004) and from the estimated model of Smets and Wouters (2007). The negative correlation reflects that a positive value of the shocks in Figure A.3 corresponds to an expansionary shock, while the opposite is true for the remaining shock series. Thus, our measure is consistent with these.

Table A.4: Correlation of demand shocks with other identified demand shocks

	Median correlation	# countries with p < 0.05	Sample
Fiscal shocks			
Ramey (2011)	0.16	2	1979:Q3 - 2015:Q4
Auerbach and Gorodnichenko (2012)	0.06	0	1979:Q3 - 2019:Q4
Romer and Romer (2010)	-0.06	0	1979:Q3 - 2007:Q4
Fisher and Peters (2010)	0.03	0	1979:Q3 - 2008:Q4
Uncertainty shocks			
Ahir et al. (2022)	-0.02	0	1990:Q1 - 2019:Q4
Piffer and Podstawski (2018)	0.02	1	1979:Q3 - 2019:Q4
Bloom (2009)	-0.17	9	1979:Q3 - 2017:Q4
Baker et al. (2016)	-0.08	0	1985:Q3 - 2017:Q4
Financial shocks			
Bassett et al. (2014)	0.04	0	1992:Q1 - 2010:Q4
Gilchrist and Zakrajšek (2012)	-0.22	19	1979:Q3 - 2015:Q4

Note: The first column reports the median across countries of the correlation between the relevant identified shock series and our implied foreign demand shocks. The second column reports the number of countries (out of 30) for which the correlation is statistically significant, as measured by a p-value below 0.05. The third column reports the sample period for which we have employed each of the shocks.

Table A.5: Correlation of supply shocks with other identified supply shocks

	Median correlation	# countries with p < 0.05	Sample
Productivity shocks			
Smets and Wouters (2007)	-0.05	0	1979:Q3 - 2004:Q4
Basu et al. (2006)	-0.09	0	1979:Q3 - 2011:Q4
Oil supply shocks			
Känzig (2021) (news)	-0.28	27	1979:Q3 - 2019:Q4
Baumeister and Hamilton (2019)	0.08	4	1979:Q3 - 2017:Q4
Kilian (2009)	0.03	0	1979:Q3 - 2019:Q4
Caldara et al. (2019)	0.19	7	1985:Q1 - 2015:Q4
Kilian (2008)	0.13	1	1979:Q3 - 2004:Q3
Other oil shocks			
Hamilton (2003) (oil price)	-0.13	5	1979:Q3 - 2017:Q4
Kilian (2009) (oil-spec. demand)	0.04	0	1979:Q3 - 2017:Q4

Note: The first column reports the median across countries of the correlation between the relevant identified shock series and our implied foreign supply shocks. The second column reports the number of countries (out of 30) for which the correlation is statistically significant, as measured by a p-value below 0.05. The third column reports the sample period for which we have employed each of the shocks.

Table A.6: Correlation of monetary policy shocks with other identified MP shocks

	Median correlation	# countries with p < 0.05	Sample
US monetary policy shocks			
Jarociński and Karadi (2020)	0.09	2	1990:Q1 - 2019:Q4
Romer and Romer (2004)	-0.21	3	1979:Q3 - 2007:Q4
Smets and Wouters (2007)	-0.27	8	1979:Q3 - 2004:Q4
Gertler and Karadi (2015)	0.06	1	1990:Q1 - 2016:Q4
Euro area monetary policy shocks			
Jarociński and Karadi (2020)	-0.25	23	1999:Q1 - 2019:Q4

Note: The first column reports the median across countries of the correlation between the relevant identified shock series and our implied foreign MP shocks. The second column reports the number of countries (out of 30) for which the correlation is statistically significant, as measured by a p-value below 0.05. The third column reports the sample period for which we have employed each of the shocks.

A.4 Investment and credit

We now consider the impulse response of investment and credit following a foreign demand shock, otherwise employing our main specification.

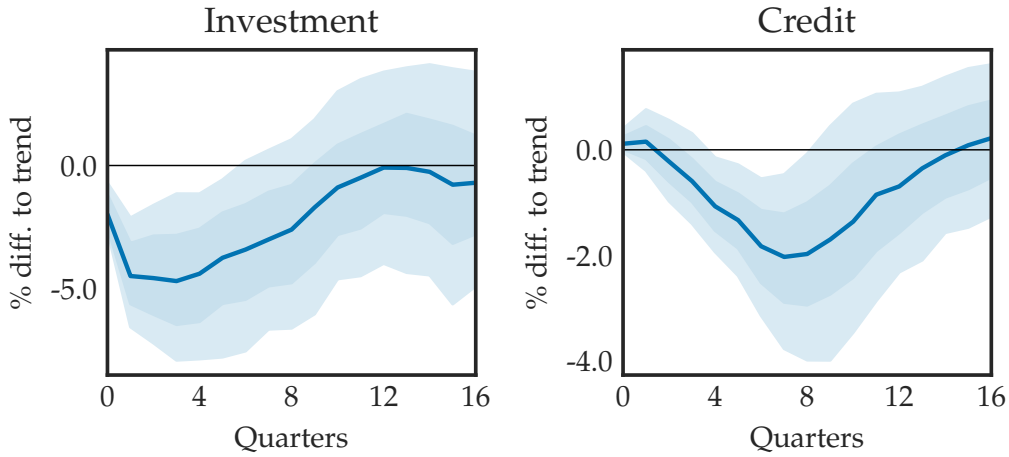


Figure A.4: LP results for investment and credit

Note: See Figure 2.

A.5 Details of the variance decomposition

In order to compute the Forecast Error Variance Decomposition (FEVD), we take the simple approach of following the SVAR literature, which provides a mapping from structural impulse responses to the FEVD. This facilitates comparison between our results and the existing literature, which builds mostly on SVAR models.

To account for the fact that our data is pooled across several countries, we estimate the FEVD separately for each country, and then report quantiles over the set of FEVDs across all countries. We do this because otherwise the estimator of the FEVD can be severely (downward) biased. Intuitively, the IRF recovered using the pooled estimator represents an average IRF across countries. However, using the average IRF for all countries to measure the FEVD may understate the average FEVD, because the "true" IRF is different for each country. A similar issue arises when estimating the R^2 in a standard pooled linear regression.

We compute the FEVD as follows. For each accepted draw, we calculate the contribution of shock j to the variance of variable i at horizon h by accumulating the squared structural impulse responses as follows. The h-step mean-squared forecast error of variable i is $\sum_{k=1}^{K}\sum_{l=0}^{h}\Theta_{i,k,l}^2$, and the portion attributable to shock j is $\sum_{l=0}^{h}\Theta_{i,j,l}^2$. Thus, the FEVD is

$$\text{FEVD}_{i,j,h} = \frac{\sum_{l=0}^{h}\Theta_{i,j,l}^2}{\sum_{k=1}^{K}\sum_{l=0}^{h}\Theta_{i,k,l}^2}.$$

Here, $\Theta_{i,j,l}$ is the structural impulse response of variable i to shock j at horizon l. This is calculated for every accepted draw in the simulation.

In Table A.7 we report the FEVD of each variable at selected horizons alongside quantiles across the distribution of countries.

Table A.7: Forecast error variance decomposition (FEVD) of foreign demand shocks

h	Y	C	X	M
4	22.1 (2.3,45.5)	5.8 (0.9,19.4)	12.8 (1.9,39.1)	15.1 (1.7,48.1)
16	23.5 (9.8,43.9)	16.6 (8.3,30.8)	22.4 (8.7,44.1)	25.6 (9.9,44.0)
∞	26.6 (13.7,40.9)	21.4 (11.2,32.3)	28.4 (13.1,41.0)	26.2 (13.8,41.2)

Note: $h \to \infty$ refers to $h = 40$. Parentheses indicate 2.5% and 97.5% quantiles across countries.

A.6 Empirical robustness checks

We now turn to the results from a series of empirical sensitivity checks.

A.6.1 Controlling for Kilian index

We consider using the Kilian index as a control variable in the main regressions. The IRFs are shown in Figure A.5.

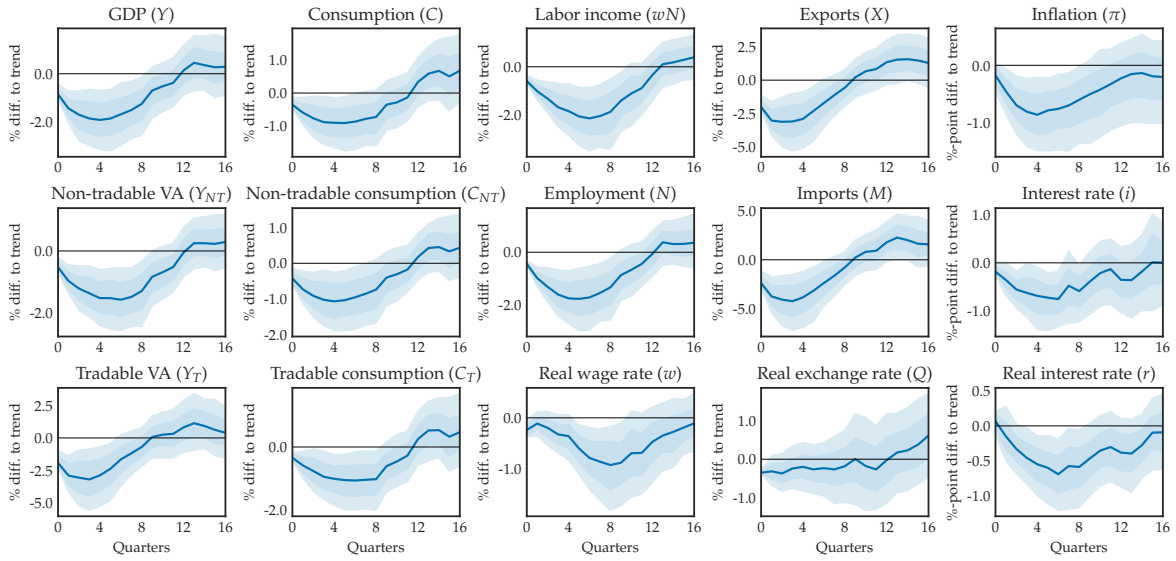


Figure A.5: LP results controlling for the Kilian index.

Note: See Figure 2.

A.6.2 Controlling for CPB index

We consider using the CPB index as a control variable in the main regressions. The IRFs are shown in Figure A.6.

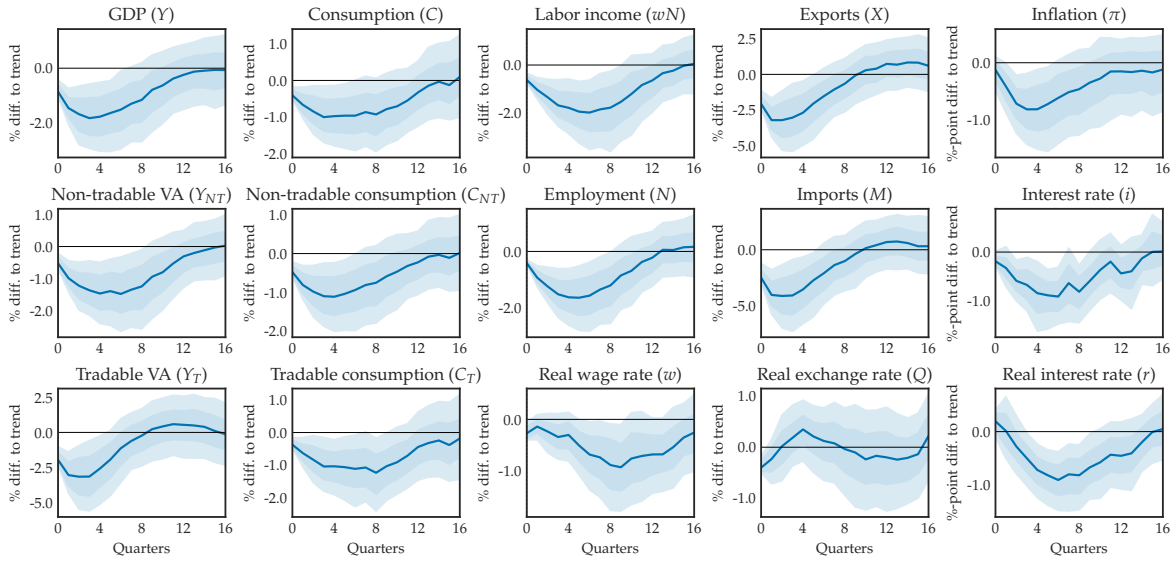


Figure A.6: LP results controlling for the CPB index.

Note: See Figure 2.

A.6.3 Controlling for OECD-wide GDP

We consider using OECD-wide GDP as a control variable in the main regressions. The IRFs are shown in Figure A.7.

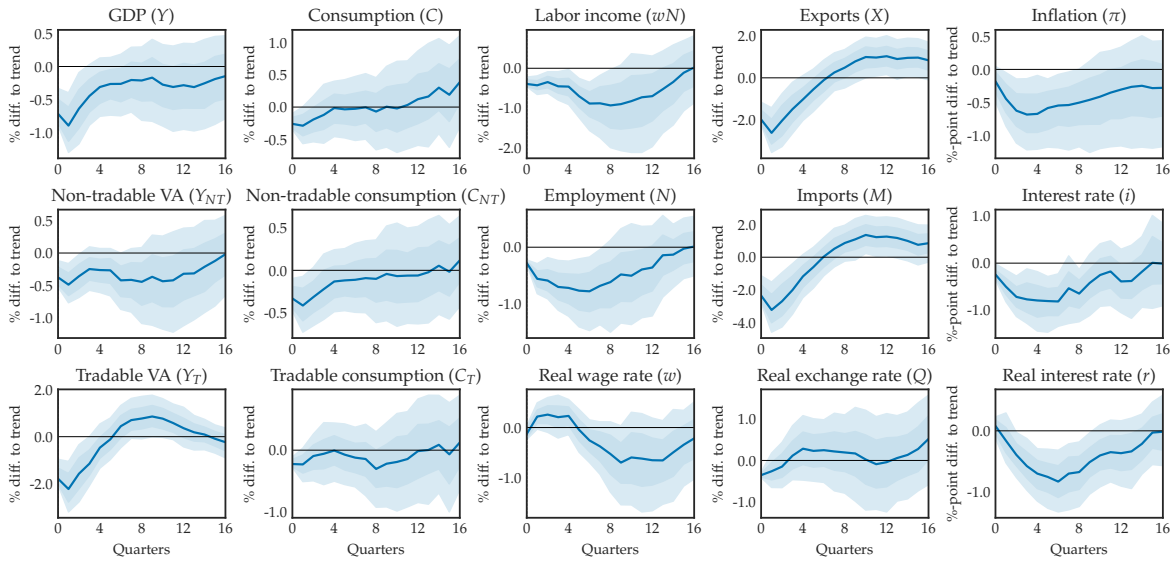


Figure A.7: LP results controlling for OECD GDP.

Note: See Figure 2.

A.6.4 Controlling for oil price

We consider using the oil price as a control variable in the main regressions. The IRFs are shown in Figure A.8.

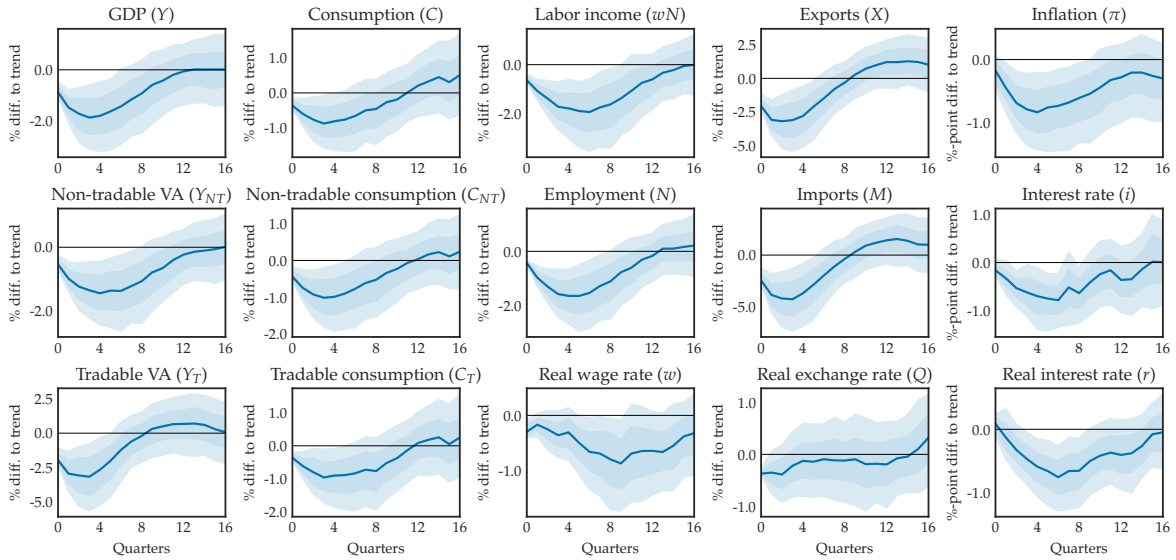


Figure A.8: LP results controlling for the oil price.

Note: See Figure 2.

A.6.5 Controlling for commodity price

We consider using commodity prices as a control variable in the main regressions. The IRFs are shown in Figure A.9.

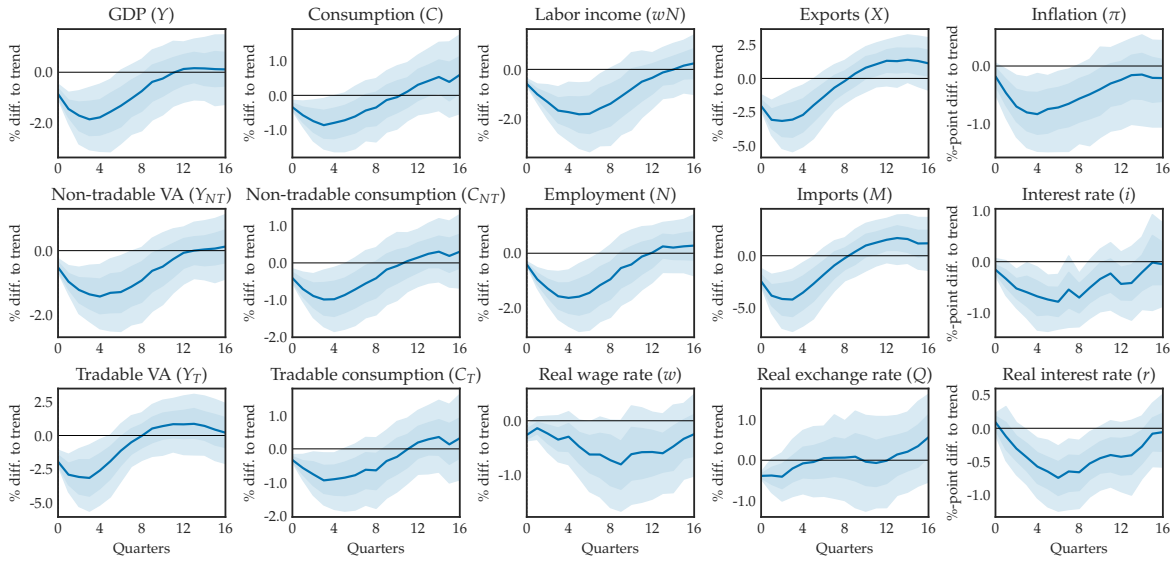


Figure A.9: LP results controlling for commodity prices.

Note: See Figure 2.

A.6.6 Controlling for Global Financial Crisis dummy

We consider using a dummy for the Global Financial Crisis as a control variable in the main regressions. The IRFs are shown in Figure A.10.

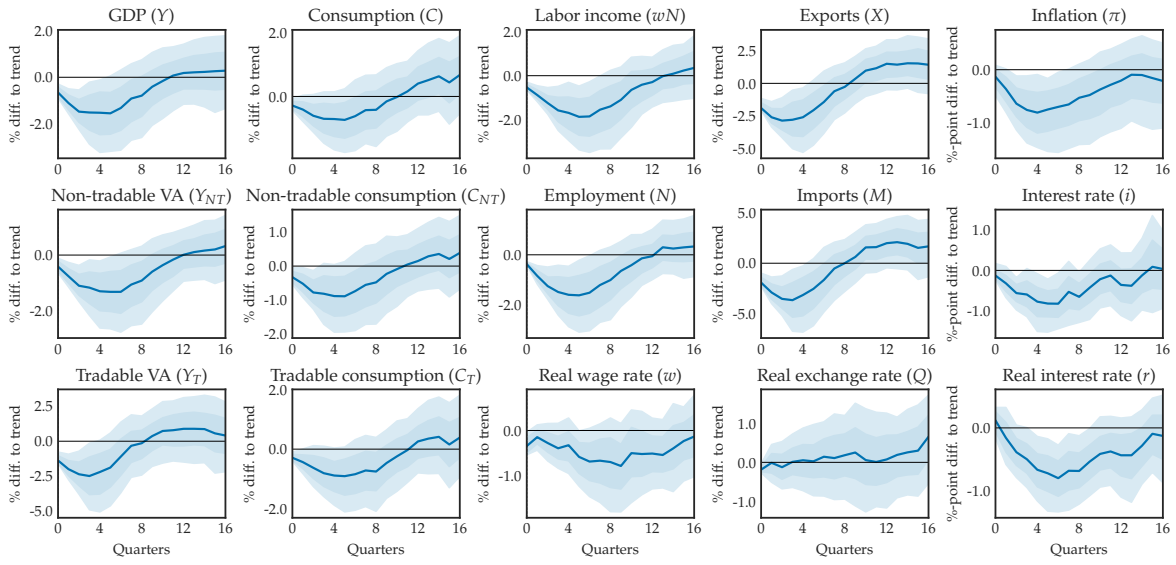


Figure A.10: LP results controlling for GFC dummy.

