The Transmission of Foreign Demand Shocks*

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Abstract

We show that incorporating household heterogeneity enables a New Keynesian model of a small open economy to match key stylized facts about the transmission of foreign demand shocks. In representative-agent versions of the model, a shortfall in foreign demand leads to a counterfactual increase in domestic consumption, as the central bank lowers interest rates in response to the shock. By contrast, with empirically plausible marginal propensities to consume, household heterogeneity generates a strong labor-income channel, leading to a decline in domestic consumption, including of both tradable and non-tradable goods, consistent with the data. As a result, foreign demand shocks play a substantially larger role in domestic business cycles than implied by existing models that abstract from such heterogeneity. While monetary policy is well suited to counteract such shocks, traditional fiscal policies are less effective, as they provide insufficient stimulus to the tradable sector. This shortcoming is particularly relevant for economies with a fixed exchange rate or in a monetary union.

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1 Introduction

In small open economies, external shocks are widely believed to be important drivers of domestic business cycles. Shocks to foreign demand for domestic goods represent a prominent example. Yet, the existing open-economy business-cycle literature has struggled to provide a convincing account of the transmission mechanism of foreign demand shocks that can fit the data.

In this paper, we offer a detailed study of the transmission of such shocks. Using data from 31 small open OECD economies, we first characterize and quantify their empirical effects. We establish three key findings regarding the response of the domestic economy to a *negative* foreign demand shock: *First*, we observe a drop in consumption, output, employment, and other aggregate variables. *Second*, consumption of both tradable and non-tradable goods displays a decline. *Third*, foreign demand shocks account for a substantial share (around 20%) of domestic business cycles.

Our second contribution is to develop a structural business-cycle model that can account for these facts. Through the lens of this model, it becomes clear that a high average marginal propensity to consume (MPC) out of transitory income is a necessary ingredient for explaining the decline in domestic consumption and its components, as well as the observed comovement patterns.

As a benchmark, we first show that open-economy representative-agent New Keynesian (RANK) models are hard to reconcile with the empirical evidence. The intuition is as follows: When foreign demand for domestic goods drops, an inflation-targeting domestic central bank reduces the nominal interest rate in response to the decline in domestic economic activity and inflation.[1] The resulting decline in the real interest rate triggers the powerful intertemporal substitution effect characteristic of RANK models, leading to a counterfactual *increase* in domestic consumption, including both tradable and non-tradable goods. Furthermore, since the implied correlation between domestic output and consumption is negative, whereas the unconditional correlation between these two variables is strongly positive in the data, standard RANK models attribute a very small role to foreign demand shocks in driving domestic business fluctuations, as found, e.g., by Justiniano and Preston (2010), but in contrast to our empirical findings.

1. Likewise, under a fixed exchange rate, the uncovered interest rate parity (UIP) condition induces the domestic central bank to reduce the interest rate in tandem with the foreign central bank, assuming that foreign inflation also drops, as we observe in the data.

To account for our results, we instead propose a small open economy heterogeneous-agent New-Keynesian (SOE-HANK) model featuring idiosyncratic income risk and borrowing constraints, tradable and non-tradable goods, and cross-country input-output linkages. Our model implies a sizeable but realistic MPC. Consistent with the closed-economy HANK literature (e.g., Kaplan et al., 2018, or Auclert, 2019), a strong direct income effect dominates the intertemporal substitution effect. In our SOE-HANK model, a decline in foreign demand induces an inward shift in domestic firms' labor demand curve, reducing wages and hours worked, and thereby households' labor income. With a high average MPC, this gives rise to a *drop* in consumption that more than offsets the intertemporal substitution effect described above. This mechanism allows the model to account for the observed decline in aggregate consumption. We first establish this result analytically in a stylized version of the model, and then corroborate our point in a quantitative model calibrated to match the average small open OECD economy. We also confirm this finding under a fixed exchange rate. Moreover, we demonstrate that the presence of a strong, negative income effect is key to obtaining a simultaneous decline in consumption of both tradable and non-tradable goods, as in the data.