Note: See Figure 2.

A.6.7 Excluding the US

We consider a case where we set the weight of the US to zero in the construction of foreign variables, so as to exclude the U.S. economy entirely from our analysis.

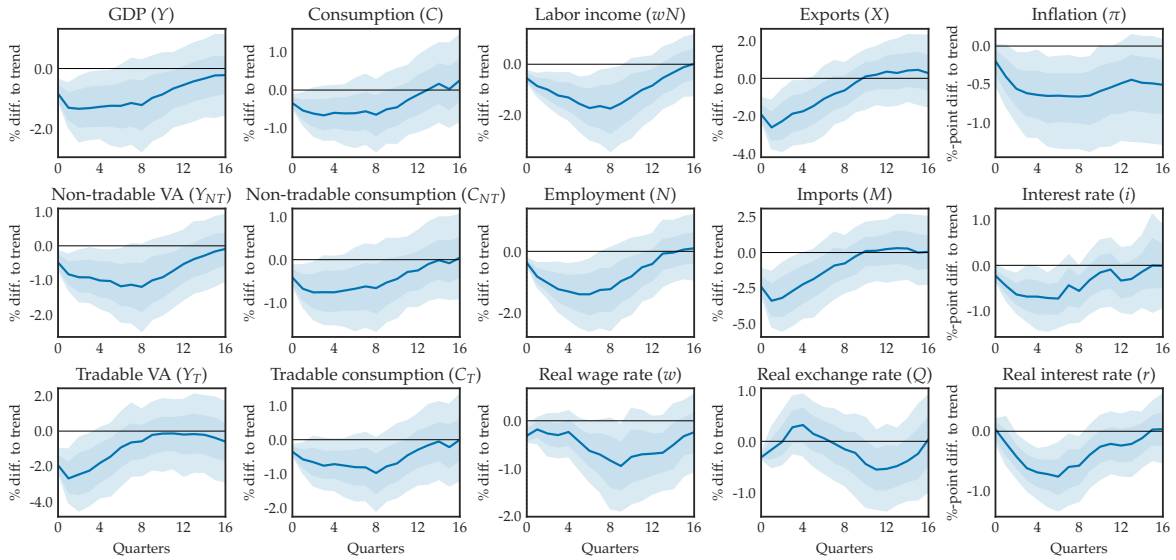


Figure A.11: LP results when excluding the US.

Note: See Figure 2.

A.6.8 Fixed and floating exchange rates

We estimate the IRFs separately for fixed and floating exchange rate countries. We follow the classification of country-episodes into exchange rate regimes of Ilzetzki et al. (2019). In particular, we use their monthly coarse classification, and collapse this to the quarterly frequency by averaging. We then denote a country as having a fixed exchange rate in a given quarter if the value of the classification is below 2, and a floating exchange rate otherwise. The results for each sample are shown in Figures A.12 and A.13.

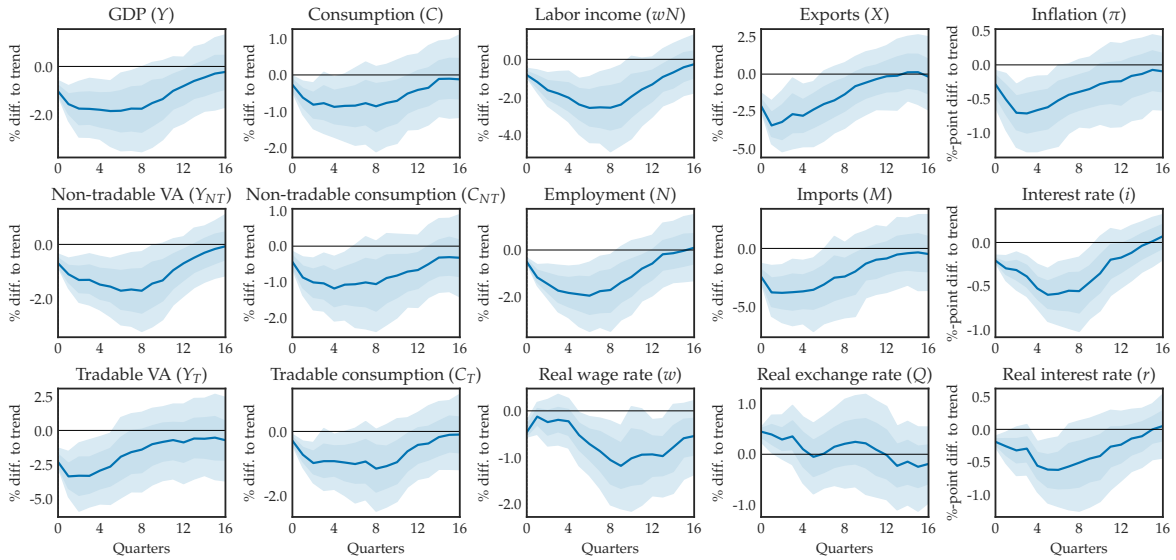


Figure A.12: LP results with fixed exchange rate countries only

Note: See Figure 2.

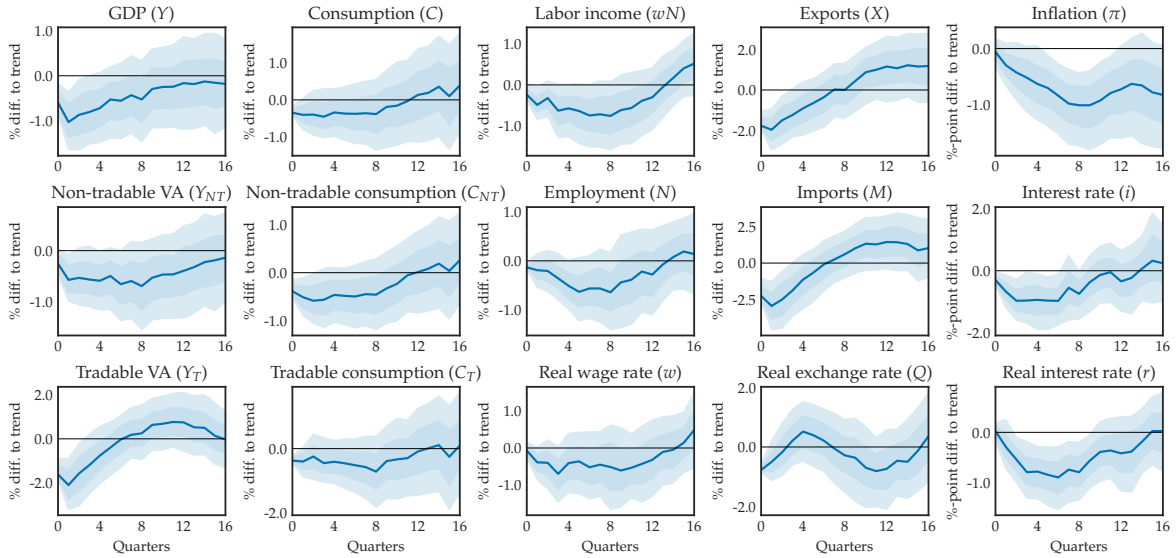


Figure A.13: LP results with floating exchange rate countries only

Note: See Figure 2.

A.6.9 Structural Vector Autoregression

We consider using a structural VAR model instead of local projections. The results are reported in Figure A.14 (solid blue lines). As seen from the figure, this produces results that largely appear like smoothed versions of our LP results (dashed black lines), consistent with the insights of Plagborg-Møller and Wolf (2021).

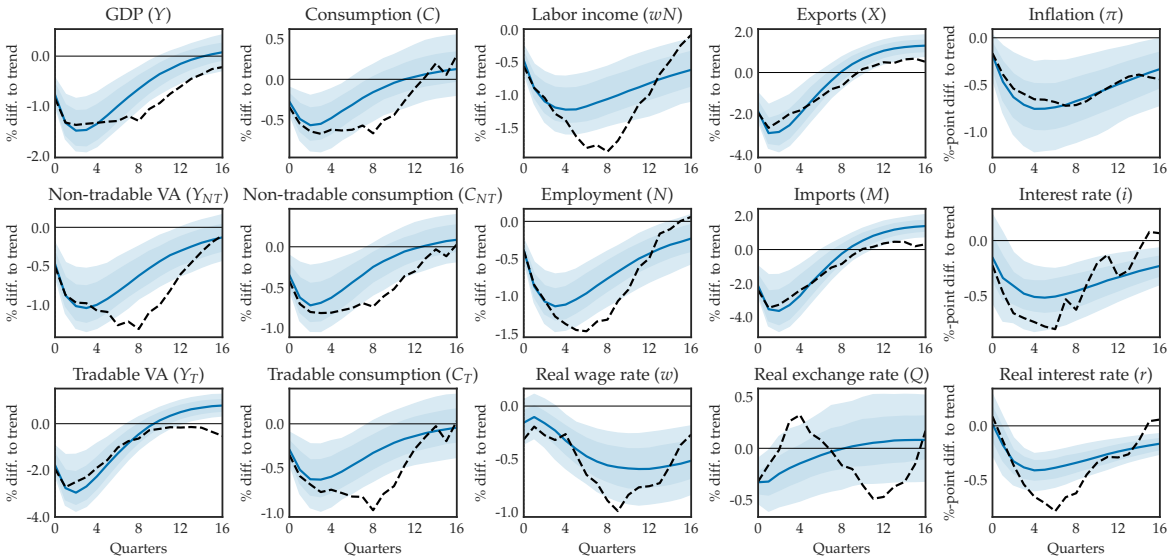


Figure A.14: SVAR IRFs

Note: The figure plots SVAR-based IRFs (solid blue lines) alongside the associated 95 and 68 pct. confidence intervals. For ease of comparison, the figure also reports our baseline LP results presented in Figure 2 (dashed black lines). The SVAR does not include a global control.

A.6.10 More lags

We use $p = 4$ lags instead of $p = 2$. The IRFs are shown in Figure A.15.

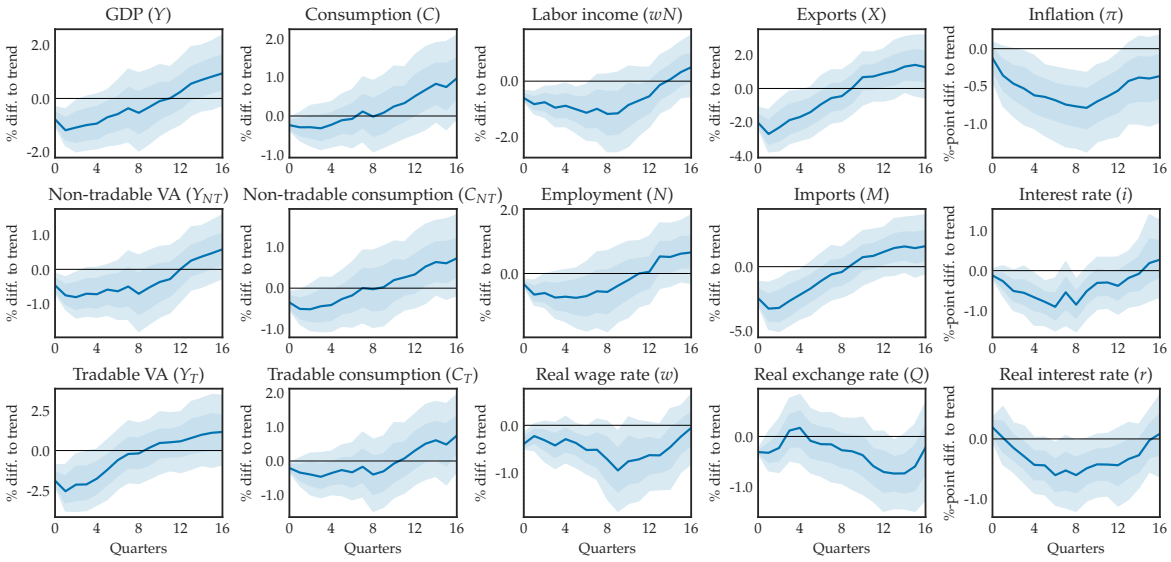


Figure A.15: LP results with 4 lags

Note: See Figure 2.

A.6.11 Balanced sample

We restrict the sample to a balanced panel starting in 1996. The IRFs are shown in Figure A.16.

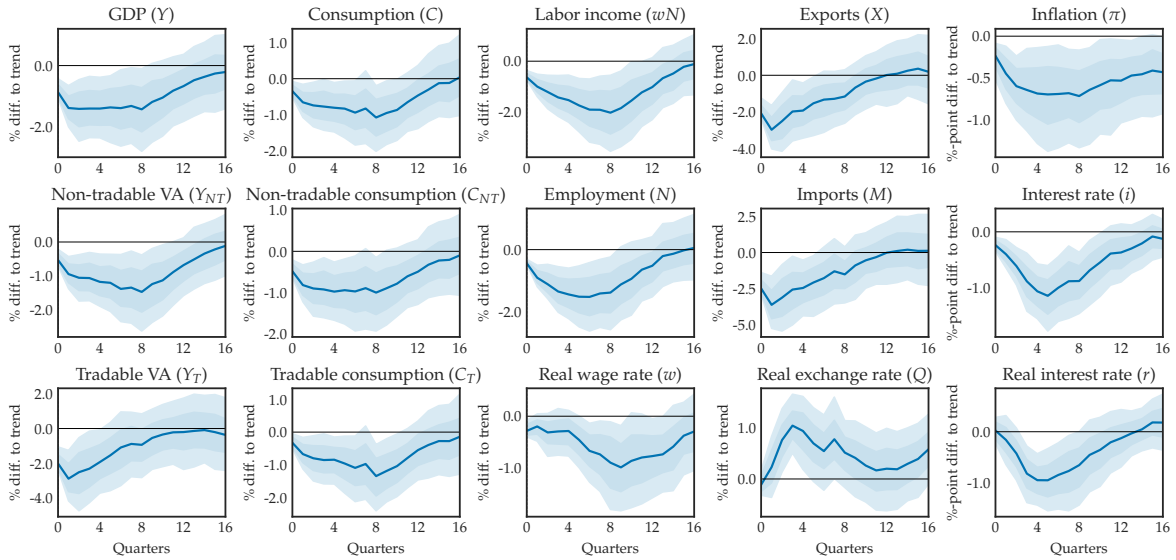


Figure A.16: LP results with balanced panel starting in 1996

Note: See Figure 2.

A.6.12 Only large economies on right-hand side

We consider constructing $Y^*_{j,t}$ using only large economies (the G7). For the list of large economies, see Table A.1. The IRFs are shown in Figure A.17.

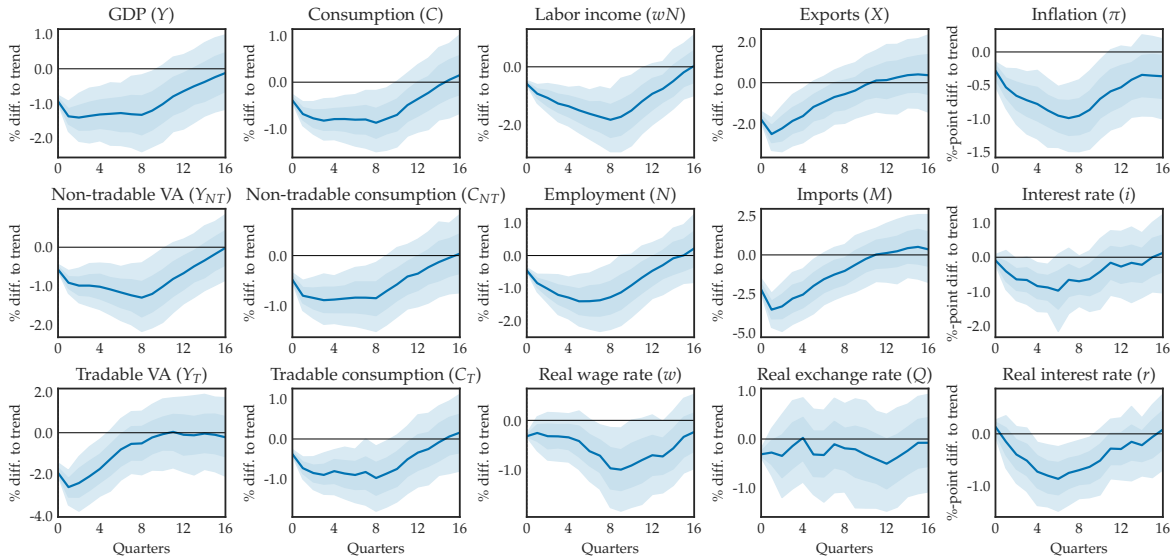


Figure A.17: LP results with only G7 economies used in the construction of $Y^*_{j,t}$.

Note: See Figure 2.

A.6.13 Common foreign economy

We consider constructing a common foreign economy using GDP weights, such that $Y^*_{j,t} = Y^*_t, \forall j$. The IRFs are shown in Figure A.18.

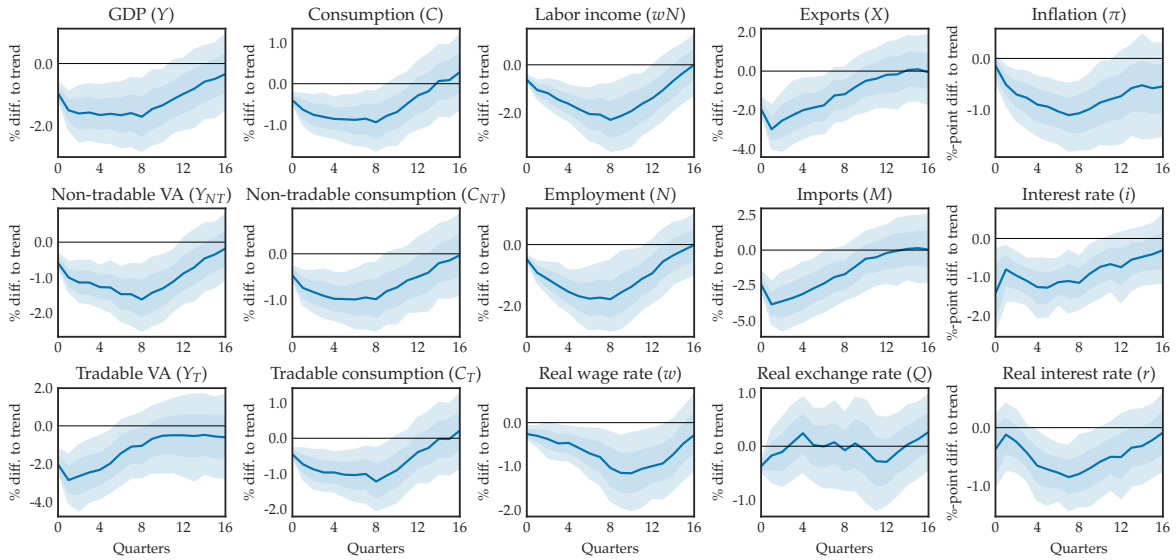


Figure A.18: LP results with a common foreign economy.

Note: See Figure 2.

A.6.14 No sign restrictions

We consider estimating IRFs without sign restrictions, i.e. simply estimating

$$Z_{j,t+h} = \beta_h Y^*_{j,t} + \sum_{k=1}^{p} \delta^Z_{h,k} Z_{j,t-k} + \sum_{k=1}^{p} \delta^{Y^*}_{h,k} Y^*_{j,t-k} + \gamma_h V_{t+h} + \varepsilon_{j,t,h}, \tag{A.1}$$

The IRFs are shown in Figure A.19.

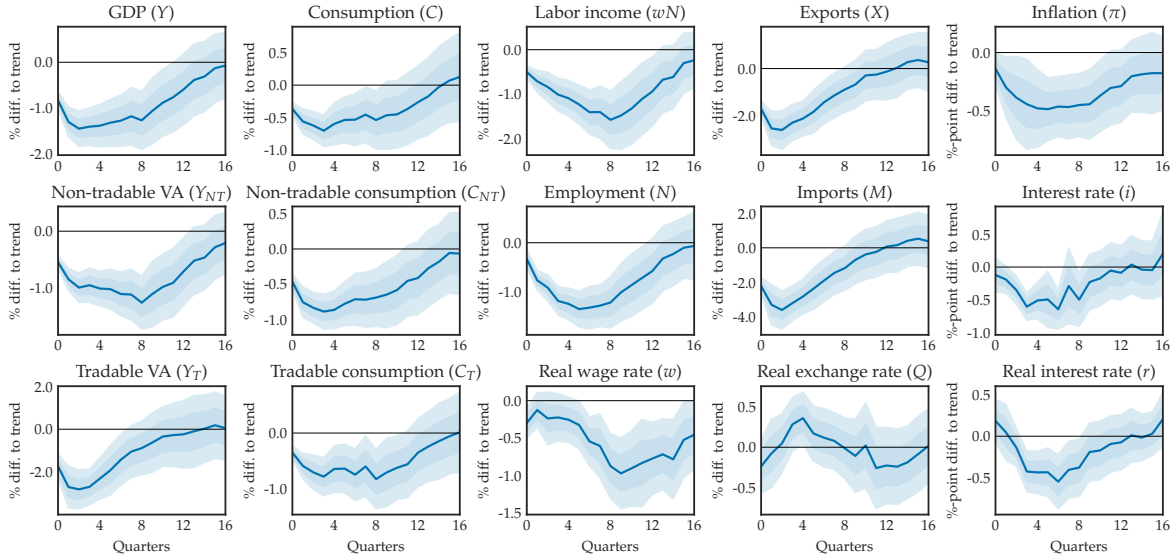


Figure A.19: LP results without sign restrictions.

Note: See Figure 2.

A.6.15 Long-run restrictions

We consider estimating the effects of foreign demand shocks with long-run restrictions. The IRFs are shown in Figure A.20.