Finally, the fact that our HANK model reproduces the positive correlation between domestic output and consumption *conditional* on a foreign demand shock paves the way for such shocks to potentially account for a sizeable share of domestic business-cycle fluctuations. Conditional on foreign demand shocks, the calibrated HANK model can account for more than 50% of the unconditional covariance between domestic output and consumption observed in the data. In contrast, the RANK model produces a negative comovement between these variables. In other words, the HANK model is able to generate a forceful propagation of foreign shocks to domestic variables endogenously, while the RANK model is not.

We then turn to the implications for macroeconomic policy. A negative foreign demand shock reduces income and consumption of households working in both domestic sectors, with particularly strong effects in the tradable sector. Monetary policy is well suited to counteract the effects of such shocks: A monetary expansion simultaneously stimulates the non-tradable sector and depreciates the real exchange rate and the terms of trade, thereby supporting the tradable sector. In contrast, expansionary fiscal policy leads to an appreciation of the terms of trade, consistent with the insights of the textbook Mundell-Fleming model. This aggravates the initial shortfall in foreign demand for domestic tradables. In other words, expansionary fiscal policy provides inadequate stimulus to the tradable sector, under both fixed and

floating exchange rates.

These results pose an important challenge for countries that cannot set an independent monetary policy, such as those with a fixed exchange rate or in a monetary union. This is especially relevant when foreign demand shocks are quantitatively important for domestic fluctuations, as we find. We show that a fiscal devaluation (as studied by Farhi et al., 2014, among others) can mitigate this problem. A fiscal devaluation—in the form of a reduction in the payroll tax combined with an increase in the value-added tax—successfully depreciates the terms of trade, and is therefore able to stabilize income and consumption in both domestic sectors.

1.1 Related Literature

Our work is mainly related to four branches of the existing literature. First, we contribute to the empirical literature quantifying the effects of foreign demand shocks on small open economies. Most existing studies utilize structural vector autoregression (VAR) models identified using small open-economy assumptions and, in some cases, sign restrictions. We adopt a complementary pooled local projections approach. Examples include Canova (2005), Eickmeier (2007), Mumtaz and Surico (2009), Charnavoki and Dolado (2014), and Feldkircher and Huber (2016). The findings of these papers can be summarized as follows: Negative foreign demand shocks tend to reduce domestic GDP, consumption, wages, and often prices, while the effect on net exports is inconclusive. Our findings are broadly consistent with this literature, but we extend it by documenting positive sectoral comovement and quantifying the contribution of foreign demand shocks. Moreover, while most studies focus on one or a few countries, we use data from 31 OECD economies.

Second, we connect to the literature aimed at proposing structural models to explain these results. Early contributions to this literature typically constructed international Real Business Cycle models (e.g., Backus et al., 1992). In the last few decades, the literature has turned to models with nominal rigidities (e.g., Gali and Monacelli, 2005; Corsetti, 2007). The line of research on the relative importance of foreign shocks in explaining domestic business cycles, especially in small open economies, is closely related to our work. Estimated models in this tradition—even those of large scale—typically imply that foreign shocks are largely unimportant for domestic business cycles. Examples include Justiniano and Preston (2010) for Canada, Adolfson et al. (2007) and Christiano et al. (2011) for Sweden, and Bergholt (2015) for Norway. Strikingly, Justiniano and Preston (2010) find that—in an estimated representative-

agent model—*all* shocks originating in the US explain less than 3% of the variation in Canadian output and other macroeconomic aggregates. This is strongly at odds with their own empirical findings, according to which U.S. shocks explain $40-80\%$ of business fluctuations in Canada. The small role attributed to foreign disturbances by RANK models is a reflection of the counterfactual responses of domestic variables to foreign shocks in some of these models. Christiano et al. (2011) and Adolfson et al. (2013) both obtain a positive response of domestic consumption to a negative foreign demand shock in estimated structural models, while the model of Bergholt (2015) features positive responses of both output and consumption to this type of shock. Lubik and Schorfheide (2007) find that a foreign recession causes domestic output to rise, implying that business cycles are negatively correlated across countries. In this respect, a key contribution of this paper is to show that our SOE-HANK model can account for the empirical response of the domestic economy, conditional on foreign demand shocks.