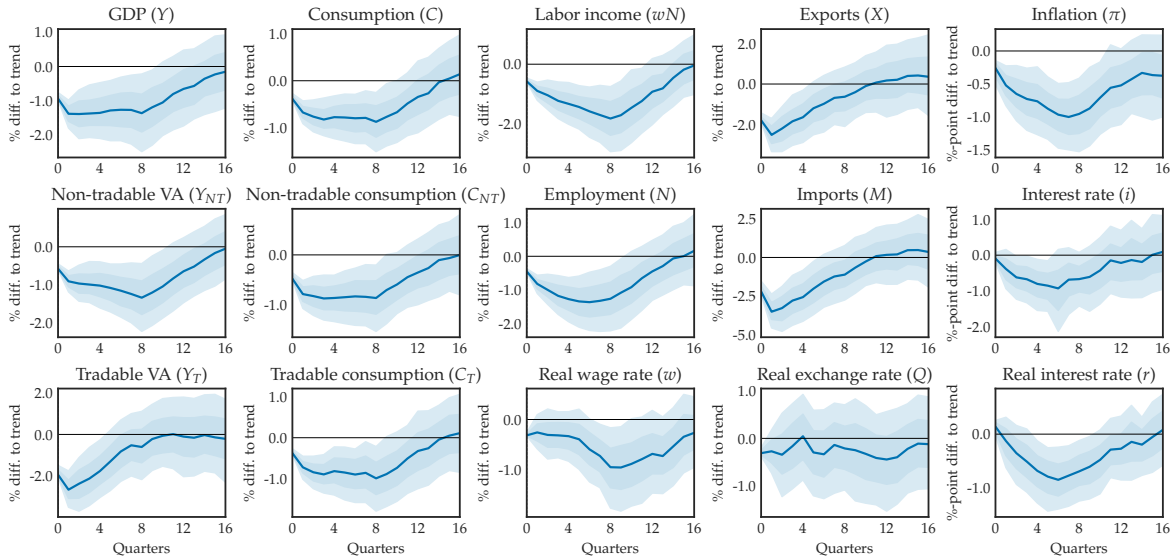


Figure A.20: LP results with long-run restrictions.

Note: See Figure 2.

A.6.16 Effects of foreign monetary policy

We now consider the effects of a foreign monetary policy shock.

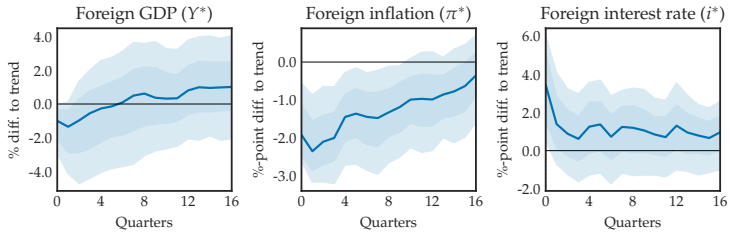


Figure A.21: Effects of foreign monetary policy shock in the foreign economy

Note: The figure reports impulse responses of $Y^*_{j,t}$, $\pi^*_{j,t}$, and $i^*_{j,t}$ to a contractionary foreign monetary policy shock (when $Z_{j,t} = C_{j,t}$). The shaded areas indicate 95 and 68 pct. confidence bands. We use Driscoll-Kraay standard errors (see Driscoll and Kraay, 1998).

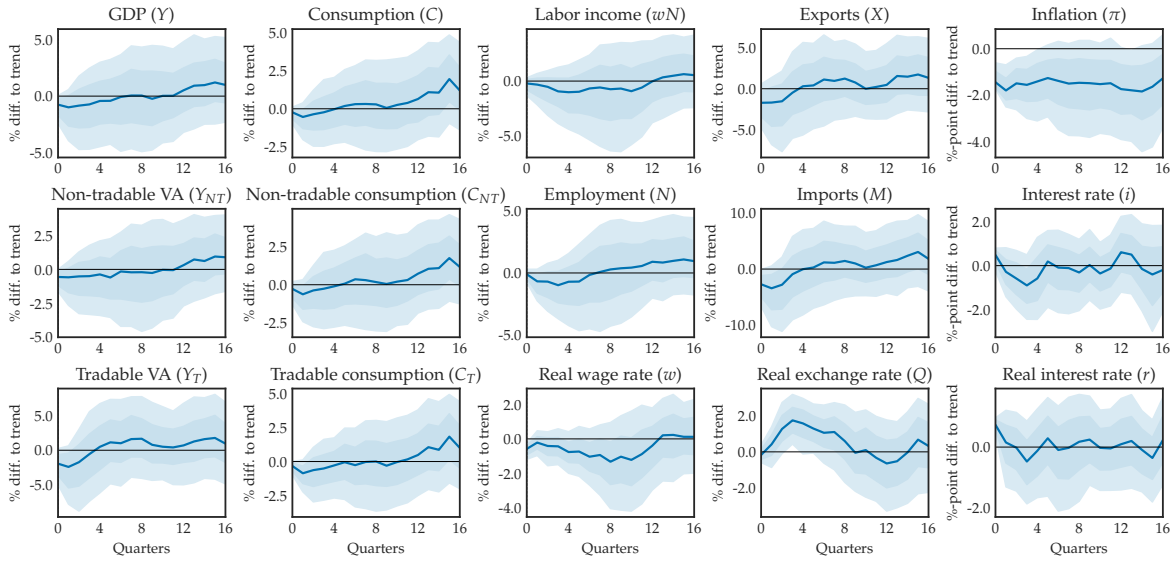


Figure A.22: Effects of foreign monetary policy shock in the small open economy

Note: The figure reports impulse responses of domestic outcome variables to a contractionary foreign monetary policy shock. The shaded areas indicate 95 and 68 pct. confidence intervals. We use Driscoll-Kraay standard errors (see Driscoll and Kraay, 1998).

A.6.17 Extra figures to fiscal consolidation shock

We report the results of our robustness checks in the analysis of foreign fiscal consolidations.

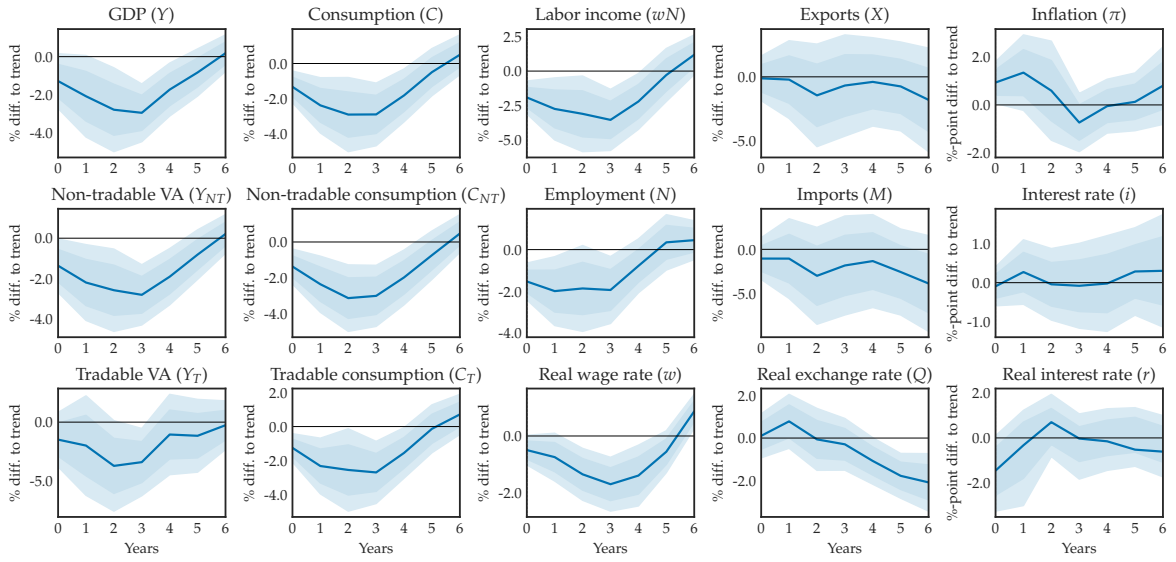


Figure A.23: Effects of fiscal consolidation in the small open economy when controlling for the Baumeister-Hamilton index

Note: See Figure 7.

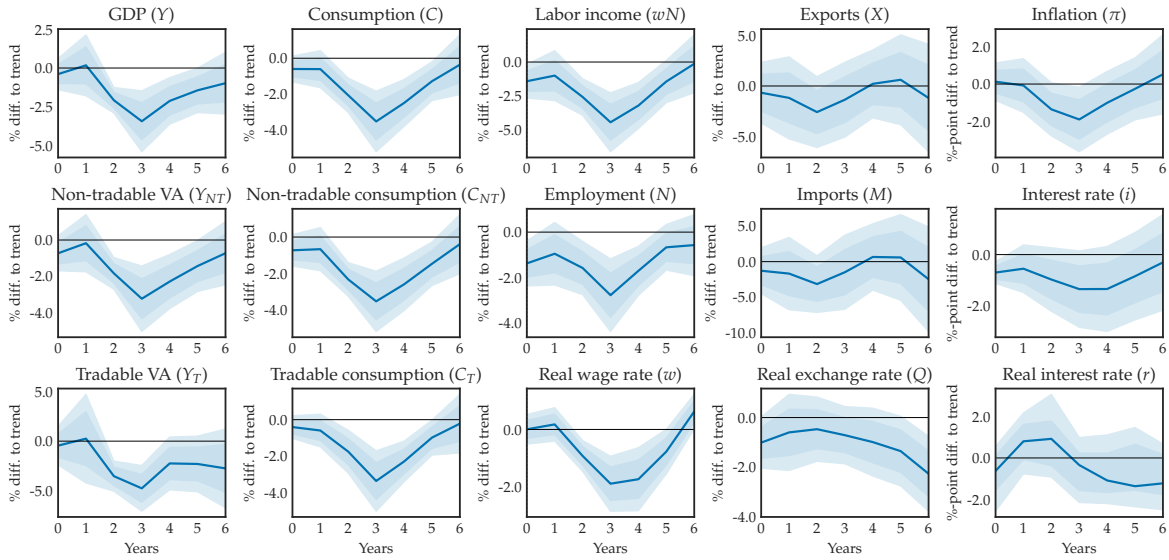


Figure A.24: Effects of fiscal consolidation in the small open economy when using the fiscal consolidation series of Alesina et al. (2019)

Note: See Figure 7.

B Model Appendix: Stylized model

This appendix contains further details on the model presented in Section 3.

B.1 Stylized model

The following set of equations characterizes the equilibrium in a version of the canonical Gali and Monacelli (2005) small open economy model with sticky wages instead of sticky prices and with incomplete markets.

$$C_{H,t} = (1-\alpha)\left(\frac{P_{H,t}}{P_t}\right)^{-\eta} C_t, \tag{B.1}$$

$$C_{F,t} = \alpha\left(\frac{P_{F,t}}{P_t}\right)^{-\eta} C_t, \tag{B.2}$$

$$C^*_{H,t} = \alpha\left(\frac{P^*_{H,t}}{P^*}\right)^{-\eta^*} C^*_t, \tag{B.3}$$

$$C_t + A_t = (1+r_{t-1})\,A_{t-1} + N_t w_t, \tag{B.4}$$

$$C_t = \mathcal{C}_t\left(\left\{r_s, Y^{hh}_s\right\}_{s=0}^{\infty}\right), \tag{B.5}$$

$$Y^{hh}_t = \frac{W_t N_t}{P_t}, \tag{B.6}$$

$$Y_t = Z_t N_t, \tag{B.7}$$

$$W_t = P_{H,t} Z_t, \tag{B.8}$$

$$w_t = \frac{W_t}{P_t}, \tag{B.9}$$

$$\pi_{w,t} = \kappa_w\left(\frac{\xi N_t^{\frac{1}{\varphi}}}{\frac{1}{\mu_w} w_t} - 1\right) + \beta \mathbb{E}_t \pi_{w,t+1}, \tag{B.10}$$

$$Q_t = E_t \frac{P^*_t}{P_t}, \tag{B.11}$$

$$P_t = \left[\alpha P_{F,t}^{1-\eta} + (1-\alpha) P_{H,t}^{1-\eta}\right]^{\frac{1}{1-\eta}}, \tag{B.12}$$

$$P_{F,t} = E_t P^*_t, \tag{B.13}$$

$$P^*_{H,t} = \frac{P_{H,t}}{E_t}, \tag{B.14}$$

$$i_t = i_{ss} + \phi^{\pi} \mathbb{E}_t \pi_{H,t+1}, \tag{B.15}$$

$$Y_t = C^*_{H,t} + C_{H,t}, \tag{B.16}$$

$$1 + r_t = (1 + r^*_t) \frac{\mathbb{E}_t Q_{t+1}}{Q_t}. \tag{B.17}$$

- Equations (B.1) through (B.3) are domestic and foreign household CES-demand functions, respectively.
- Equations (B.4) and (B.5) are budget constraint and consumption function of domestic households and together make up the household block of the model.
- Equation (B.6) defines real labor income.
- Equations (B.7) and (B.8) are the production function and associated first-order condition for labor demand of domestic firms.
- Equation (B.9) defines the real wage.
- Equation (B.10) is the New-Keynesian wage Phillips-curve (NKWPC).
- Equation (B.11) is the definition of the real exchange rate.
- Equation (B.12) is the domestic CPI which follows from the CES specification of consumer preferences over consumption bundles.
- Equations (B.13) and (B.14) reflect the law of one price of domestic and foreign goods, respectively.
- Equation (B.15) is the Taylor rule for the domestic central bank.
- Equation (B.16) is domestic goods market clearing.
- Equation (B.17) is the UIP condition in real terms.

Linearization

We linearize the model around a non-stochastic steady state. We focus on a steady state where prices and output are normalized to 1 and the NFA position is zero. Since certainty equivalence holds under a first-order approximation we drop the expectation operator in the following derivations.

B.1.1 Domestic price level

We start by deriving $P_{H,t}$ as a function of P_t and Q_t since this will be useful in terms of rewriting the budget constraint of the households. First, linearize (B.12) around the steady state:

$$\begin{aligned} dP_t &= (1-\alpha)\, dP_{H,t} + \alpha dP_{F,t} \\ \Leftrightarrow dP_{H,t} &= \frac{1}{1-\alpha} dP_t - \frac{1}{1-\alpha} \alpha dP_{F,t}. \end{aligned}$$

Use the sequence space version of the law of one price in (B.13), $dP_{F,t} = dE_t + dP_t^*$, and the real exchange rate in (B.11), $dQ_t = dE_t + dP_t^* - dP_t$, to rewrite the last term and arrive at:

$$dP_{H,t} = dP_t - \frac{\alpha}{1-\alpha} dQ_t. \tag{B.18}$$

Note that this can also be written in terms of inflation:

$$d\pi_{H,t} = d\pi_t - \frac{\alpha}{1-\alpha} \left(dQ_t - dQ_{t-1} \right). \tag{B.19}$$

B.1.2 Household income

Now we express real household labor income $Y_t^{hh} \equiv W_t N_t / P_t$ as a function of domestic production and the real exchange rate. First, use (B.7) and (B.8) to substitute out W_t and Z_t:

$$Y_t^{hh} = \frac{W_t N_t}{P_t} = \frac{P_{H,t}}{P_t} Y_t.$$

Next, linearize and use (B.18):

$$\begin{aligned} dY_t^{hh} &= dY_t + (dP_{H,t} - dP_t) \\ dY_t^{hh} &= dY_t - \frac{\alpha}{1-\alpha} dQ_t. \end{aligned} \tag{B.20}$$

B.1.3 UIP and Taylor rule

Start with (B.19) forwarded one period:

$$d\pi_{H,t+1} = d\pi_{t+1} - \frac{\alpha}{1-\alpha} \left(dQ_{t+1} - dQ_t \right). \tag{B.21}$$

The Taylor rule in (B.15) in real terms can be written as $dr_t + d\pi_{t+1} = \phi^\pi d\pi_{H,t+1}$. Use this to substitute π_{t+1} out of (B.21) and rearrange:

$$d\pi_{H,t+1} = -dr_t + \phi^\pi \pi_{H,t+1} - \frac{\alpha}{1-\alpha}\left(dQ_{t+1} - dQ_t\right). \tag{B.22}$$

Use the UIP condition in (B.17) to substitute dr_t out of (B.22):

$$(1-\phi^\pi) d\pi_{H,t+1} + dr^* = -\frac{1}{1-\alpha}\left(dQ_{t+1} - dQ_t\right).$$

From here on we set $d\boldsymbol{r}^* = 0$ for analytical clarity. In sequence space, the above can then be written as

$$\left(1-\phi^\pi\right) d\boldsymbol{\pi_H} = \frac{1}{1-\alpha} \boldsymbol{G}^{r,Q} d\boldsymbol{Q}, \tag{B.23}$$

where

$$\boldsymbol{G}^{r,Q} \equiv \begin{bmatrix} 1 & -1 & 0 & \cdots & 0 \\ 0 & 1 & -1 & \cdots & 0 \\ 0 & 0 & 1 & \cdots & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & \cdots & 1 \end{bmatrix}.$$

The UIP condition in sequence space and with this notation can be written as

$$d\boldsymbol{r} = -\boldsymbol{G}^{r,Q} d\boldsymbol{Q}. \tag{B.24}$$

B.1.4 NKWPC

Linearizing the NKWPC in (B.10) around the zero-inflation steady state with $w_{ss} = 1$ and $\frac{1}{\mu_w} w_{ss} = \xi$, we get:

$$\begin{aligned}
d\pi_{w,t} &= \kappa_w \left(\frac{1}{\varphi} dY_t - dw_t \right) + \beta d\pi_{w,t+1} \\
\Leftrightarrow d\pi_{H,t} &= \kappa_w \left(\frac{1}{\varphi} dY_t - dw_t \right) + \beta d\pi_{H,t+1} \\
\Leftrightarrow d\pi_{H,t} &= \kappa_w \left(\frac{1}{\varphi} dY_t - (dP_{H,t} - dP_t) \right) + \beta d\pi_{H,t+1} \\
\Leftrightarrow d\pi_{H,t} &= \kappa_w \left(\frac{1}{\varphi} dY_t + \frac{\alpha}{1-\alpha} dQ_t \right) + \beta d\pi_{H,t+1},
\end{aligned}$$

where the first line uses labor market clearing $dN_t = dY_t$ and the second line uses $\pi_{w,t} = \pi_{H,t}$ from the firm FOC in (B.8). We now write the NKPC in sequence space:

$$\boldsymbol{\Gamma} d\boldsymbol{\pi_H} = \frac{\kappa_w}{\varphi} d\boldsymbol{Y} + \kappa_w \frac{\alpha}{1-\alpha} d\boldsymbol{Q},$$

where

$$\boldsymbol{\Gamma} \equiv \begin{bmatrix} 1 & -\beta & 0 & \cdots & 0 \\ 0 & 1 & -\beta & \cdots & 0 \\ 0 & 0 & 1 & \cdots & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & \cdots & 1 \end{bmatrix}.$$

Finally, we can substitute out $d\boldsymbol{\pi_H}$ using (B.23) to establish a link between the real exchange rate and output:

$$0 = (\phi^\pi - 1) \kappa_w \frac{1}{\varphi} d\boldsymbol{Y} + \frac{1}{1-\alpha} \left((\phi^\pi - 1) \kappa_w \alpha \boldsymbol{I} + \boldsymbol{\Gamma} \boldsymbol{G}^{r,Q} \right) d\boldsymbol{Q},$$

or equivalently, solving for $d\boldsymbol{Q}$,

$$d\boldsymbol{Q} = -\boldsymbol{G}^{Q,Y} d\boldsymbol{Y}, \tag{B.25}$$

where

$$\boldsymbol{G}^{Q,Y} \equiv \Xi \left(\phi^{\pi} - 1\right) \kappa_w \frac{1}{\varphi}, \tag{B.26}$$

$$\Xi \equiv \left(\frac{1}{1-\alpha} \left(\left(\phi^{\pi} - 1\right) \alpha \kappa_w \boldsymbol{I} + \boldsymbol{\Gamma} \boldsymbol{G}^{r,Q} \right) \right)^{-1}. \tag{B.27}$$

B.1.5 Households

Linearizing the consumption function in (B.5) we have

$$d\boldsymbol{C} = \boldsymbol{M}^{r} d\boldsymbol{r} + \boldsymbol{M} d\boldsymbol{Y}^{hh},$$

where $\boldsymbol{M}^{r}$ and $\boldsymbol{M}$ are the Jacobians of $\boldsymbol{C}$ w.r.t the real interest rate and household labor income $Y^{hh} = W_t N_t / P_t$, respectively. Using the expression for household income $d\boldsymbol{Y}^{hh}$ from (B.20) yields

$$d\boldsymbol{C} = \boldsymbol{M}^{r} d\boldsymbol{r} + \boldsymbol{M} d\boldsymbol{Y} - \frac{\alpha}{1-\alpha} \boldsymbol{M} d\boldsymbol{Q}. \tag{B.28}$$

We can now derive the response of consumption as a function of output. Starting from (B.28) and substituting out interest rates and the real exchange rate using (B.24) and (B.25) gives

$$\begin{aligned}
d\boldsymbol{C} &= \boldsymbol{M}^{r} d\boldsymbol{r} + \boldsymbol{M} d\boldsymbol{Y} - \frac{\alpha}{1-\alpha} \boldsymbol{M} d\boldsymbol{Q} \\
&= \boldsymbol{M}^{r} d\boldsymbol{r} + \boldsymbol{M} d\boldsymbol{Y} + \frac{\alpha}{1-\alpha} \boldsymbol{M} \boldsymbol{G}^{Q,Y} d\boldsymbol{Y} \\
&= -\boldsymbol{M}^{r} \boldsymbol{G}^{r,Q} d\boldsymbol{Q} + \boldsymbol{M} d\boldsymbol{Y} + \frac{\alpha}{1-\alpha} \boldsymbol{M} \boldsymbol{G}^{Q,Y} d\boldsymbol{Y} \\
&= \left(\boldsymbol{M} + \boldsymbol{M}^{r} \boldsymbol{G}^{r,Q} \boldsymbol{G}^{Q,Y} + \frac{\alpha}{1-\alpha} \boldsymbol{M} \boldsymbol{G}^{Q,Y} \right) d\boldsymbol{Y} \\
&= \boldsymbol{G}^{C,Y} d\boldsymbol{Y},
\end{aligned} \tag{B.29}$$

where

$$\boldsymbol{G}^{C,Y} \equiv \boldsymbol{M} + \boldsymbol{M}^{r} \boldsymbol{G}^{r,Q} \boldsymbol{G}^{Q,Y} + \frac{\alpha}{1-\alpha} \boldsymbol{M} \boldsymbol{G}^{Q,Y}. \tag{B.30}$$

Note that (B.29) describes the partial equilibrium response of consumption as a function of the response of domestic production to the foreign demand shock. Conditional on the response of production, the matrix $\boldsymbol{G}^{C,Y}$ determines the response of consumption, including its sign.