Third, our work is related to the recent literature studying traditional business-cycle questions through the lens of models with heterogeneous agents. In general, the HANK literature emphasizes the role of high MPCs in shaping the transmission of shocks, see, e.g., Kaplan et al. (2018), Bayer et al. (2019), Hagedorn et al. (2019), and Auclert et al. (2020, 2024). We build on this work by focusing on the role of MPCs in the transmission of foreign demand shocks. A recently emerging branch of this literature extends HANK models to open-economy settings. De Ferra et al. (2020) study the macroeconomic and distributional implications of a current-account reversal, and find that a revaluation of foreign-currency debt has larger aggregate ramifications when debt and leverage are concentrated among poor, high-MPC households. Hong (2020) studies the business cycles of emerging economies through the lens of a HANK model. Others focus on the cross-country transmission of monetary policy shocks and their distributional effects (e.g., Zhou, 2022; Oskolkov, 2023), or the optimal design of monetary policy (Acharya and Challe, 2025). Bellifemine et al. (2023) emphasize how a large non-tradable sector coupled with high MPCs amplifies the effects of monetary policy on employment in a HANK model of a monetary union. In recent work, we compare fiscal multipliers in open-economy HANK and RANK models (Druedahl et al., 2025).

The papers most closely related to ours are those by Auclert et al. (2021b) and Guo et al. (2023). The former emphasizes the role of the so-called *real income channel*, through which an increase in import prices reduces consumption of high-MPC households. This channel is at the core of the analysis of Auclert et al. (2021b), who focus on the

effects of exchange-rate shocks, which work primarily through changes in relative prices. While a similar channel operates in our model, it is quantitatively less important for foreign demand shocks; instead, changes in labor income take centre stage. Guo et al. (2023) study different types of shocks originating abroad—an increase in demand for domestic tradables or a drop in foreign interest rates—in a SOE-HANK model. Their focus is on the interaction between business cycles and income inequality, which gives rise to a stabilization-inequality trade-off for monetary policy. They also show that in response to either shock, households' consumption response is shaped by their degree of integration in international product and financial markets. Our analysis is complementary: we focus less on inequality and more on the transmission channels of foreign demand shocks, including their empirical validation and implications for business-cycle comovement across sectors and countries.

The papers discussed above share a small open-economy framework. In contrast, Chen et al. (2023), Acharya and Pesenti (2024), and Bayer et al. (2024) employ two-country HANK models to study the positive and/or normative aspects of monetary policy spillovers across countries, and Giagheddu (2020) considers the distributional impact of fiscal devaluations in a two-country setting. Aggarwal et al. (2023) offer a reinterpretation of macroeconomic developments after the COVID-19 pandemic through the lens of a multi-country HANK model.

Finally, our paper is also related to the literature on deleveraging and sudden stops, in which a strong link between domestic income and consumption emerges from financial accelerator mechanisms. Fornaro (2018) studies international debt deleveraging in a framework with heterogeneity across countries, rather than the household-level heterogeneity emphasized in HANK models. He shows that deleveraging episodes depress global demand and interest rates and that, in a monetary union, the inability to adjust through exchange-rate depreciation amplifies these effects, potentially leading to a liquidity trap and a severe aggregate recession. Other contributions based on representative-agent small open economy models include Mendoza (2010), Benigno and Romei (2014), Fornaro (2015), and Ottonello (2021). Our HANK framework instead generates a powerful response of domestic consumption that operates primarily through changes in labor income rather than through financial accelerator effects.

Structure The paper proceeds as follows. In the next section, we present our empirical findings. We establish our main points in a stylized model in Section 3, before proceeding to present the full model in Section 4. Section 5 provides the details

about the calibration of the model. We present and discuss our model-based results in Section 6, while Section 7 is dedicated to policy analysis. Section 8 concludes.

2 Empirical results

In this section, we estimate the effects of foreign demand shocks on small open economies and present our empirical findings.

2.1 Empirical strategy

We study the effects of a shock to foreign demand on various economic outcomes in a small open economy. To this end, we employ sign restrictions (Uhlig, 2005; Arias et al., 2018) to obtain identification, and pooled local projections (LP) (Jordà, 2005; Corsetti et al., 2021) to estimate impulse response functions (IRFs).

The empirical approach is as follows. We take the point of view of a small open economy, indexed by j. For each country j, we use trade weights to construct a country-specific measure of the foreign economy, consisting of foreign output ($Y^*_{j,t}$), foreign inflation ($\pi^*_{j,t}$), and the foreign nominal interest rate ($i^*_{j,t}$). Each of these are trade-weighted averages across the trading partners of country j. To be consistent with a "small open economy" assumption, we exclude those countries for which country j represents a significant trading partner. See Appendix A.1 for details.

Our aim is to project domestic economic outcomes in the small open economy onto identified foreign demand shocks. Specifically, we therefore estimate the following pooled LP equation by OLS for $h = 1, \dots, H$:

$$Z_{j,t+h} = \beta_h X_{j,t} + \sum_{k=1}^{p} \delta_{h,k} X_{j,t-k} + \gamma_h V_{t+h} + \varepsilon_{j,t,h}, \tag{2.1}$$

where $X_{j,t} = (Z_{j,t}, Y^*_{j,t}, \pi^*_{j,t}, i^*_{j,t})'$, and p is the number of lags. We include a control variable V_t capturing time-varying global factors, following the approach of Cloyne et al. (2023). As a baseline, we use the index of industrial production in the OECD plus six major economies developed by Baumeister and Hamilton (2019). In Section 2.4, we discuss the distinction between foreign and global shocks, and we consider a range of alternative ways to control for global factors.

The coefficients in β_h give the (reduced-form) IRF of a given domestic variable $Z_{j,t}$ in response to shocks to the four variables in $X_{j,t}$. To identify a foreign demand shock,

we impose sign restrictions on the responses of the *foreign* variables, leaving the responses of domestic variables unrestricted. This requires us to estimate equivalent regression equations for the three foreign variables:

$$Y^*_{j,t+h} = \beta^Y_h X_{j,t} + \sum_{k=1}^{p} \delta^Y_{h,k} X_{j,t-k} + \gamma_h V_{t+h} + \varepsilon^Y_{j,t,h}, \tag{2.2}$$

$$\pi^*_{j,t+h} = \beta^\pi_h X_{j,t} + \sum_{k=1}^{p} \delta^\pi_{h,k} X_{j,t-k} + \gamma_h V_{t+h} + \varepsilon^\pi_{j,t,h}, \tag{2.3}$$

$$i^*_{j,t+h} = \beta^i_h X_{j,t} + \sum_{k=1}^{p} \delta^i_{h,k} X_{j,t-k} + \gamma_h V_{t+h} + \varepsilon^i_{j,t,h}. \tag{2.4}$$

We then impose the following sign and zero restrictions: First, a foreign demand shock moves foreign output, inflation, and the nominal interest rate *in the same direction* on impact. Second, since the domestic economy is small, domestic shocks (that is, shocks to $Z_{j,t}$) do not affect foreign variables. The restrictions are implemented by drawing candidate "rotation matrices", and keeping only those rotations of impulse responses that satisfy the identifying assumptions. The details of this procedure are described in Appendix A.2. Note that we formally identify four separate shocks in the process: A foreign demand shock, a foreign supply shock, a foreign monetary policy shock, and a domestic shock. The identifying assumptions for each of these are summarized in Appendix Table A.3.