B.1.6 Goods market clearing

Substitute the CES demand functions in equations (B.1)–(B.3) into the goods market clearing condition (B.16) to get

$$\begin{aligned} dY_t &= dC_{H,t} + dC^*_{H,t} \\ &= (1-\alpha)\, dC_t + \alpha dC^*_t + \frac{\alpha}{1-\alpha}\chi dQ_t, \end{aligned}$$

where $\chi = \eta\,(1-\alpha) + \eta^*$ is the composite trade elasticity.
Writing this in sequence space and substituting in for $d\boldsymbol{Q}$ from (B.25) yields

$$\begin{aligned} d\boldsymbol{Y} &= (1-\alpha)\, d\boldsymbol{C} + \alpha d\boldsymbol{C}^* + \frac{\alpha}{1-\alpha}\chi d\boldsymbol{Q} \\ &= (1-\alpha)\, d\boldsymbol{C} - \frac{\alpha}{1-\alpha}\chi \boldsymbol{G}^{Q,Y} d\boldsymbol{Y} + \alpha d\boldsymbol{C}^*. \end{aligned}$$

Use (B.29) to derive the general equilibrium solution for output in response to a foreign demand shock as

$$\begin{aligned} d\boldsymbol{Y} &= (1-\alpha)\, \boldsymbol{G}^{C,Y} d\boldsymbol{Y} - \frac{\alpha}{1-\alpha}\chi \boldsymbol{G}^{Q,Y} d\boldsymbol{Y} + \alpha d\boldsymbol{C}^* \\ &= \left\{ \boldsymbol{I} - (1-\alpha)\boldsymbol{G}^{C,Y} + \frac{\alpha}{1-\alpha}\chi \boldsymbol{G}^{Q,Y} \right\}^{-1} \alpha d\boldsymbol{C}^* \\ &= \boldsymbol{G}^{Y,C^*} d\boldsymbol{C}^*, \end{aligned} \tag{B.31}$$

where

$$\boldsymbol{G}^{Y,C^*} = \left\{ \boldsymbol{I} - (1-\alpha)\boldsymbol{G}^{C,Y} + \frac{\alpha}{1-\alpha}\chi \boldsymbol{G}^{Q,Y} \right\}^{-1} \alpha. \tag{B.32}$$

Finally, insert this into (B.29) to get that

$$d\boldsymbol{C} = \left(\boldsymbol{M} + \boldsymbol{M}^r \boldsymbol{G}^{r,Q} \boldsymbol{G}^{Q,Y} + \frac{\alpha}{1-\alpha} \boldsymbol{M} \boldsymbol{G}^{Q,Y} \right) \boldsymbol{G}^{Y,C^*} d\boldsymbol{C}^*.$$

B.1.7 Floating vs. fixed exchange rate regimes

We now consider the case of a fixed exchange rate, in which case the Taylor rule (B.15) is replaced by $dE_t = 0$. From the definition of the real exchange rate $Q_t = E_t \frac{P^*_t}{P_t}$ under the assumption of a constant foreign price level, we get $dQ_t = -dP_t$.

Combining with the linearized version of (B.12) and using $dP_{F,t} = 0$ we find that:

$$dP_{H,t} = \frac{1}{1-\alpha} dP_t = -\frac{1}{1-\alpha} dQ_t.$$

We get the following expression for household income:

$$\begin{aligned} dY_t^{hh} &= dY_t + (dP_{H,t} - dP_t) \\ &= dY_t + \left(-\frac{1}{1-\alpha} dQ_t - (-dQ_t) \right) \\ &= dY_t - \frac{\alpha}{1-\alpha} dQ_t, \end{aligned}$$

which is unchanged compared to the floating exchange rate case.

Next, we consider the implications for the matrix $\boldsymbol{G}^{Q,Y}$, whose entries depend on the Taylor rule under a floating exchange rate. Note that the matrix $\boldsymbol{G}^{r,Q}$ depends only on the real UIP condition, which still holds under a peg.

To proceed, start from the real UIP condition $dr_t = dr_t^* + dQ_{t+1} - dQ_t$ and rewrite it in terms of cross-country inflation levels using the Fisher equation:

$$\begin{aligned} & di_t - d\pi_{t+1} = dr_t^* + dQ_{t+1} - dQ_t \\ \Leftrightarrow\ & -d\pi_{t+1} = dr_t^* - di_t^* + dQ_{t+1} - dQ_t \\ \Leftrightarrow\ & -d\pi_{t+1} = -d\pi_{t+1}^* + dQ_{t+1} - dQ_t, \end{aligned}$$

where the second line uses $di_t = di_t^*$, which follows from the fixed exchange rate assumption. Using $d\pi_{H,t} = \frac{1}{1-\alpha} d\pi_t$ and writing in sequence-space yields:

$$d\boldsymbol{\pi_H} = \frac{1}{1-\alpha} \left(\boldsymbol{G}^{r,Q} d\boldsymbol{Q} + d\boldsymbol{\pi}^* \right).$$

Inserting in the NKPC and solving for $d\boldsymbol{Q}$ gives:

$$\begin{aligned} \boldsymbol{\Gamma} \frac{1}{1-\alpha} \left(\boldsymbol{G}^{r,Q} d\boldsymbol{Q} + d\boldsymbol{\pi}^* \right) &= \kappa_w \frac{1}{\varphi} d\boldsymbol{Y} + \kappa_w \frac{\alpha}{1-\alpha} d\boldsymbol{Q} \\ \Leftrightarrow \boldsymbol{\Gamma} \frac{1}{1-\alpha} d\boldsymbol{\pi}^* &= \kappa_w \frac{1}{\varphi} d\boldsymbol{Y} + \frac{1}{1-\alpha} \left[\kappa_w \alpha - \boldsymbol{\Gamma} \boldsymbol{G}^{r,Q} \right] d\boldsymbol{Q} \\ \Leftrightarrow d\boldsymbol{Q} &= \left(\frac{1}{1-\alpha} \left[\kappa_w \alpha - \boldsymbol{\Gamma} \boldsymbol{G}^{r,Q} \right] \right)^{-1} \left\{ \boldsymbol{\Gamma} \frac{1}{1-\alpha} d\boldsymbol{\pi}^* - \kappa_w \frac{1}{\varphi} d\boldsymbol{Y} \right\}. \end{aligned}$$

Defining $\Xi_{\text{Peg}} \equiv \left(\frac{1}{1-\alpha} \left[\kappa_w \alpha - \boldsymbol{\Gamma} \boldsymbol{G}^{r,Q} \right] \right)^{-1}$ we obtain a relation similar to that from the

floating exchange rate model:

$$d\boldsymbol{Q} = \Xi_{\text{Peg}} \left\{ \boldsymbol{\Gamma} \frac{1}{1-\alpha} d\boldsymbol{\pi}^* - \kappa_w \frac{1}{\varphi} d\boldsymbol{Y} \right\}.$$

The notable difference is that under a floating exchange rate, we have found that Ξ tends to have positive entries (for the parameter combinations we consider), whereas Ξ_{Peg} tends to have negative entries. Hence shifting exchange rate regime flips the sign of the $\boldsymbol{Q}, \boldsymbol{Y}$ relation. In the absence of a domestic monetary policy response to increasing inflation, the sign of the movement in the domestic real interest rate flips over. If we set $d\boldsymbol{\pi}^* = 0$ we obtain the following expression for $\boldsymbol{G}^{Q,Y}$ under a peg:

$$\boldsymbol{G}^{Q,Y} = \Xi_{\text{Peg}} \kappa_w \frac{1}{\varphi},$$

such that $d\boldsymbol{Q} = -\boldsymbol{G}^{Q,Y} d\boldsymbol{Y}$. From here on, the rest of the algebra carries through to the main results using the new definition of $\boldsymbol{G}^{Q,Y}$.

C Model Appendix: Quantitative model

This appendix contains additional details on the model in Section 4.

C.1 Producers

We begin by stating the problem of the producers in the economy, and the associated first-order conditions. We choose to present the problem in the most general way possible, which means that we are including a VAT, τ_t^v, and a payroll subsidy, ζ_t^p (used for the study of fiscal devaluations in Section 7), as well as capital formation (as considered in Appendix E.1). The version relevant for our baseline model presented in Section 4 is obtained by setting $\tau_t^v = \zeta_t^p = 0$ and $\alpha_s^K = 0$. Note that the production function for the model with capital is given by:

$$Z_{s,t} = \mathcal{Z}_s X_{s,t}^{\alpha_s^X} H_{s,t}^{1-\alpha_s^X} - F_s, \tag{C.1}$$

where $H_{s,t}$ is a CES aggregate of labor and capital:

$$H_{s,t} = \left[\left(1-\alpha_s^K\right)^{\frac{1}{\eta_{KL}}} N_{s,t}^{\frac{\eta_{KL}-1}{\eta_{KL}}} + \left(\alpha_s^K\right)^{\frac{1}{\eta_{KL}}} K_{s,t-1}^{\frac{\eta_{KL}-1}{\eta_{KL}}} \right]^{\frac{\eta_{KL}}{\eta_{KL}-1}}.$$

Here, $0 \leq \alpha_s^K \leq 1$ is the share parameter for capital, and $\eta_{KL} > 0$ is the elasticity of substitution between labor and capital. As noted above, when α_s^K equals zero, this collapses to the expression presented in Section 4 (see equation 4.14).

The problem of the firm can be stated as:

$$V_{s,t}^F \equiv \max_{P_{s,t}, Z_{s,t}, X_{s,t}, N_{s,t}, K_{s,t}} \left\{ D_{s,t} + \frac{1}{1+r_{ss}} \mathbb{E}_t V_{s,t+1}^F \right\}$$

s.t.

$$Z_{s,t}^j = \left(\frac{P_{s,t}^j}{P_{s,t}} \right)^{-\epsilon^P} Z_{s,t},$$

and subject to the production function. Flow dividends are given by:

$$D_{s,t} = (1-\tau_t^v) \frac{P_{s,t} Z_{s,t} - P_{s,t}^X X_{s,t}}{P_t} - \left(1-\zeta_t^p\right) \frac{W_{s,t}}{P_t} N_{s,t} - r_{s,t}^K K_{s,t-1} - (1-\tau_t^v) \frac{P_{s,t}}{P_t} \frac{\theta_s^P}{2} \pi_{s,t}^2 Z_{s,t}.$$

The price adjustment cost is paid in units of each sector's own good.

Denote by $\lambda_{s,t}$ the Lagrange multiplier associated with the demand function (4.13). The first-order conditions for factor demands are:

$$
\begin{aligned}
&(1-\tau_t^v)\,\frac{P_{s,t}}{P_t}\frac{\partial Z_{s,t}}{\partial X_{s,t}} - (1-\tau_t^v)\,\frac{P_{s,t}^X}{P_t} - \lambda_{s,t}\frac{\partial Z_{s,t}}{\partial X_{s,t}} = 0,\\
&(1-\tau_t^v)\,\frac{P_{s,t}}{P_t}\frac{\partial Z_{s,t}}{\partial N_{s,t}} - \left(1-\zeta_t^p\right)\frac{W_{s,t}}{P_t} - \lambda_{s,t}\frac{\partial Z_{s,t}}{\partial N_{s,t}} = 0,\\
&\left(1-\mathbb{E}_t\tau_{t+1}^v\right)\mathbb{E}_t\frac{P_{s,t+1}}{P_{t+1}}\frac{\partial Z_{s,t+1}}{\partial K_{s,t}} - \mathbb{E}_t r_{s,t+1}^K - \mathbb{E}_t\lambda_{s,t+1}\frac{\partial Z_{s,t+1}}{\partial K_{s,t}} = 0.
\end{aligned}
$$

Defining real marginal costs as $mc_{s,t} = (1-\tau_t^v)\,\frac{P_{s,t}}{P_t} - \lambda_{s,t}$, we get the first-order conditions for optimal inputs of intermediate goods, labor, and capital:

$$
mc_{s,t}\frac{\partial Z_{s,t}}{\partial X_{s,t}} = (1-\tau_t^v)\,\frac{P_{s,t}^X}{P_t}, \tag{C.2}
$$

$$
mc_{s,t}\frac{\partial Z_{s,t}}{\partial N_{s,t}} = \left(1-\zeta_t^p\right)\frac{W_{s,t}}{P_t}, \tag{C.3}
$$

$$
\mathbb{E}_t mc_{s,t+1}\frac{\partial Z_{s,t+1}}{\partial K_{s,t}} = \mathbb{E}_t r_{s,t+1}^K. \tag{C.4}
$$

The marginal products are derived from the production function absent the fixed cost, so that $Z_{s,t} + F_s = \mathcal{Z}_s X_{s,t}^{\alpha_s^X} H_{s,t}^{1-\alpha_s^X}$ is gross output. The marginal products of intermediate goods, labor and capital are given by:

$$
\begin{aligned}
\frac{\partial Z_{s,t}}{\partial X_{s,t}} &= \alpha_s^X\frac{Z_{s,t}+F_s}{X_{s,t}},\\
\frac{\partial Z_{s,t}}{\partial N_{s,t}} &= \left(1-\alpha_s^X\right)\left(1-\alpha_s^K\right)^{\frac{1}{\eta_{KL}}}\mathcal{Z}_s X_{s,t}^{\alpha_s^X} H_{s,t}^{\frac{1}{\eta_{KL}}-\alpha_s^X} N_{s,t}^{-\frac{1}{\eta_{KL}}},\\
\frac{\partial Z_{s,t+1}}{\partial K_{s,t}} &= \left(1-\alpha_s^X\right)\left(\alpha_s^K\right)^{\frac{1}{\eta_{KL}}}\mathcal{Z}_s X_{s,t+1}^{\alpha_s^X} H_{s,t+1}^{\frac{1}{\eta_{KL}}-\alpha_s^X} K_{s,t}^{-\frac{1}{\eta_{KL}}}.
\end{aligned}
$$

The first-order condition for price-setting ($P_{s,t}$) is:

$$
\begin{aligned}
(1-\tau_t^v)\,\frac{1}{P_t}Z_{s,t} - (1-\tau_t^v)\,\theta_s^P\left(\frac{P_{s,t}}{P_{s,t-1}}-1\right)Z_{s,t}\frac{1}{P_{s,t-1}} - \epsilon^P\lambda_{s,t}\left(\frac{P_{s,t}^j}{P_{s,t}}\right)^{-\epsilon^P-1}Z_{s,t}\frac{1}{P_{s,t}}\\
+\frac{\left(1-\mathbb{E}_t\tau_{t+1}^v\right)}{1+r_{ss}}\theta_s^P\left(\frac{\mathbb{E}_t P_{s,t+1}}{P_{s,t}}-1\right)\mathbb{E}_t Z_{s,t+1}\frac{\mathbb{E}_t P_{s,t+1}}{P_{s,t}^2} = 0.
\end{aligned}
$$

Imposing a symmetric equilibrium, we may rewrite this as:

$$\pi_{s,t}\left(1+\pi_{s,t}\right)=\frac{\epsilon^{P}}{\theta_{s}^{P}}\left(\frac{mc_{s,t}}{\left(1-\tau_{t}^{v}\right)}-\frac{P_{s,t}}{P_{t}}\frac{1}{\mu_{s}}\right)+\frac{1}{1+r_{ss}}\frac{\left(1-\mathbb{E}_{t}\tau_{t+1}^{v}\right)}{\left(1-\tau_{t}^{v}\right)}\mathbb{E}_{t}\pi_{s,t+1}\left(1+\mathbb{E}_{t}\pi_{s,t+1}\right)\frac{\mathbb{E}_{t}Z_{s,t+1}}{Z_{s,t}},$$

where $\frac{1}{\mu}=\frac{\epsilon^{P}-1}{\epsilon^{P}}$.

C.2 Capital firms

In the model with capital, the producers in each sector rent capital services from a capital firm, which owns and accumulates the capital stocks of both sectors. The capital firm chooses investment $I_{s,t}$ and capital $K_{s,t}$ in each sector $s\in\{T,NT\}$, debt b_{t}^{cap}, and dividends d_{t}^{cap}, all in units of the investment good. The latter is a CES aggregate of domestic and foreign investment goods with an import share of $0<\alpha_{I}<1$ and an elasticity of substitution equal to $\eta_{H,F}$. The domestic investment good is valued at the consumer price index P_{t}, and the domestic component of investment in sector s consists of final goods produced in that sector. Total investment is $I_{t}\equiv I_{T,t}+I_{NT,t}$.

Let β_{t+1}^{I} denote the one-period discount factor between t and $t+1$ (in units of the investment good), and define the cumulative discount factor:

$$B_{t}^{I}\equiv\prod_{j=1}^{t}\beta_{j}^{I},\qquad B_{0}^{I}\equiv1. \tag{C.5}$$

The factor B_{t}^{I} gives the discount from date 0 to date t as a product of future one-period discount factors. The discount factor is $\beta_{t+1}^{I}=\frac{1}{1+\mathbb{E}_{t}r_{t+1}^{I}}$, where:

$$r_{t}^{I}\equiv\frac{1+i_{t-1}}{1+\pi_{t}^{I}}-1, \tag{C.6}$$

with π_{t}^{I} denoting the inflation rate of the price of investment goods.

The capital firm maximizes the discounted value of dividends:

$$\max_{\{K_{s,t},I_{s,t},b_{t}^{cap},d_{t}^{cap}\}}\mathbb{E}_{0}\sum_{t=0}^{\infty}B_{t}^{I}\,d_{t}^{cap}, \tag{C.7}$$

subject to a flow-of-funds constraint:

$$\sum_s \frac{P_t}{P_{I,t}} r^K_{s,t} K_{s,t-1} - I_t - g\left(\frac{I_t}{I_{t-1}}\right) I_t - d^{cap}_t - \psi^{cap}(d^{cap}_t - \bar{d}^{cap})^2 + b^{cap}_t - (1+r^I_t) b^{cap}_{t-1} = 0, \tag{C.8}$$

where $\psi^{cap} > 0$ denotes the (quadratic) cost of deviating from the steady-state level of dividend payouts $\bar{d}^{cap}$, thus capturing the dividend-smoothing motive. The capital stock of each sector follows a standard accumulation equation:

$$K_{s,t} = (1-\delta) K_{s,t-1} + I_{s,t}, \tag{C.9}$$

and the firm faces the borrowing constraint:

$$b^{cap}_t = \theta \sum_s \frac{P_t}{P_{I,t}} r^K_{s,t} K_{s,t-1}. \tag{C.10}$$

Here, $r^K_{s,t}$ is the real rental rate of capital in sector s, in units of the consumption good, which $P_t/P_{I,t}$ converts into units of the investment good, and $g\left(\frac{I_t}{I_{t-1}}\right) = \frac{\phi^I}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2$ denotes quadratic adjustment costs on total investment, with $\phi^I > 0$. Moreover, $\delta > 0$ is the depreciation rate of capital, and $\theta > 0$ denotes the maximum debt-to-earnings ratio faced by the capital firm, where earnings are summed over the two sectors. Earnings are quarterly, so θ is four times the annual debt-to-earnings ratio reported in Table D.2. In the specification of the borrowing constraint (C.10), we follow the arguments in Drechsel (2023) and use real earnings without subtracting investment expenses or debt service costs of the firm.

The capital firm is owned by households through the mutual fund, so the dividend D_t in the no-arbitrage condition (4.8) is the consolidated cash flow of the producers and the capital firm. The expected path of investment is capitalized in the price of equity p^D_t and thus in the return on household wealth at the date of the shock.

Finally, the CES aggregator defining the price of investment goods is given by:

$$P_{I,t} = \left[(1-\alpha_I) P_t^{1-\eta_{H,F}} + \alpha_I P_{F,t}^{1-\eta_{H,F}}\right]^{\frac{1}{1-\eta_{H,F}}}, \tag{C.11}$$

where $P_{F,t} = E_t P^*_{F,t}$ as in Section 4. The demands for the two components of investment in sector s are $I^H_{s,t} = (1-\alpha_I)\left(P_t/P_{I,t}\right)^{-\eta_{H,F}} I_{s,t}$ and $I^F_{s,t} = \alpha_I \left(P_{F,t}/P_{I,t}\right)^{-\eta_{H,F}} I_{s,t}$, so that $P_{I,t} I_t = P_t \sum_s I^H_{s,t} + P_{F,t} \sum_s I^F_{s,t}$. Thus, $I^H_{s,t}$ is measured in units of the consumption good, and $P_t I^H_{s,t}$ buys $P_t I^H_{s,t}/P_{s,t}$ units of the good of sector s.

First-Order Conditions Let λ_t^{cap} denote the multiplier on the flow-of-funds constraint, $\mathcal{Q}_{s,t}$ the multiplier on the accumulation equation of sector s, and ω_t^{cap} the multiplier associated with the borrowing constraint, all in units of date-t dividends. The Lagrangian is

$$\begin{aligned}\mathcal{L} = \mathbb{E}_0 \sum_{t=0}^{\infty} B_t^I \Bigg\{ & d_t^{cap} + \lambda_t^{cap} \Bigg[\sum_s \frac{P_t}{P_{I,t}} r_{s,t}^K K_{s,t-1} - I_t - g\left(\frac{I_t}{I_{t-1}}\right) I_t \\ & \qquad - d_t^{cap} - \psi^{cap}\left(d_t^{cap} - \bar{d}^{cap}\right)^2 + b_t^{cap} - \left(1 + r_t^I\right) b_{t-1}^{cap} \Bigg] \\ & - \sum_s \mathcal{Q}_{s,t} \left[K_{s,t} - (1-\delta) K_{s,t-1} - I_{s,t}\right] \\ & - \omega_t^{cap} \left[b_t^{cap} - \theta \sum_s \frac{P_t}{P_{I,t}} r_{s,t}^K K_{s,t-1} \right] \Bigg\},\end{aligned}$$

where $B_{t+1}^I / B_t^I = \beta_{t+1}^I$ discounts a date-$t+1$ term back to date t.
The first-order condition for $K_{s,t}$ is the pricing equation for capital in sector s:

$$\mathcal{Q}_{s,t} = \beta_{t+1}^I \mathbb{E}_t \left[\lambda_{t+1}^{cap} \frac{P_{t+1}}{P_{I,t+1}} r_{s,t+1}^K + (1-\delta) \mathcal{Q}_{s,t+1} + \theta \omega_{t+1}^{cap} \frac{P_{t+1}}{P_{I,t+1}} r_{s,t+1}^K \right]. \tag{C.12}$$

Writing $x_t \equiv I_t / I_{t-1}$, the derivative of the Lagrangian with respect to $I_{s,t}$ is

$$\mathcal{Q}_{s,t} - \lambda_t^{cap} \left[1 + g(x_t) + g'(x_t) x_t\right] + \mathbb{E}_t \beta_{t+1}^I \lambda_{t+1}^{cap} g'(x_{t+1}) x_{t+1}^2 = 0,$$

so that

$$\frac{\mathcal{Q}_{s,t}}{\lambda_t^{cap}} = 1 + g\left(\frac{I_t}{I_{t-1}}\right) + g'\left(\frac{I_t}{I_{t-1}}\right) \frac{I_t}{I_{t-1}} - \mathbb{E}_t \beta_{t+1}^I \frac{\lambda_{t+1}^{cap}}{\lambda_t^{cap}} g'\left(\frac{I_{t+1}}{I_t}\right) \left(\frac{I_{t+1}}{I_t}\right)^2. \tag{C.13}$$

The right-hand side is the same for both sectors, because the adjustment cost is paid on total investment, so $\mathcal{Q}_{T,t} = \mathcal{Q}_{NT,t}$ at every date. Subtracting the two pricing equations for capital then gives

$$\mathbb{E}_t \left[\left(\lambda_{t+1}^{cap} + \theta \omega_{t+1}^{cap}\right) \frac{P_{t+1}}{P_{I,t+1}} \left(r_{T,t+1}^K - r_{NT,t+1}^K\right) \right] = 0,$$

which along a perfect-foresight transition path reduces to $r_{T,t+1}^K = r_{NT,t+1}^K$: the firm splits investment between the two sectors so as to equalize their rental rates from the period after the shock onwards. In the period of the shock the two capital stocks are

predetermined, and the two rental rates adjust in equilibrium.

The first-order conditions for debt b_t^{cap} and dividends d_t^{cap} are

$$\lambda_t^{cap} - \omega_t^{cap} = \mathbb{E}_t \beta_{t+1}^I (1 + r_{t+1}^I) \lambda_{t+1}^{cap}, \tag{C.14}$$

$$\lambda_t^{cap} = \frac{1}{1 + 2\psi^{cap}(d_t^{cap} - \bar{d}^{cap})}. \tag{C.15}$$

From the latter, a unit of internal funds is worth more than a unit of dividends when dividends are below their steady-state level, which is what makes the firm borrow.

In the steady state $\lambda^{cap} = 1$ and $\beta^I = 1/(1+r)$, so the condition for debt gives $\omega^{cap} = 0$, the condition for investment gives $\mathcal{Q}_s = 1$, and the pricing equation for capital gives $r_s^K = r + \delta$ in both sectors. The borrowing constraint (C.10) then determines the level of debt, $b^{cap} = \theta \sum_s r_s^K K_s$, and the flow of funds (C.8) pins down the level of dividends.

Adjustment costs The investment adjustment cost enters the flow of funds (C.8) in units of the investment good. The adjustment cost on investment in sector s, $g\left(I_t / I_{t-1}\right) I_{s,t}$, is paid in units of the good of sector s, as is the price adjustment cost of the producers. The adjustment costs in the goods market clearing conditions, (4.25) and (4.26), are thus given by:

$$\Xi_{s,t} = \frac{\theta_s^P}{2} \pi_{s,t}^2 Z_{s,t} + g\left(\frac{I_t}{I_{t-1}}\right) I_{s,t}. \tag{C.16}$$

The dividend adjustment cost is virtual: it affects the value of internal funds λ_t^{cap}, but absorbs no goods and is not deducted from the dividends received by households. All adjustment costs are zero in the steady state and of second order along the transition path.

Market clearing In the model with capital, the goods market clearing conditions (4.25) and (4.26) include the domestic component of investment in each sector:

$$Z_{NT,t} = C_{NT,t} + G_{NT,t} + X_{NT \to T,t} + X_{NT \to NT,t} + \frac{P_t}{P_{NT,t}} I_{NT,t}^H + \Xi_{NT,t}, \tag{C.17}$$

$$Z_{T,t} = C_{H,t} + G_{H,t} + C_{H,t}^* + X_{T \to T,t} + X_{T \to NT,t} + \frac{P_t}{P_{H,t}} I_{T,t}^H + \Xi_{T,t}, \tag{C.18}$$

with $\Xi_{s,t}$ given by (C.16). Imports include the foreign component of investment,

$$M_t = C_{F,t} + X_{F\to T,t} + X_{F\to NT,t} + I^F_{T,t} + I^F_{NT,t}. \tag{C.19}$$

The definition of net exports (4.27) also subtracts investment spending:

$$NX_t \equiv \frac{\mathcal{P}_t}{P_t} Y_t - C_t - \frac{P^G_t}{P_t} G_t - \frac{P_{I,t}}{P_t} I_t - \sum_s \frac{P_{s,t}}{P_t} \Xi_{s,t}. \tag{C.20}$$

C.3 Intermediate-good retailers

Demand for intermediate goods in sector s is:

$$X_{s\to s,t} = \Theta_{s\to s} \left(\frac{P_{s,t}}{P^X_{s,t}}\right)^{-\eta_X} X_{s,t}, \tag{C.21}$$

$$X_{s'\to s,t} = \Theta_{s'\to s} \left(\frac{P_{s',t}}{P^X_{s,t}}\right)^{-\eta_X} X_{s,t}, \tag{C.22}$$

$$X_{F\to s,t} = \Theta_{F\to s} \left(\frac{P_{F,t}}{P^X_{s,t}}\right)^{-\eta_X} X_{s,t}. \tag{C.23}$$

Correspondingly, the price index of the intermediate-good bundle is then given by:

$$P^X_{s,t} = \left[\Theta_{s\to s} \left(P_{s,t}\right)^{1-\eta_X} + \Theta_{s'\to s} \left(P_{s',t}\right)^{1-\eta_X} + \Theta_{F\to s} \left(P_{F,t}\right)^{1-\eta_X}\right]^{\frac{1}{1-\eta_X}}.$$

C.4 Labor unions

Within each sector, the effective labor input is assembled from all union-specific tasks using a CES technology:

$$N_{s,t} = \left(\int_j \left(N^j_{s,t}\right)^{\frac{\epsilon^W-1}{\epsilon^W}} dj\right)^{\frac{\epsilon^W}{\epsilon^W-1}},$$

where $\epsilon^W > 0$ is the elasticity of substitution between labor types. The sectoral wage index is given by $W_{s,t} = \left(\int_j \left(W^j_{s,t}\right)^{1-\epsilon^W} dj\right)^{\frac{1}{1-\epsilon^W}}$. Each union asks the same hours of every member. Mean efficiency within a sector is one, so a union's task is $N^j_{s,t} = \int e_{i,t} l^j_{i,s,t} di = s_s l^j_{s,t}$, where the integral runs over the mass s_s of households

working in the sector, and in the symmetric equilibrium each of them supplies $l_{i,s,t} = \int_j l^j_{s,t} dj = N_{s,t}/s_s = L_{s,t}$ hours per household, as in (4.1) and (4.2).

The problem of union j in sector s is to maximize the discounted stream of future utility of its members, *per member*, net of a virtual Rotemberg adjustment cost on nominal wages:

$$\sum_{t=0}^{\infty} \left(\beta^U\right)^t \mathbb{E}_t \left(\frac{1}{s_s} \int \left\{ u\left(c_{i,s,t}\right) - \nu \frac{l_{i,s,t}^{1+\frac{1}{\varphi}}}{1+\frac{1}{\varphi}} \right\} d\mathcal{D}_{s,t} - \frac{\theta_s^W}{2} \left(\frac{W^j_{s,t}}{W^j_{s,t-1}} - 1 \right)^2 \right),$$

where $\mathcal{D}_{s,t}$ is the distribution over the sector's households and β^U denotes the discount factor of the union, which we pin down using the steady-state real interest rate, $\beta^U = \frac{1}{1+r_{ss}}$ (discounting at the real interest rate follows Hagedorn et al., 2019).

The union takes $W_{s,t}$, $N_{s,t}$, and the distribution as given and chooses $W^j_{s,t}$. The first-order condition for $W^j_{s,t}$ is

$$\begin{aligned} &\frac{\left(1-\tau_t\right)\left(1-\epsilon^W\right) N^j_{s,t}}{P_t s_s^2} \int e_{i,t} u'\left(c_{i,s,t}\right) d\mathcal{D}_{s,t} + \frac{\epsilon^W N^j_{s,t}}{s_s^2 W^j_{s,t}} \int \nu l_{i,s,t}^{\frac{1}{\varphi}} d\mathcal{D}_{s,t} \\ &-\theta_s^W \left(\frac{W^j_{s,t}}{W^j_{s,t-1}} - 1 \right) \frac{1}{W^j_{s,t-1}} + \beta^U \mathbb{E}_t \theta_s^W \left(\frac{W^j_{s,t+1}}{W^j_{s,t}} - 1 \right) \frac{W^j_{s,t+1}}{\left(W^j_{s,t}\right)^2} = 0. \end{aligned}$$

After imposing a symmetric equilibrium in which $W^j_{s,t} = W_{s,t}$, $N^j_{s,t} = N_{s,t}$ and $l_{i,s,t} = L_{s,t}$ for every member, this expression can be rewritten as a sector-specific New Keynesian wage Phillips Curve:

$$\begin{aligned} \theta_s^W \pi^w_{s,t} \left(1 + \pi^w_{s,t}\right) = \epsilon^W L_{s,t} \left\{ \nu L_{s,t}^{\frac{1}{\varphi}} - \frac{\epsilon^W - 1}{\epsilon^W} \frac{\left(1-\tau_t\right) W_{s,t}}{P_t} U'\left(C_{s,t}\right) \right\} \\ + \beta^U \mathbb{E}_t \theta_s^W \pi^w_{s,t+1} \left(1 + \mathbb{E}_t \pi^w_{s,t+1}\right), \end{aligned}$$

which is (4.19) after dividing by θ_s^W, and where the slope of the NKWPC is given by $\kappa^w = \epsilon^W/\theta_s^W$. The level parameter ν is calibrated so that the expression in curly brackets vanishes in the steady state.

C.5 Specification of the tax rate

We apply the following functional form for the tax rate τ_t:

$$\tau_t = \begin{cases} \tau_{ss} & \text{if } t < t_B \\ (1-\omega(\tilde{t}))\tau_{ss} + \omega(\tilde{t})\tilde{\tau}_t & \text{if } t \in [t_B, t_B + \Delta_B], \tilde{t} = (t - t_B)/\Delta_B \\ \tilde{\tau}_t & \text{if } t > t_B + \Delta_B \end{cases},$$

where

$$\begin{aligned} \tilde{\tau}_t &= \tau_{ss} \left(B_{t-1}/B_{ss}\right)^{\epsilon_B}, \\ \omega(x) &= 3x^2 - 2x^3 \in [0,1], \text{ and } \omega'(x) \geq 0 \text{ for } x \in [0,1]. \end{aligned}$$

We set $\Delta_B = 20$ such that the full effect of stabilizing taxes is phased in over another 20 quarters (after the initial $t_B = 50$ quarters of constant taxes). Finally, we set $\epsilon_B = 1$ such that taxes increase when government debt is higher than in steady state, and convergence back to the steady-state level of debt is thus ensured. Our results are fully robust to alternative assumptions regarding the phase-in. We explore the implications of allowing an immediate gradual adjustment of the tax rate in Appendix E.4.2.

C.6 Debt-dependent discount factor

To close the RANK model and ensure stationarity, we assume that a debt-dependent interest rate premium ι_t enters the consumption Euler equation. That is, we subtract ι_t from the interest rate in the Euler equation:

$$C_t^{-\sigma} = \tilde{\beta}_t \mathbb{E}_t (1 + r_{t+1}^a - \iota_t) C_{t+1}^{-\sigma}.$$

To ensure comparability, we do the same in the HANK model, even though it is not necessary, since this model is already stationary. Note that our approach is equivalent to an endogenous discount factor or so-called Uzawa preferences (Schmitt-

Grohé and Uribe, 2003), which can be seen by rewriting the expression as follows:

$$\begin{aligned} C_t^{-\sigma} &= \bar{\beta}_t \mathbb{E}_t (1 + r_{t+1}^a - \iota_t) C_{t+1}^{-\sigma} \Leftrightarrow \\ C_t^{-\sigma} &= \bar{\beta}_t \mathbb{E}_t \left(1 + r_{t+1}^a - \frac{\iota_t}{1 + r_{t+1}^a} \left(1 + r_{t+1}^a \right) \right) C_{t+1}^{-\sigma} \Leftrightarrow \\ C_t^{-\sigma} &= \bar{\beta}_t \mathbb{E}_t \left(1 - \frac{\iota_t}{1 + r_{t+1}^a} \right) \left(1 + r_{t+1}^a \right) C_{t+1}^{-\sigma} \Leftrightarrow \\ C_t^{-\sigma} &= \tilde{\beta}_t \mathbb{E}_t \left(1 + r_{t+1}^a \right) C_{t+1}^{-\sigma}, \end{aligned}$$

where $\tilde{\beta}_t \equiv \left(1 - \frac{\iota_t}{1 + r_{t+1}^a} \right) \bar{\beta}_t$ is now an endogenous discount factor. The discount factor is declining in ι_t, which in turn is given by:

$$\iota_t = \begin{cases} 0 & \text{if } t < t_{NFA} \\ (1 - \omega(\tilde{t})) + \omega(\tilde{t}) \tilde{\iota}_t - 1 & \text{if } t \in [t_{NFA}, t_{NFA} + \Delta_{NFA}], \tilde{t} = (t - t_{NFA}) / \Delta_{NFA}, \\ \tilde{\iota}_t - 1 & \text{if } t > t_{NFA} + \Delta_{NFA} \end{cases}$$

where

$$\begin{aligned} \tilde{\iota}_t &= (1 + NFA_{t-1})^{\epsilon_{NFA}}, \\ \omega(x) &= 3x^2 - 2x^3 \in [0,1], \text{ and } \omega'(x) \geq 0 \text{ for } x \in [0,1]. \end{aligned}$$

The net foreign asset position is zero in steady state by construction of the calibration, so the rule is stated in terms of the level $1 + NFA_{t-1}$ rather than, e.g., as a ratio to NFA_{ss}. Effectively, an improved net foreign asset position (a rise in NFA_{t-1}) raises ι_t and thus reduces the discount factor, making households more inclined to spend their wealth, and vice versa. We choose $t_{NFA} = 250$, $\Delta_{NFA} = 30$ and $\epsilon_{NFA} = 0.5$. Our results are again not sensitive to the exact phase-in chosen, as long as it initiates far out in the future.

D Summary of parameter values

Table D.1 and D.2 summarize the parameter values employed in the baseline calibration of the model.

Table D.1: Calibration of foreign economy, households and government

	Description	Value	Target/source
	Foreign economy		
i^*	Foreign interest rate (annual)	2%	Standard value
α^*	Size of export market	0.42	$\frac{(\text{Exports+Imports})/2}{\text{GDP}} = 42\%$
η^*	Armington elasticity	2	Boehm et al. (2023)
ρ^*	Export rigidity	0.90	Boehm et al. (2023)
	Households		
$1/\sigma$	Intertemporal sub. elasticity	0.40	Standard value
φ	Frisch elasticity	0.50	Chetty et al. (2011)
$\bar{\beta}$, HA	Mean discount factor	0.931	Foreign interest rate
$\bar{\beta}$, RA	Mean discount factor	0.995	Foreign interest rate
$\Delta\beta$	Discount factor dispersion	0.060	MPC $= 0.51$ (annual)
ρ_e	Persistence of idiosyncratic income	0.966	Floden and Lindé (2001)
σ_e	Std. of idiosyncratic income	0.13	Floden and Lindé (2001)
s_T	Share of households working in T	0.30	Data
α_T	Share of T in home basket	0.47	Data
α_F	Share of foreign T in home basket	0.32	$\frac{C_F}{\text{Imports}} = 29\%$
$\eta_{T,NT}$	Sub. elasticity for C_T and C_{NT}	0.50	Akinci (2011)
$\eta_{H,F}$	Sub. elasticity for C_F and C_H	2	Boehm et al. (2023)
	Government and monetary policy		
$\frac{G}{GDP}$	Public consumption to GDP	0.20	Data
$\frac{B}{GDP}$	Government debt to GDP	0.58	Data
s_T^G	Share of G going to T	0.20	Cardi and Restout (2023)
ϕ^π	Taylor rule coefficient	1.25	Standard value
ρ^r	Degree of interest rate smoothing	0.90	Standard value

Table D.2: Calibration of firms and sectors

	Description	Value	Target/source
	Production and input-output structure		
α_T^X	Intermediate goods share, T	0.81	$\frac{P_T^X X_T}{P_T^X X_T + W_T N_T} = 0.81$
α_{NT}^X	Intermediate goods share, NT	0.57	$\frac{P_{NT}^X X_{NT}}{P_{NT}^X X_{NT} + W_{NT} N_{NT}} = 0.57$
η_X	Sub. elasticity for intermediates	0.50	See text
ϵ_T^P	Sub. elasticity for final goods, T	6	Markup of 20%
ϵ_{NT}^P	Sub. elasticity for final goods, NT	6	Markup of 20%
ϵ_T^w	Sub. elasticity for labor, T	6	Markup of 20%
ϵ_{NT}^w	Sub. elasticity for labor, NT	6	Markup of 20%
F_T	Fixed cost, T	0.26	$\frac{\text{Wealth}}{\text{Income}} = 2.5$ (annual)
F_{NT}	Fixed cost, NT	0.31	$\frac{D_T}{D} = \frac{Y_T}{Y}$
	Nominal rigidities		
θ_T^P	Rotemberg price parameter, T	30	Slope of NKPC = 0.2
θ_{NT}^P	Rotemberg price parameter, NT	60	Slope of NKPC = 0.1
θ_T^w	Rotemberg wage parameter, T	240	Slope of NKWPC = 0.025
θ_{NT}^w	Rotemberg wage parameter, NT	240	Slope of NKWPC = 0.025
	Model with capital formation		
η_{KL}	Sub. elasticity for capital-labor	0.50	Gechert et al. (2022)
δ	Depreciation rate of capital	0.025	Standard value
ϕ^I	Investment adjustment cost	1	Standard value
ψ	Dividend adjustment cost	0.146	Jermann and Quadrini (2012)
α_T^K	Capital share, T	0.25	$\frac{\text{Spending on K,T}}{\text{Spending on K,NT}} = \frac{0.09}{0.21}$
α_{NT}^K	Capital share, NT	0.28	$\frac{I}{Y} = 0.23$
α_T^X	Intermediate goods share, T	0.74	$\frac{P_T^X X_T}{P_T^X X_T + W_T N_T + r_T^K K_T} = 0.74$
α_{NT}^X	Intermediate goods share, NT	0.46	$\frac{P_{NT}^X X_{NT}}{P_{NT}^X X_{NT} + W_{NT} N_{NT} + r_{NT}^K K_{NT}} = 0.46$
F_T	Fixed cost, T	0.23	$\frac{\text{Wealth}}{\text{Income}} = 2.5$ (annual)
F_{NT}	Fixed cost, NT	0.30	$\frac{D_T}{D} = \frac{Y_T}{Y}$
α_I	Import share of investment	0.40	OECD average
θ	Debt-to-earnings ratio	3.8	OECD average

D.1 Calibration details

We now describe some details of the calibration strategy.

D.1.1 Sectoral data

We calibrate the supply side of the economy using the OECD STAN database using the longest time span available (OECD, 2020, 2021a). In the following, we assume that the tradable sector ("T") in the model corresponds to the manufacturing sector in the data (STAN code C, ISIC 4 code: D10T33), and the non-tradable sector ("NT") corresponds to the service sector, which in the OECD classification is the sum of Market Services and non-Market Services (STAN codes: G, H, I, J, K, L, M, N, O, P, Q, R, S, T, U).