Our identification strategy thus proceeds in two steps: The first is the use of sign restrictions, which builds on previous literature studying the responses of small open economies to foreign shocks; see, e.g., Canova (2005), Eickmeier (2007), Mumtaz and Surico (2009), Charnavoki and Dolado (2014), and Feldkircher and Huber (2016). The restriction that demand shocks induce a positive comovement between output, inflation, and the interest rate has also been employed in other contexts (see, e.g., Furlanetto et al., 2019). The combination of sign restrictions and local projections follows the methodology outlined by Plagborg-Møller and Wolf (2021) based on methods in Rubio-Ramírez et al. (2010) and Arias et al. (2018).[2] The second step is the "small open economy" assumption: The domestic economy is small compared to the foreign economy, and therefore does not affect it. In other words, there is a one-way interaction from the large foreign to the small domestic economy. This assumption

2. To our knowledge, the only existing application of sign restrictions combined with LP is by Alpanda et al. (2021) in the context of monetary policy shocks.

is routinely made in both theoretical and empirical studies of small open economies.

A potential concern may be that the system (2.1)-(2.4) is only *set-identified*, given our reliance on sign restrictions. That is, other types of shocks than what we think of as "pure" foreign demand shocks may satisfy the sign restrictions. In Appendix A.3 we report and analyze the implied shocks from our estimation procedure. For each of the identified shocks, we find evidence that they are correlated with some of the relevant identified shock series from the existing literature, though the magnitude of these correlations is modest.

2.2 Data and estimation

We use data from all 38 OECD countries. Since the G7 countries can generally not be considered small open economies, these are used exclusively in the construction of the foreign variables, $Y^*_{j,t}, \pi^*_{j,t}, i^*_{j,t}$. This leaves us with a panel of 31 small open economies for the construction of domestic economic outcomes, $Z_{j,t}$ (Appendix A.1 contains the complete list of countries). These countries are generally very open to foreign trade, as reflected by an average ratio of exports to GDP of 44%. For each country, the sample begins between 1947 and 1996, depending on data availability for the country in question (with most countries starting in the latter part of this span). The effective number of countries and observations in the dataset therefore varies across outcome variables. We end the sample in 2019:Q4 to avoid the volatility of the pandemic and post-pandemic period. We take logs of all variables where applicable, and detrend the data using a country-specific regression on $(1, t, t^2)$. As a baseline, we include $p = 2$ lags. A detailed description of the variables and the transformations we apply is provided in Appendix A.1.

2.3 Results

We first consider the effects of a foreign demand shock on the foreign economy itself. The estimation results are reported in Figure 1 alongside 68 and 95 percent confidence bands (see Appendix A.2 for details on the computation of these). The results highlight the nature of the shock faced by the small open economy: A prolonged contraction in output of its trading partners, alongside a persistent decline in foreign inflation and the foreign nominal interest rate.

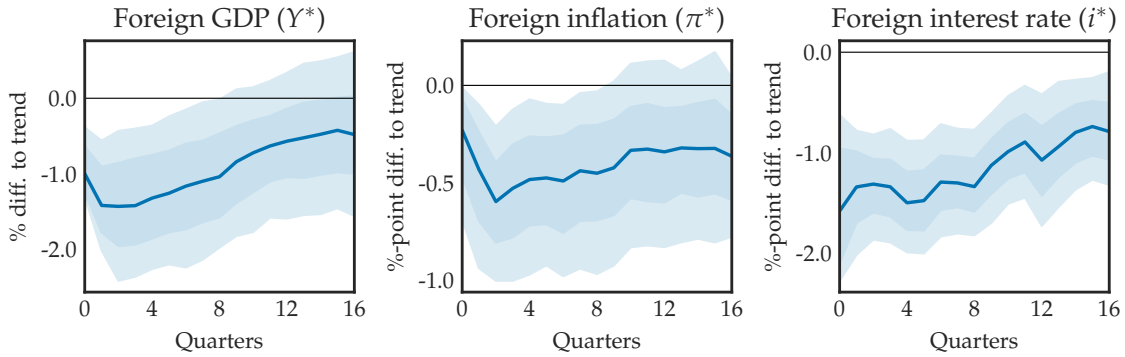


Figure 1: Effects of a foreign demand shock in the foreign economy

Note: The figure reports impulse responses of $Y^*_{j,t}$, $\pi^*_{j,t}$, and $i^*_{j,t}$ to a negative foreign demand 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).