To calibrate the Cobb-Douglas share parameter in the production function (α_s^X), we need sectoral data on the cost of each input; $P_s^X X_s$ and $W_s N_s$. For costs associated with labor we use "total labor costs" (variable name : LABR), while for $P_s^X X_s$ we use total purchases of intermediate goods (variable name : INTI). We then calibrate α_s^X to match the following target:

$$\text{Spending on intermediate inputs} = \frac{P_s^X X_s}{P_s^X X_s + W_s N_s}.$$

In the model with capital, we also need data on the costs associated with capital, $r_s^K K_s$, in order to also pin down α_s^K. Data on total costs associated with capital is not readily available. Instead, we use the capital accumulation equation in steady state:

$$K_s = \frac{I_s}{\delta},$$

which relates the capital stock to investment and the depreciation rate. We obtain data on investment from the STAN database using gross fixed capital formation (variable name : GFCF). Then, multiplying through by the steady state cost of capital $r^K = \delta + r$, we obtain a measure of the cost of capital:

$$r_s^K K_s = \frac{\delta + r}{\delta} I_s.$$

We proceed to calibrate the parameters α_s^X to satisfy the equation:

$$\text{Spending on intermediate inputs} = \frac{P_s^X X_s}{P_s^X X_s + W_s N_s + r_s^K K_s}.$$

For capital, we jointly calibrate α_T^K and α_{NT}^K to match an aggregate investment rate of 23%, and the ratio of capital spending between the two sectors:

$$\frac{\text{Cap. spending in T}}{\text{Cap. spending in NT}} = \frac{r_T^K K_T}{P_T^X X_T + W_T N_T + r_T^K K_T} \Big/ \frac{r_{NT}^K K_{NT}}{P_{NT}^X X_{NT} + W_{NT} N_{NT} + r_{NT}^K K_{NT}}.$$

Input-output matrix For the input-output matrix of the model, we use the input-output matrix from the STAN database for the year 2010. Given that the model features only two broader sectors, we need to recalculate the IO matrix. We first define total spending on intermediate goods in each sector as:

$$X_T = X_{NT\to T} + X_{T\to T} + X_{F\to T},$$
$$X_{NT} = X_{NT\to NT} + X_{T\to NT} + X_{F\to NT}.$$

We then specify the IO matrix as:

$$\boldsymbol{\Theta} = \begin{array}{c} \\ T \\ NT \\ F \end{array} \begin{array}{c} \begin{array}{cc} T & NT \end{array} \\ \begin{bmatrix} \frac{X_{T\to T}}{X_T} & - \\ - & \frac{X_{NT\to NT}}{X_{NT}} \\ - & - \end{bmatrix} \end{array},$$

where we have left four elements empty, namely the amount of intermediate goods purchased from the other domestic sector and from abroad. We calibrate the model to match i) the aggregate import-to-GDP ratio, and ii) the ratio of imports in the tradable sector to imports in the non-tradable sector $\frac{X_{F\to T}}{X_{F\to NT}}$. This allows us to pin two additional parameters in $\boldsymbol{\Theta}$. The remaining parameters are obtained from the restriction that the columns must sum to 1.[6]

6. In principle we could calibrate the remaining entries in $\boldsymbol{\Theta}$ using data on import of intermediate goods by the tradable sector. However, given our calibration of domestic consumption of tradables C_T, using that strategy implies that the ratio of imported intermediates to value-added in the tradables sector becomes too high. The consequence of this is that households' imports of final goods are almost zero, since at the aggregate level we match an import-to-GDP ratio of 42%.

Import of final goods. To calibrate the share of foreign tradables in the domestic consumption basket, α_F, we use data on imports by end-use contained in the OECD dataset *BTDIXE_I4*, part of the STAN database. We then calculate total imports, M, as the sum of imports used as intermediate inputs in production, M^X, and imports going to household consumption, M^C. We calibrate α_F to match the ratio of household imports over aggregate imports, $\frac{M^C}{M^X+M^C}$, which for our sample equals 29%.

Import content of investment. Our calibration of the import share of investment goods relies on the OECD's Trade in Value Added database (see OECD, 2021b). We use the origin shares for value added in gross fixed capital formation, and obtain the import share as 1 minus the domestic share. We compute the annual average value across the 31 small open economies in the OECD, and then take the average over time. This yields an average of 40%.

D.1.2 Jacobians

We now present some properties of the calibrated household structure.

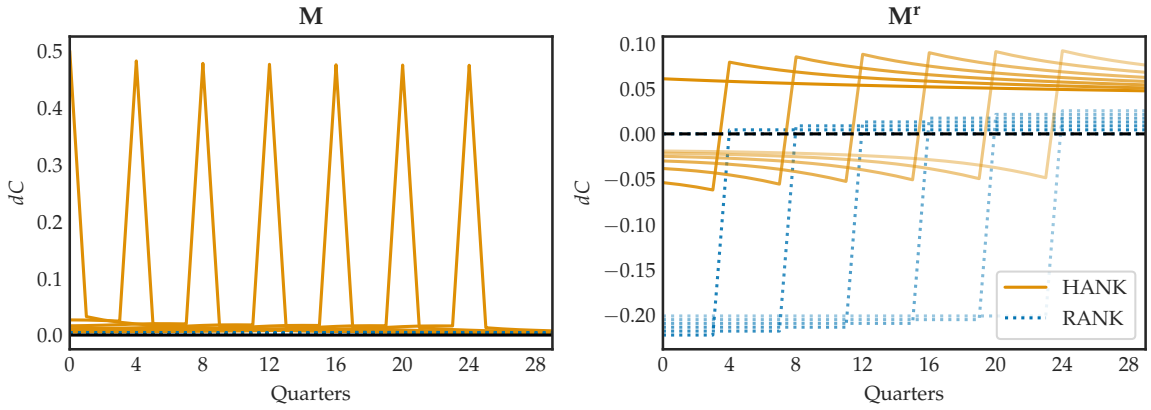
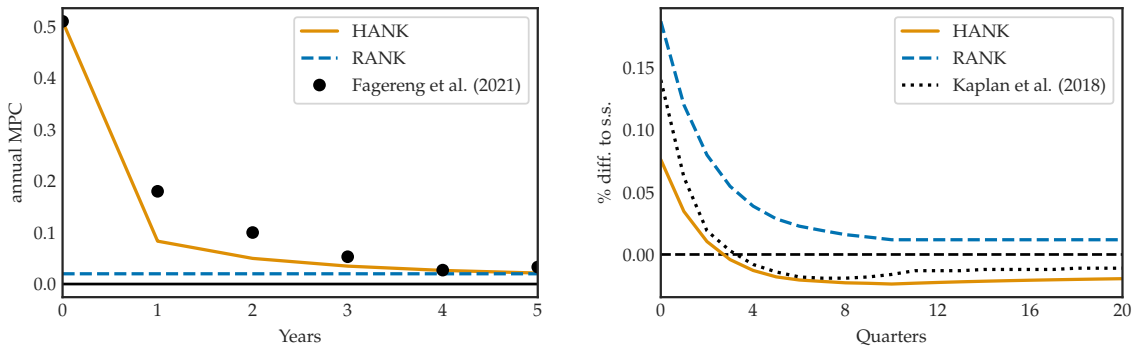


Figure D.1: Columns of Jacobians in HANK and RANK

Note: The left panel shows the columns of the intertemporal marginal propensities to consume ($\mathbf{M}$). The right panel shows the effect of real interest rate changes on consumption ($\mathbf{M}^r$). In both panels, the matrix entries are plotted for the quantitative HANK and RANK models presented in Section 4.



(a) Calibration of MPCs.

(b) Interest rate sensitivity.

Figure D.2: Household calibration moments

Note: Panel (a): Annual MPCs from the HANK and RANK models vis-a-vis estimates from Fagereng et al. (2021). Panel (b): Consumption response to a persistent interest rate decrease vis-a-vis the corresponding response from Kaplan et al. (2018).

D.1.3 Calibration of debt-to-earnings ratio

To pin down the relevant debt-to-earnings ratio for the sample of OECD countries, we rely on the following strategy. From the Financial Indicators database of the OECD (see OECD, 2025f), we obtain an annual measure of debt of non-financial corporations for each country. We obtain earnings from the STAN database in the form of gross operating surplus, and subtract earnings of financial and insurance activities from the total figure. We then divide these two series to obtain a measure of debt to earnings. We compute an annual average across the OECD economies, excluding the G7 countries (and Luxembourg, which is an outlier in this case), and then take the average value over time to arrive at a value of 3.8. In comparison, Drechsel (2023) uses a value of 4.6 for the US. The slightly lower figure we obtain is consistent with the fact that financial markets in the US are more developed than the OECD average.

D.1.4 Foreign economy responses

In Figure D.3 we plot the estimated IRFs for the foreign economy to a foreign demand shock in the LP in Section 2 along with the smoothed versions we feed into the model as our main shock. We smooth the IRFs using a Gaussian filter and assume that they converge to zero after 6 quarters for M^*, 13 quarters for π^*, and 14 quarters for i^*. We do this using a smoothing parameter of 1 for M^* and π^*, and 2 for i^*, which is estimated with more noise in the LP.

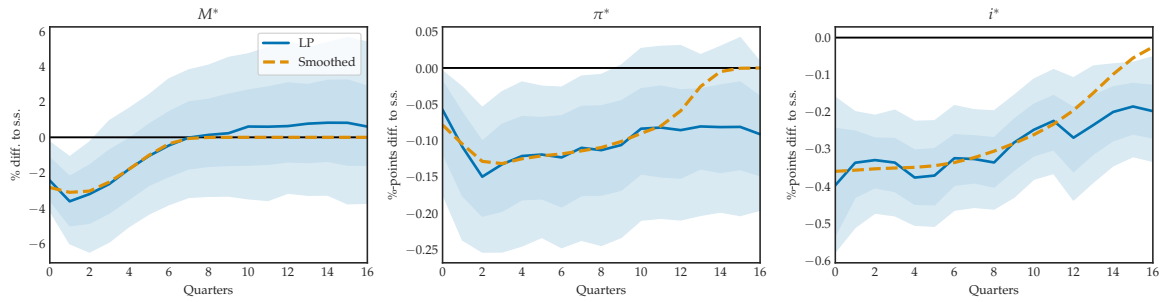


Figure D.3: Response in foreign economy to a foreign demand shock

Note: The figure reports the foreign demand shock as estimated in the data alongside the smoothed versions used in the quantitative model exercise.

We then conduct a similar exercise for a foreign supply shock. Here the smoothing horizons are $10, 13, 5$, respectively, and the smoothing parameters are unchanged. The results are reported in Figure D.4 below.

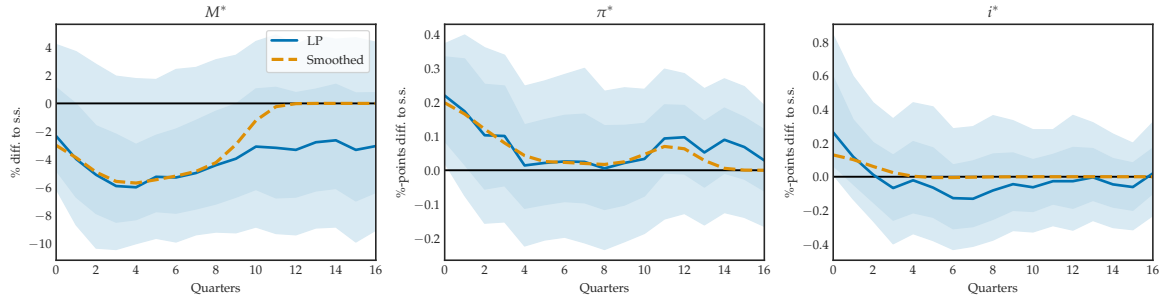


Figure D.4: Response in foreign economy to a foreign supply shock

Note: The figure reports the foreign supply shock as estimated in the data alongside the smoothed versions used in the quantitative model exercise.

E Additional model results

We now present a set of additional results from the quantitative model.

E.1 Model analysis with capital

We now extend the model to allow for capital formation in an effort to assess whether the model can account for our empirical findings along this dimension. As discussed briefly in Section 2, we observe a notable decline in investment following a negative foreign demand shock in the data. In a frictionless environment, however, the observed drop in the real interest rate would lead to an *increase* in investment, all else equal. To counteract this force, we incorporate a financial friction in the form of an earnings-based borrowing constraint, as in Lian and Ma (2021) and Drechsel (2023). Since earnings tend to decline after a negative demand shock, this generates a contraction in credit issuance. This mechanism is also consistent with the data: As seen in Appendix Figure A.4, we observe a clear decline in real credit to the private nonfinancial sector after a negative foreign demand shock.

Formally, we now assume that production requires inputs of a CES aggregate of capital and labor, in addition to intermediate goods. Capital services are rented from a capital firm, which owns and accumulates the capital stocks of the two sectors. The firm maximizes discounted dividends subject to an earnings-based borrowing constraint and a standard law of motion for capital. In addition to standard investment adjustment costs, it incurs a cost of adjusting dividend payouts, following Jermann and Quadrini (2012), which introduces a borrowing motive. We describe the details of the problem and the associated first-order conditions in Appendix C. We set the depreciation rate of capital to 2.5% per quarter, as is standard in the literature. The elasticity of substitution between capital and labor in production is set to 0.5, consistent with the meta-study of Gechert et al. (2022).[7] The import share of investment goods and the debt-to-earnings ratio are calibrated to match sample averages across the OECD countries. We pin down the dividend adjustment cost parameter using the calibrated value of Jermann and Quadrini (2012). Finally, since we do not incorporate variable capital utilization, we choose a moderate value of the investment

7. The capital share in the CES production input is calibrated to match sector-specific expenditure shares. We also recalibrate the expenditure shares of intermediate goods to account for the use of capital in production. See Appendix D.1 for details.

adjustment cost parameter, which we set to 1, a value well within the range of available estimates in the literature (e.g., Christiano et al., 2005 or Liu et al., 2013). All parameter values are summarized in Table D.2.

We then turn to the quantitative results, which are reported in Figure E.1. Investment falls on impact; by about one percent in the HANK model and a quarter of a percent in the RANK model, compared to slightly more than two percent in the data. From the second quarter onwards, however, the response of investment turns positive, reaching its peak around six to seven percent above steady state after five quarters in the HANK model (and slightly less in the RANK model). Altogether, neither model can therefore account for the investment dynamics observed empirically. The investment boom spills over to some of the other variables. In particular, we now observe a counterfactual increase in imports due to the import content of investment goods, and a less persistent contraction in output and consumption. The responses of the remaining variables are qualitatively similar to our previous findings.

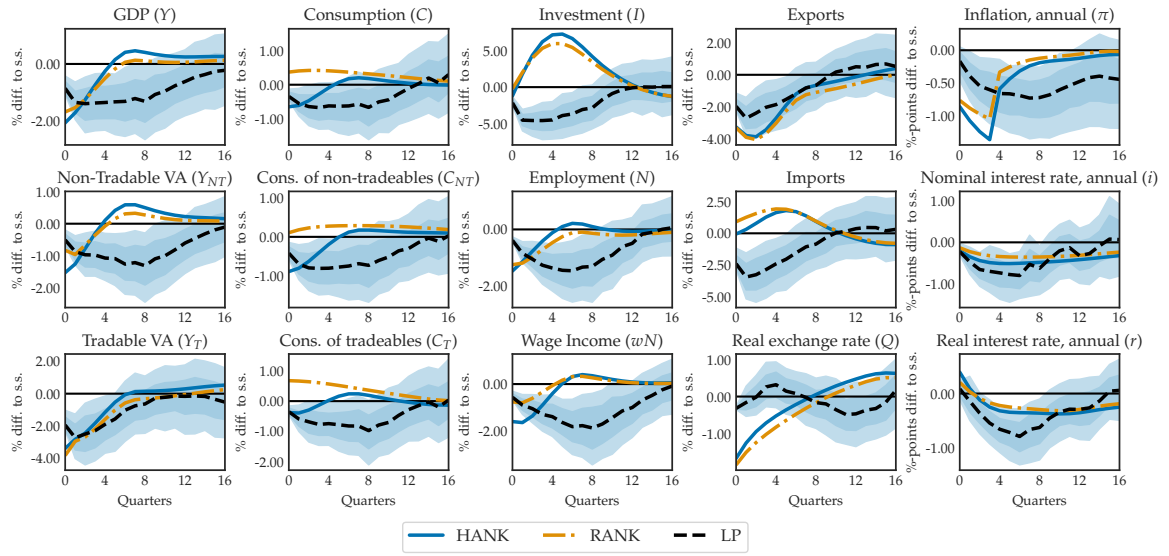


Figure E.1: Response of the domestic economy to a foreign demand shock with capital formation

Note: The figure shows the response of domestic variables to a foreign demand shock in the HANK and the RANK model after the introduction of capital.

To isolate the role of the financial friction, Figure E.2 reports the responses of output, consumption, and investment in versions of the HANK and RANK models with and without the financial friction. The right panel shows that the borrowing constraint exerts a clear negative effect on the response of investment over the first year. Without the financial friction—that is, no dividend adjustment cost ($\psi = 0$), and thus no

borrowing motive—investment rises on impact in both models. The introduction of the financial friction is required to produce the initial decline in investment. At date zero, the capital stocks are predetermined; earnings fall with the shock; and the debt limit falls with earnings, so the firm has to cut investment and/or cut dividends (the dividend adjustment cost makes it do some of both).[8] The boom in investment starting in the second quarter is driven by two forces: the currency appreciates on impact, which makes the imported component of the investment bundle cheaper, and the real interest rate falls from the second quarter onwards. Finally, cash-flow-driven investment and cash-flow-driven consumption tend to reinforce each other in the HANK model: the contractions in consumption and output are larger when the financial friction is active.

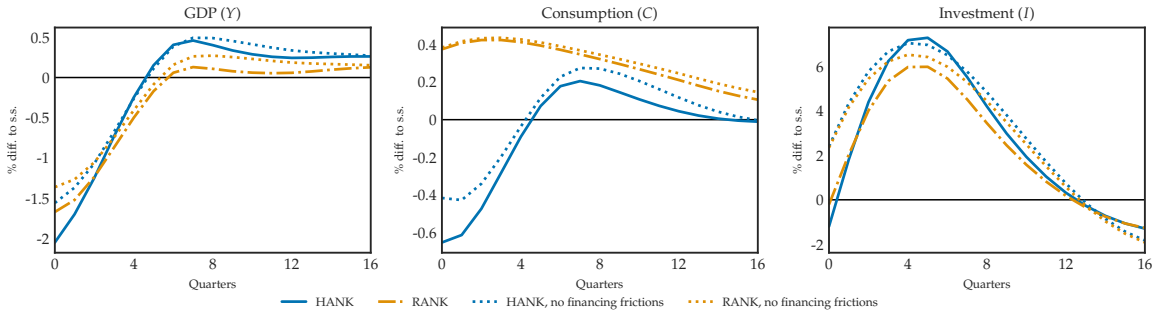


Figure E.2: Response of key variables with and without the financial friction

Note: The figure shows the response of key domestic variables to a foreign demand shock in the HANK and the RANK model with capital, alongside the corresponding responses from a model version without the financial friction on the capital firm. The latter is obtained by setting $\psi = \theta = 0$.

Obtaining a positive comovement between consumption and investment in response to demand shocks is a well-known challenge in business-cycle models (e.g., Barro and King, 1984), including those with heterogeneous agents (e.g., Auclert et al., 2020; or Bilbiie et al., 2022). Our HANK model extended with a financial friction attains this on impact, where consumption and investment both drop, whereas the RANK model entails a rise in consumption along with a drop in investment. Beyond the first quarter, however, none of the models can produce a positive comovement. Additional frictions are required in order to induce a more persistent decline in investment. Candidates include sticky expectations (as in Auclert et al., 2020),

8. The model implies a contraction in firm credit of a realistic magnitude: In the HANK model as well as in the data, credit drops by slightly more than one percent over the first three years after the shock (see Appendix Figure A.4). The model response is more front-loaded and less persistent than in the data, reflecting in part that all debt in the model is short-term (one-period), whereas the empirical counterpart has a longer average maturity.

sticky discount rates (Fukui et al., 2024), time to build (Kydland and Prescott, 1982), a sector-specific (rather than aggregate) investment adjustment cost, or a borrowing constraint featuring a smoothed measure of earnings. Overall, we conclude that the introduction of capital does not alter the main takeaways from our analysis, and that our model can account for the initial decline in investment, but neither for its size nor for its persistence.

We finally document that the main insights from the consumption decompositions presented in the main text are confirmed in the model version with capital, as seen from Figures E.3 and E.4.

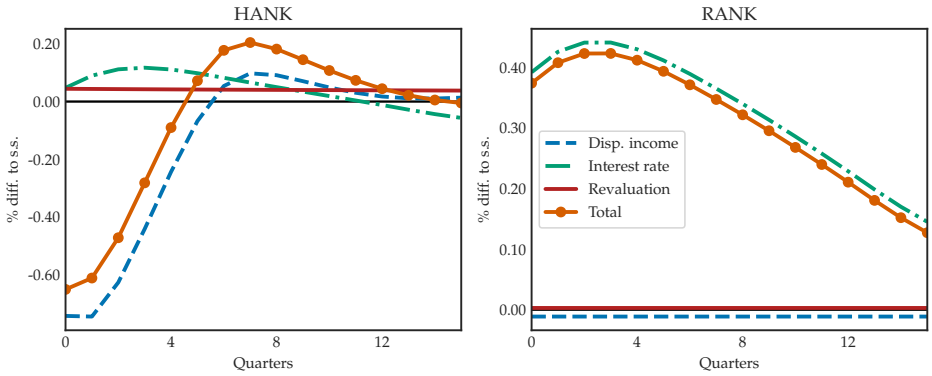


Figure E.3: Decomposed consumption response to a foreign demand shock with capital

Note: See Figure 9.

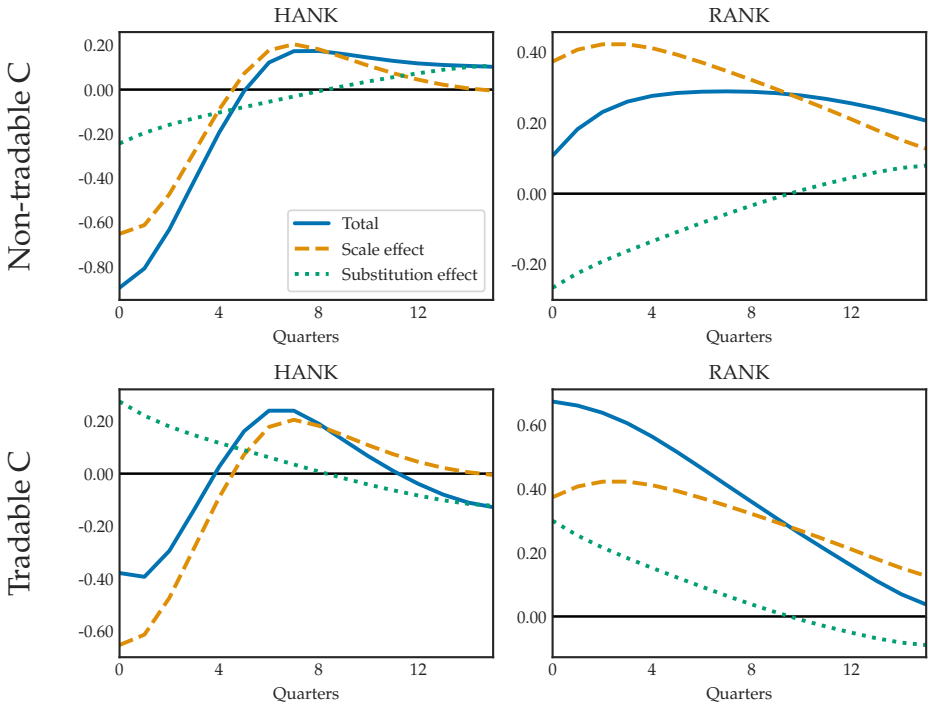


Figure E.4: Decomposed response of consumption of tradables and non-tradables to a foreign demand shock with capital

Note: See Figure 10.

E.2 Cognitive discounting in the UIP condition

We consider a UIP deviation to allow the HANK and RANK models to better match the behavior of the real exchange rate. Our extension is motivated by the findings of Galí (2020), who documents that expected interest-rate differentials in the distant future have much weaker effects on current real exchange rates in the data than implied by the UIP. He then shows that introducing cognitive discounting (as in Gabaix, 2020) into the UIP condition can alleviate this issue. Formally, we therefore replace the rational expectations operator $\mathbb{E}_t[Q_{t+1}]$ in the UIP condition with a subjective expectations operator $\tilde{\mathbb{E}}_t[Q_{t+1}]$ featuring cognitive discounting of future real-exchange-rate movements. Specifically, we let $\tilde{\mathbb{E}}_t[Q_{t+1}] = Q_{ss} + m\mathbb{E}_t[dQ_{t+1}]$, with $m \leq 1$, and where Q_{ss} is the "default" value of the real exchange rate that agents have in mind. Under this assumption, the linearized UIP condition solved forward yields $dQ_t = \sum_{k=0}^{\infty} m^k \mathbb{E}_t \left(dr^*_{t+k} - dr_{t+k}\right)$, implying that future interest-rate differentials exert a smaller influence on the current exchange rate than under full rationality ($m = 1$). We set $m = 0.6$, which represents the lower end of the range of estimates by Pfäuti and Seyrich (2022), who find values between 0.6 and 0.85. In

the numerical solution, the discounting is applied over the first 100 quarters of the transition path and m is set to one thereafter, so that the path is still anchored on the steady state at the end of the horizon.

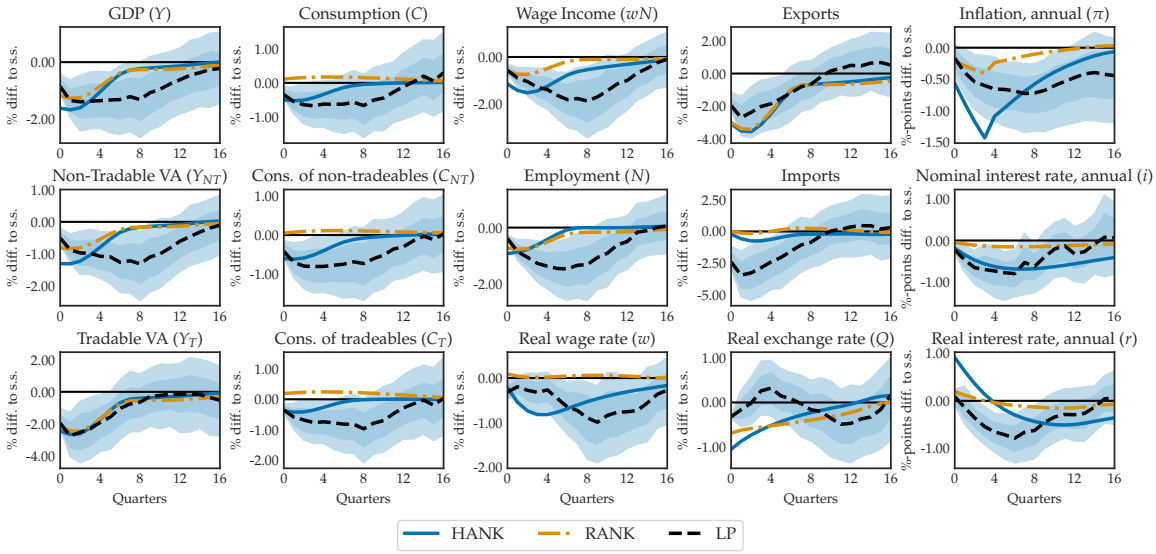


Figure E.5: Response of the domestic economy to a foreign demand shock with cognitive discounting in UIP

Note: The figure shows the response of domestic variables to a foreign demand shock in the HANK and the RANK model with cognitive discounting in the UIP condition.

As seen from the figure, this mechanism dampens the movements in the real exchange rate in both models, bringing the model-implied dynamics closer to the data. The resulting milder appreciation further contributes to a small decline in imports via expenditure switching. Beyond these effects, we note that the responses of all other variables are very similar to those observed in the baseline model.

E.3 Model analysis with a fixed exchange rate

We now present a set of results for the model with a fixed exchange rate.

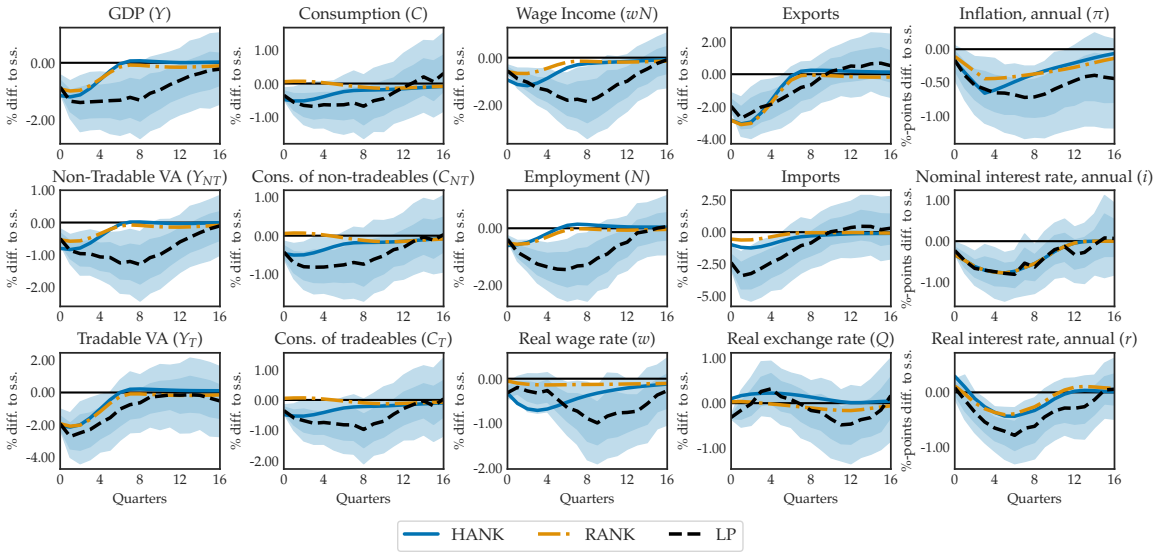


Figure E.6: Fixed exchange rate: Response of the domestic economy to a foreign demand shock

Note: The figure shows the response of domestic variables to a foreign demand shock under a fixed exchange rate in the HANK and the RANK model, alongside our empirical LP-based results from Section 2.

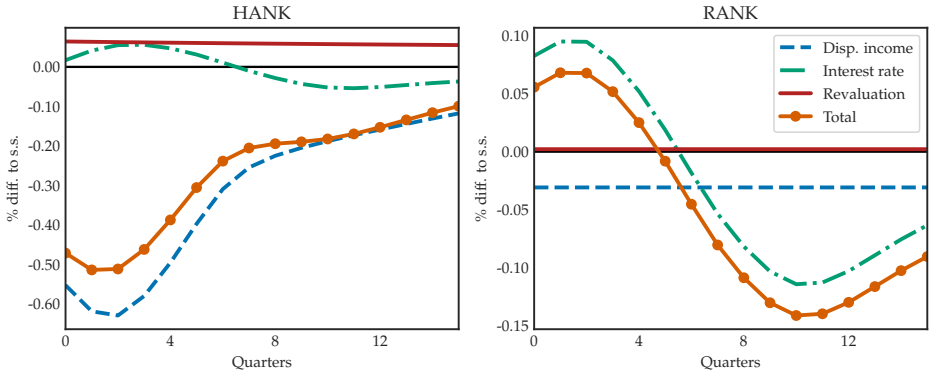


Figure E.7: Fixed exchange rate: Decomposed consumption response to a foreign demand shock

Note: See Figure 9.

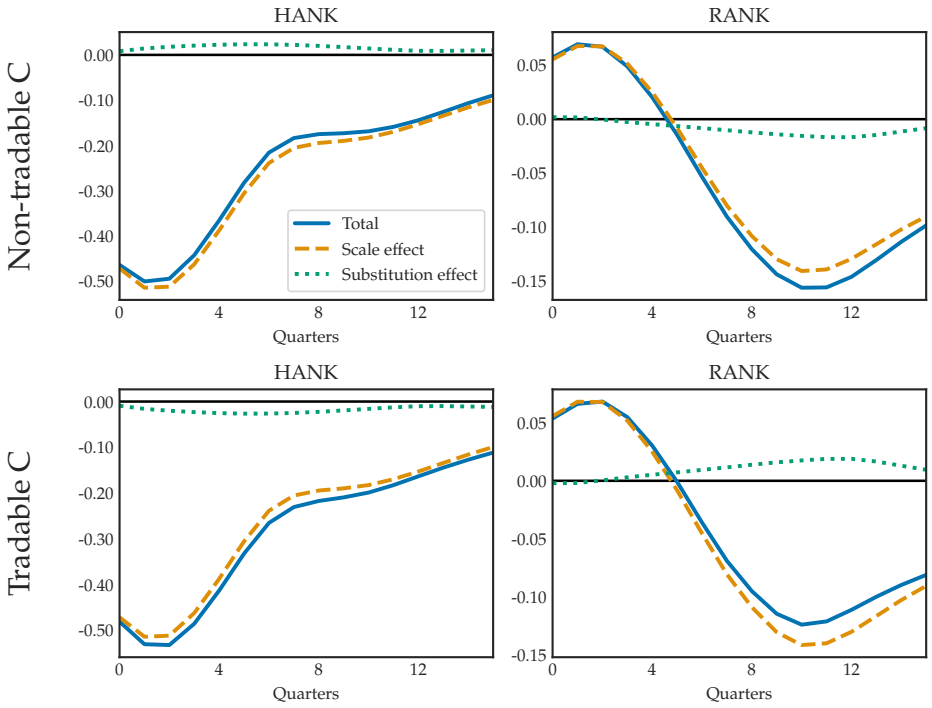


Figure E.8: Fixed exchange rate: Decomposed response of consumption of tradables and non-tradables to a foreign demand shock

Note: See Figure 10.

Table E.1 reports the same set of covariances shown in Table 1, but from the model with a fixed exchange rate instead of a floating rate.

Table E.1: Covariances

	$\text{Cov}(C, Y)$	$\text{Cov}(C_{NT}, Y)$	$\text{Cov}(C_T, Y)$
Data			
Unconditional	11.20	10.07	12.77
Conditional	7.98	10.10	10.58
Model			
HANK	2.41	2.33	2.50
RANK	-0.09	-0.07	-0.11

Note: The table reports the covariances of domestic output with domestic consumption or either of its sectoral components in the model with a fixed exchange rate.

E.4 Robustness analysis

We now consider a variety of alternative model specifications and parameter values to assess the robustness of our quantitative findings.

E.4.1 Alternative households specifications

We first consider the sensitivity of our results in the context of two alternative models that are both consistent with relatively high MPCs out of short-run income gains. The first is a two-agent New Keynesian (TANK) model à la Galí et al. (2007). A fraction λ^c of domestic households are constrained at all times and simply consume their labor income plus transfers. Unconstrained agents are on their Euler equation at all times. The household block is thus given by:

$$\begin{aligned} c_t^c &= (1-\tau_t)\, w_{s,t} L_{s,t} e_t + T_t, \\ u'\left(c_t^u\right) &= \beta \mathbb{E}_t \left(1 + r_{t+1}^a\right) u'\left(c_{t+1}^u\right), \\ C_t &= \lambda^c c_t^c + (1-\lambda^c)\, c_t^u. \end{aligned}$$

We calibrate the share of constrained agents λ^c to match the same annual MPC as in the baseline HANK model.

The second model is a two-asset extension of our baseline HANK model, as in Auclert et al. (2020). Households receive after-tax income $(1-\tau_t)\, w_{s,t} L_{s,t} e_t + T_t$. They can invest in liquid assets ℓ_t and illiquid assets a_t through a financial intermediary subject to a zero borrowing constraint. The function $d\left(a_{t-1}\right)$ governs the transfer of resources from the illiquid asset to the liquid asset:

$$d_t\left(a_{t-1}\right) = \frac{r_{ss}^a}{1+r_{ss}^a} a_{t-1} + \chi\left(a_{t-1} - \left(1+r_{ss}^a\right)\bar{a}\right),$$

where $\bar{a}$ is the long run target of illiquid assets, and χ determines the speed of tran-

sition to this level. The full problem faced by households is then given by:

$$V_t^{s,k}(e_t, a_{t-1}, \ell_{t-1}) = \max_{c_t, \ell_t} u(c_t) - v(L_{s,t}) + \beta_t \mathbb{E}_t \left[V_{t+1}^{s,k}(e_{t+1}, a_t, \ell_t) \right] \tag{E.1}$$

s.t.

$$c_t + \ell_t = \left(1 + r_t^{\ell}\right) \ell_{t-1} + d_t(a_{t-1}) + (1 - \tau_t) w_{s,t} L_{s,t} e_t + T_t, \tag{E.2}$$

$$a_t = (1 + r_t^a) a_{t-1} - d_t(a_{t-1}), \tag{E.3}$$

$$\ell_t \geq 0, \tag{E.4}$$

$$\ln e_t = \rho_e \ln e_{t-1} + \epsilon_t^e, \quad \epsilon_t^e \sim \mathcal{N}\left(0, \sigma_e^2\right). \tag{E.5}$$

We set $\chi = 0.01$ in order to match the second-year MPC estimate from Fagereng et al. (2021). We then subject each of these two alternative models to the same foreign demand shock as considered in our baseline analysis. In Figure E.9, we report the responses of GDP and aggregate consumption in each of the two models, alongside our baseline model and the empirical results from our LP analysis. As seen from the figure, each of the two alternative models have largely similar quantitative implications as our baseline model.

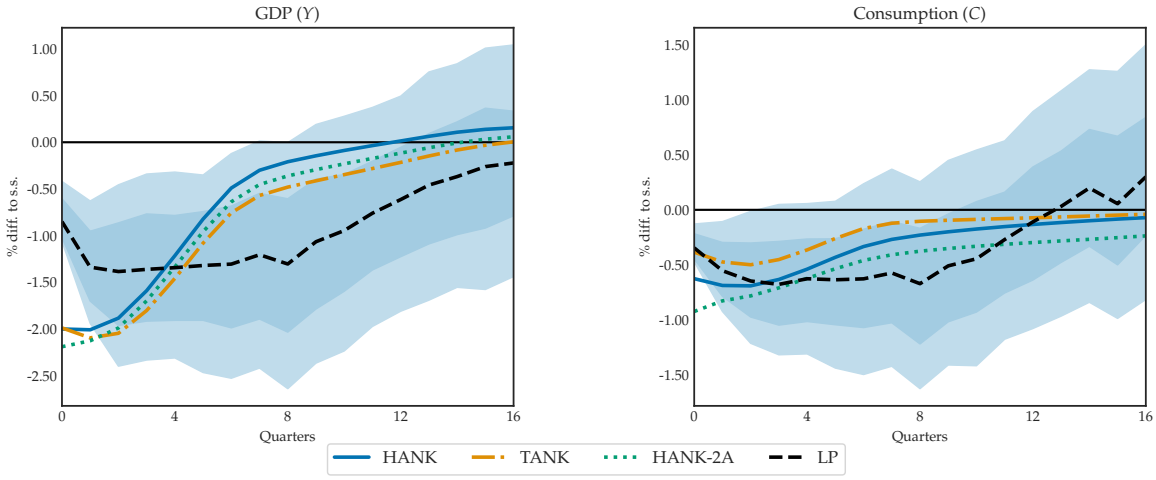


Figure E.9: Varying the household specification

Note: The figure shows the response of selected domestic variables to a foreign demand shock when varying the specification of the household block.

E.4.2 Different government budget rule

We now consider an alternative specification of the government budget rule in the model. Instead of the baseline specification presented above, we now assume that

the government sets the tax rate according to the following rule in all periods: $\tau_t - \tau = \epsilon^B \frac{B_{t-1} - B_{ss}}{Y_{ss}}$. This rule is similar to the one considered in Auclert et al. (2020). Figure E.10 reports the responses of output and consumption, alongside the implied paths for the tax rate and government debt, when the government follows this rule with $\epsilon^B = 0.10$. As seen from the figure, we observe a somewhat larger drop in consumption when the government raises taxes at an earlier point in time, as compared to our baseline model. This suggests that our baseline specification is a rather conservative approach.

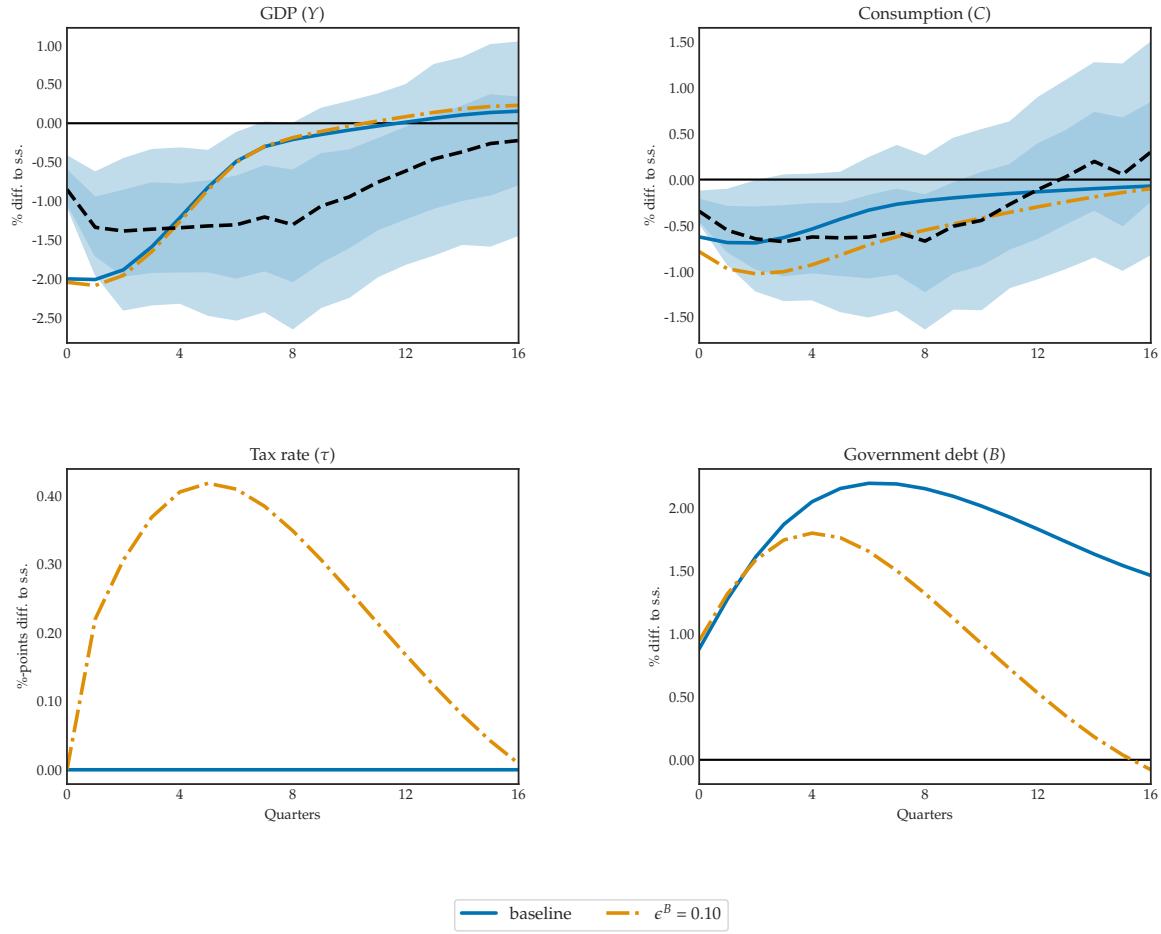


Figure E.10: Varying the budget rule

Note: The figure shows the response of selected domestic variables to a foreign demand shock when varying the specification of the budget rule.

E.4.3 Alternative parameter values

We finally consider a range of alternative parameter values. The results are reported in Figures E.11, E.12, and E.13.

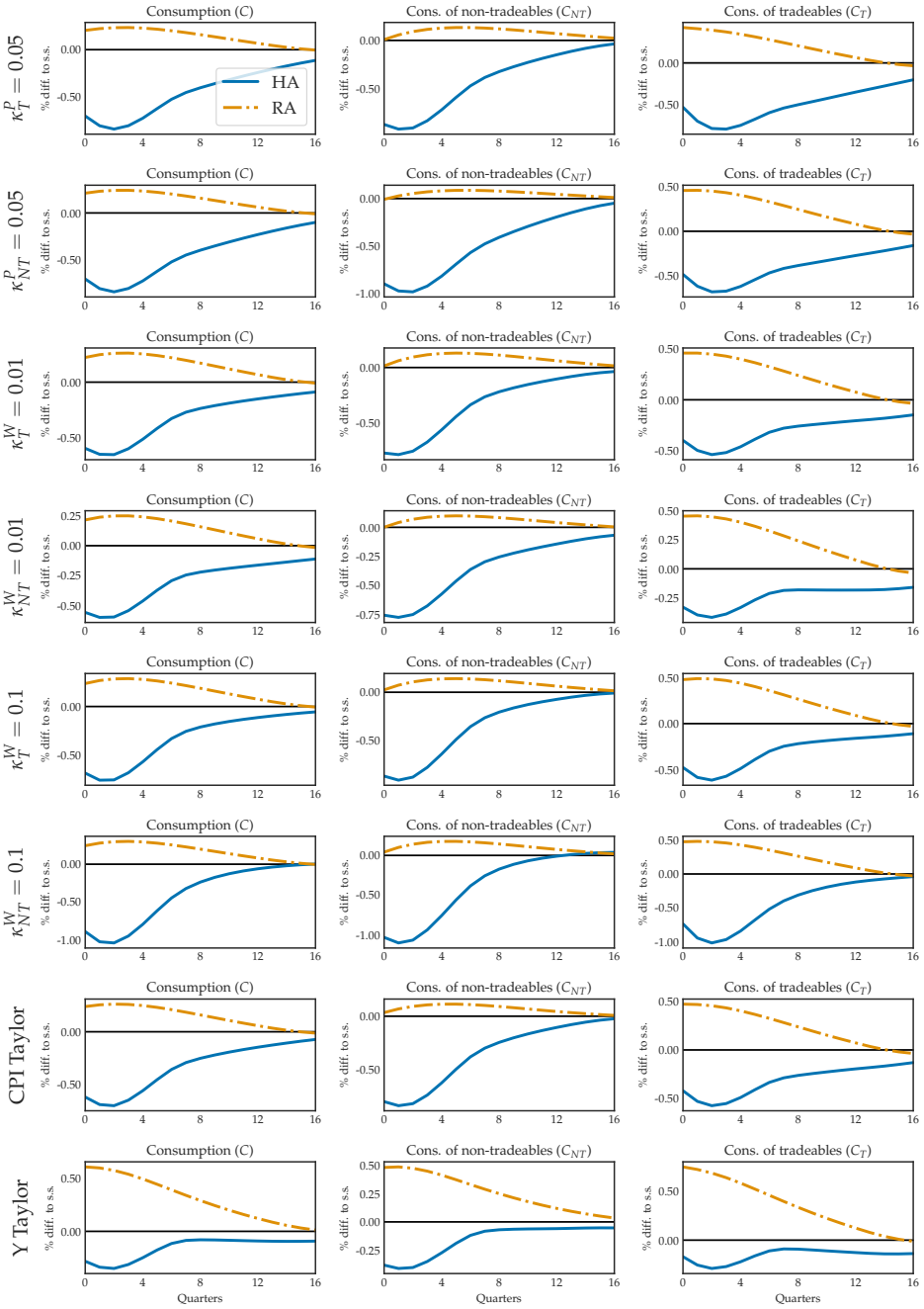


Figure E.11: Foreign demand shock responses under various NK calibrations

Note: The figure shows the response to a foreign demand shock under various different parametric assumptions. In rows 1 and 2 we change the slope of the NKPC in each sector. In rows 3 to 6 we change the slope of the NKWPC in each sector. Row 7 replaces the PPI Taylor rule with a CPI-based rule. Row 8 considers a Taylor rule featuring output as well as inflation, with $\phi^Y = 0.25$.

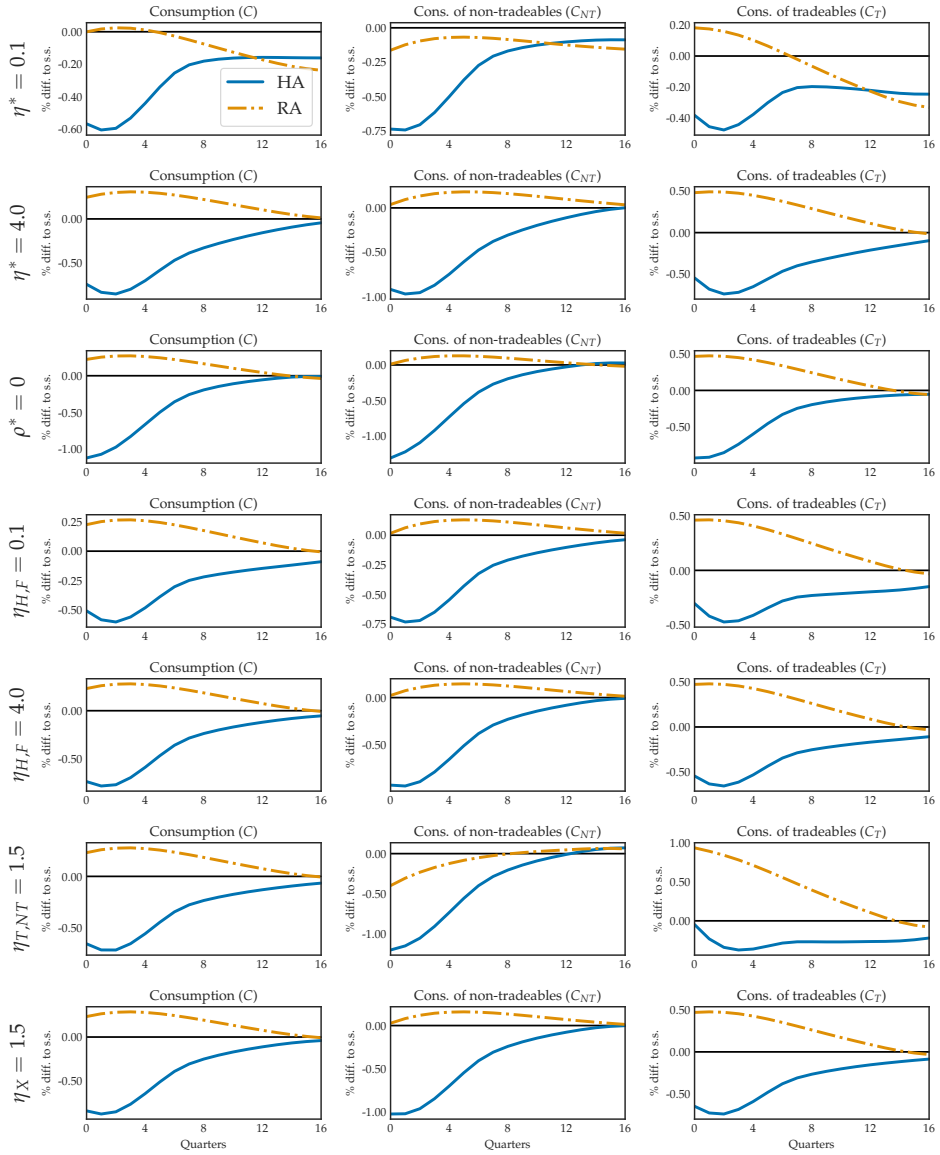


Figure E.12: Foreign demand shock responses with different trade elasticities

Note: The figure shows the response to a foreign demand shock under various different parametric assumptions. In row 1 and 2 we reduce/increase the long run elasticity of exports. In row 3 we change the persistence of the export rigidity. In row 4 and 5 we reduce/increase the elasticity of substitution between domestic and foreign tradables for domestic households. In row 6 we change the elasticity of substitution between tradables and non-tradables for domestic households. In row 7 we consider a higher elasticity of substitution between intermediate goods.

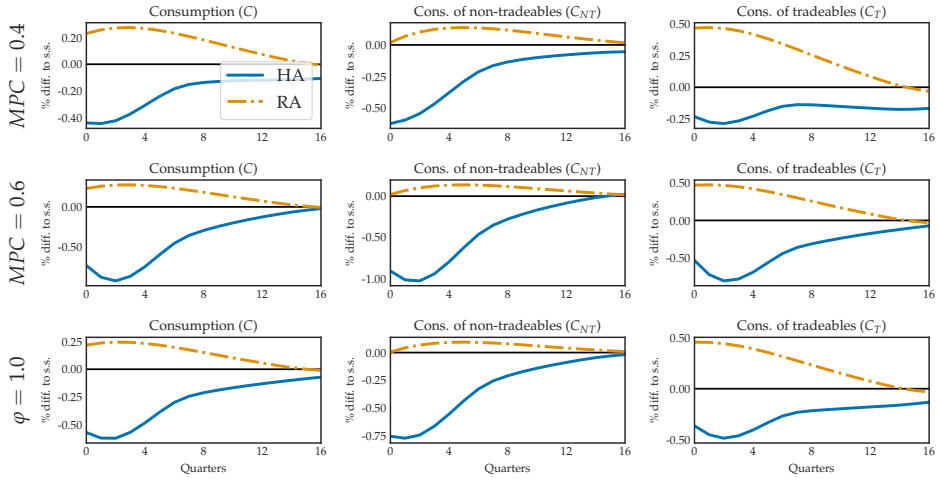


Figure E.13: Foreign demand shock responses with different calibration of households

Note: The figure shows the response to a foreign demand shock under various different parametric assumptions. In row 1 and 2 we reduce/increase the average MPC in the model compared to the baseline. In row 3 we consider a higher Frisch elasticity of labor supply.

E.5 Stabilization policy: Details

Table E.2 presents the responses of labor income to foreign and domestic demand shocks and the policy instruments considered in Section 7.

Table E.2: Cumulative labor income effects of demand shocks and policy instruments.

	Floating				**Fixed**			
	C	Y_T^{hh}	Y_{NT}^{hh}	$\frac{Y_T^{hh}}{Y_{NT}^{hh}}$	C	Y_T^{hh}	Y_{NT}^{hh}	$\frac{Y_T^{hh}}{Y_{NT}^{hh}}$
Foreign demand, β^*	-1.00	-2.86	-2.52	1.14	-1.00	-1.84	-1.82	1.01
Domestic demand, β	-1.00	-0.37	-0.75	0.49	-1.00	-0.34	-0.72	0.47
Public transfers, T	1.00	0.26	1.20	0.22	1.00	0.29	1.19	0.24
Public spending, G	1.00	0.73	2.39	0.30	1.00	0.75	2.36	0.32
Monetary policy, i	1.00	1.91	1.99	0.96	-	-	-	-
Nominal devaluation	-	-	-	-	1.00	2.50	2.15	1.16
Fiscal devaluation	-	-	-	-	1.00	2.71	2.50	1.09

Note: See notes to Table 2. Y_T^{hh} and Y_{NT}^{hh} denote labor income of households employed in the tradable and non-tradable sectors, respectively.

Figure E.14 reports the impulse responses of the real exchange rate and the terms of trade to a foreign demand shock in our baseline model, alongside the responses to

the policy instruments we consider in Section 7. Figure E.15 reports the corresponding responses from the model with a fixed exchange rate.

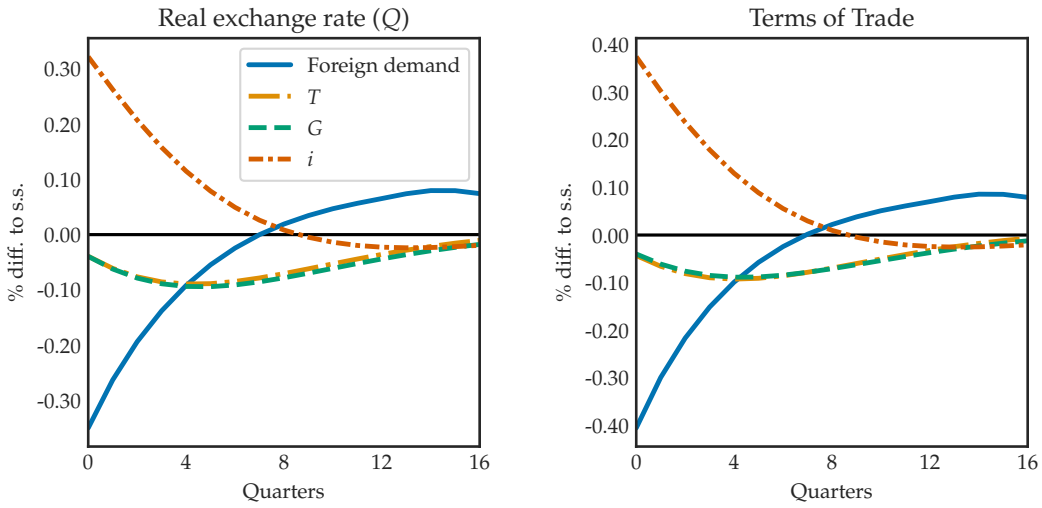


Figure E.14: International relative price dynamics under a floating exchange rate

Note: All policy instruments follow AR(1) processes with a persistence of 0.75. The foreign demand shock is scaled to generate a cumulative 1% decrease in aggregate consumption over the first 16 quarters, and the policy instruments are scaled to exactly offset this. The *real exchange rate* is $Q_t = E_t P_t^* / P_t$. The *terms of trade* is $S_t = \frac{P_{F,t}}{P_{H,t}}$.

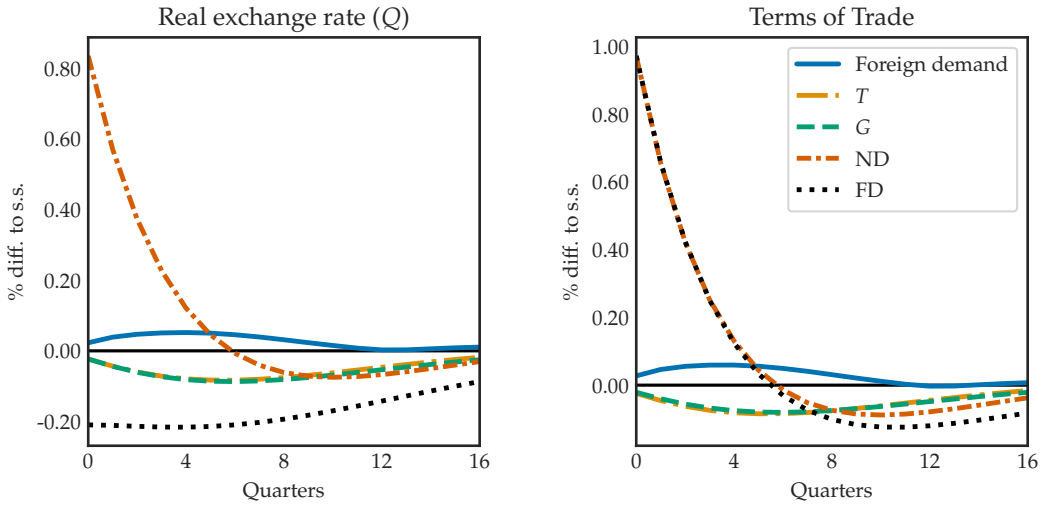


Figure E.15: International relative price dynamics under a fixed exchange rate

Note: All policy instruments follow AR(1) processes with a persistence of 0.75. The foreign demand shock is scaled to generate a cumulative 1% decrease in aggregate consumption over the first 16 quarters, and the policy instruments are scaled to exactly offset this. *FD* is fiscal devaluation and *ND* is nominal devaluation. The implementation details are in Appendix E.5.1. The *real exchange rate* is $Q_t = E_t P_t^* / P_t$. The *terms of trade* is $S_t = \frac{(1-\tau_t^v)P_{F,t}}{P_{H,t}^* E_t} = \frac{P_{F,t}}{P_{H,t}}$.

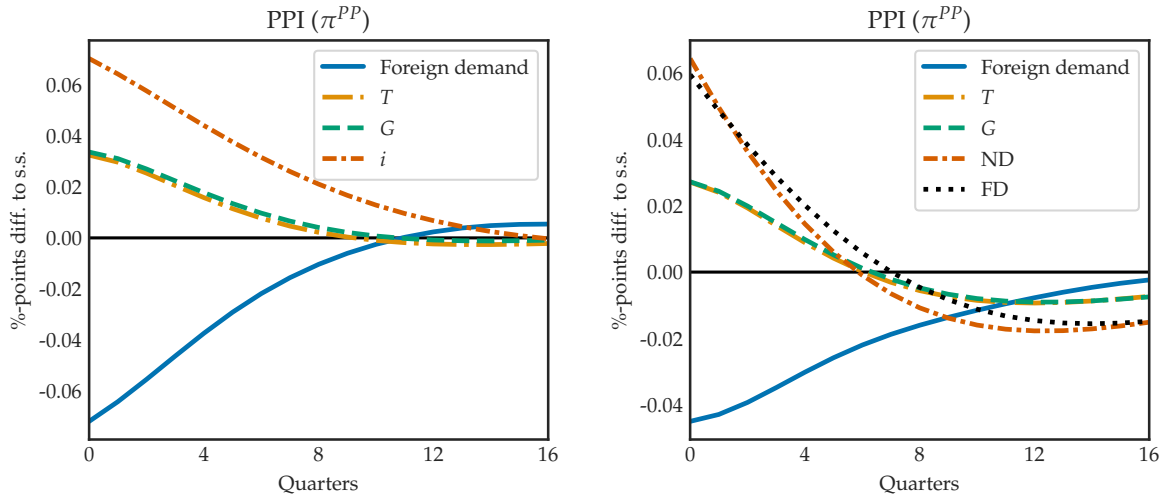
Table E.3 presents the responses of inflation to foreign and domestic demand shocks and the policy instruments considered in Section 7.

Table E.3: Cumulative inflation effects of demand shocks and policy instruments.

	Floating				Fixed			
	π^{PP}	π_H	π_{NT}	$\frac{\pi_H}{\pi_{NT}}$	π^{PP}	π_H	π_{NT}	$\frac{\pi_H}{\pi_{NT}}$
Foreign demand, β^*	-0.34	-0.34	-0.35	0.96	-0.33	-0.33	-0.33	0.97
Domestic demand, β	-0.02	-0.02	-0.02	1.01	0.01	0.01	0.01	0.94
Public transfers, T	0.14	0.13	0.14	0.93	0.03	0.02	0.03	0.68
Public spending, G	0.16	0.15	0.17	0.91	0.04	0.03	0.04	0.63
Monetary policy, i	0.46	0.45	0.46	0.99	-	-	-	-
Nominal devaluation	-	-	-	-	0.06	0.06	0.06	1.02
Fiscal devaluation	-	-	-	-	0.12	0.11	0.12	0.89

Note: See notes to Table 2. π_H and π_{NT} denote the inflation rates of tradable and non-tradable goods, respectively.

Figure E.16 presents the impulse responses of producer price inflation.



(a) Floating exchange rate

(b) Fixed exchange rate

Figure E.16: Producer price inflation dynamics

Note: All policy instruments follow AR(1) processes with a persistence of 0.75. The foreign demand shock is scaled to generate a cumulative 1% decrease in aggregate consumption over the first 16 quarters, and the policy instruments are scaled to exactly offset this. *FD* is fiscal devaluation and *ND* is nominal devaluation.

E.5.1 Details of a fiscal devaluation

We implement a fiscal devaluation using a value-added tax τ_t^v and a payroll subsidy ζ_t^p.[9] We now report the equations from the main text that change with the introduction of the tax and the subsidy.

Since the VAT is reimbursed for exports, but enforced on imports, the law of one price implies:

$$P_{H,t}^* = (1 - \tau_t^v) \frac{P_{H,t}}{E_t},$$
$$P_{F,t}^* = (1 - \tau_t^v) \frac{P_{F,t}}{E_t}.$$

Since firms maximize the discounted value of dividends, the tax and the subsidy affect the first-order conditions of the firms, as already described in Appendix C. Finally, the government budget is now:

$$B_t + \tau_t \sum_s w_{s,t} N_{s,t} + \tau_t^v Y_t = \zeta_t^p \frac{W_{T,t} N_{T,t} + W_{NT,t} N_{NT,t}}{P_t} + T_t + \frac{P_t^G}{P_t} G_t + \frac{1 + i_{t-1}}{1 + \pi_t} B_{t-1}.$$

We construct a fiscal devaluation following Farhi et al. (2014). We choose a sequence $\{\delta_t\}$ and impose the following paths for the tax and the subsidy:

$$\tau_t^v = \omega^v \frac{\delta_t}{1 + \delta_t},$$
$$\zeta_t^p = (1 - \omega^v) \frac{\delta_t}{1 + \delta_t}.$$

In the numerical model, we assume that δ_t follows an AR(1) process with persistence 0.75 to be consistent with the other shocks considered in the model. As shown in Farhi et al. (2014), it is possible—under certain conditions—to perfectly mimic a permanent, one-time unexpected nominal devaluation using the VAT and the labor subsidy. Since we consider a temporary shock, it is generally not the case that the fiscal and nominal devaluation coincide perfectly. In practice, we choose the mix of the VAT and the subsidy (determined by ω^v) to resemble the terms-of-trade movement under a nominal devaluation as closely as possible. This obtains when $\omega^v = 0.48$, which is close to the value of Farhi et al. (2014) of $\omega^v = 0.5$.

9. The exercise is conducted using our baseline model without capital, which is the one we use for the policy exercises of Section 7.

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