We then turn to our main focus; the effects of the foreign shock on the 31 small open ("domestic") economies. These responses are shown in Figure 2. The shock induces a statistically significant contraction across a range of domestic macroeconomic variables, including GDP and inflation, both of which display a decline largely similar in magnitude to that observed in the foreign economy. Moreover, two of the three main findings discussed in the introduction clearly emerge from the figure (second column): *First*, aggregate consumption in the small open economy drops. *Second*, the aggregate response is composed of reductions in consumption of both tradable and non-tradable goods. In addition to these findings, we also observe notable drops in foreign trade, employment, the real wage, and the nominal and real interest rates. The real exchange rate displays a modest appreciation on impact, but is otherwise not significant. In general, the persistence of the responses of domestic variables is somewhat smaller than what we observe in the foreign economy. Finally, we observe clear declines in both investment and private credit; see Appendix A.4.

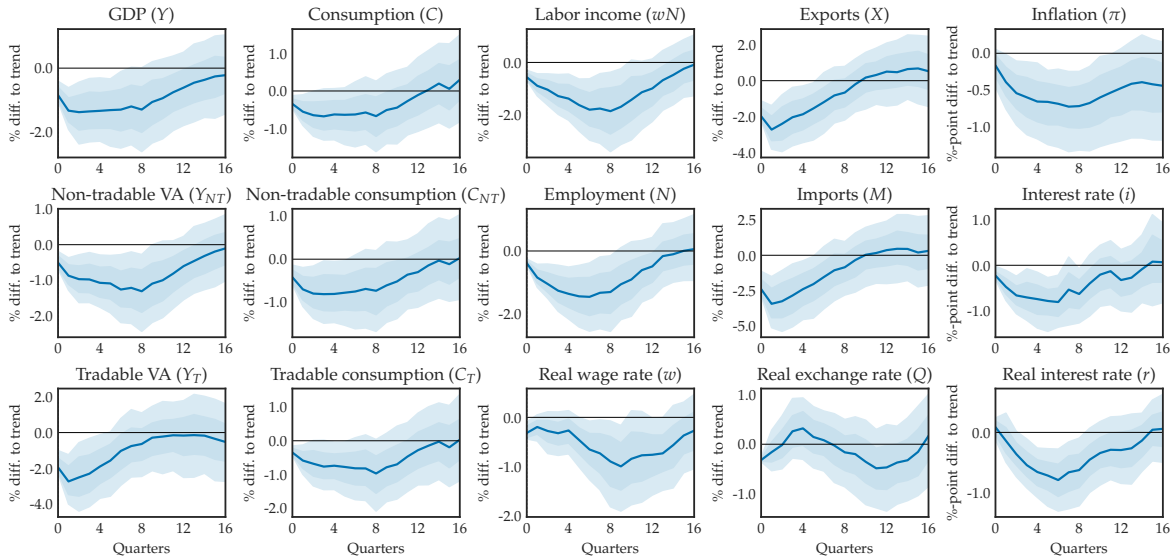


Figure 2: Effects of a foreign demand shock in the small open economy

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

To establish the third of our main empirical findings, we turn next to quantifying the importance of foreign demand shocks for domestic macroeconomic fluctuations. To this end, we estimate the share of the forecast error variance of domestic variables accounted for by each of the four shocks. We do this on a country-by-country basis and then report the median across countries (see Appendix A.5 for details). The variance decomposition is reported in Figure 3. The main takeaway is that foreign demand shocks account for around 20% of the variation in domestic macroeconomic variables at business-cycle frequencies.[3] In other words, such shocks account for a significant share of business fluctuations in small open economies, as anticipated in the introduction. Moreover, foreign demand shocks are the most important among the three foreign shocks we have identified. Altogether, foreign shocks account for around half of the observed variation in domestic variables. This finding is in line with existing studies, e.g., the VAR evidence of Justiniano and Preston (2010).

3. Recall that we are controlling for the global component V_t in our regressions, so we are effectively decomposing the variation that remains after doing so. Appendix Table A.7 reports the exact numbers and corresponding confidence intervals at selected horizons.

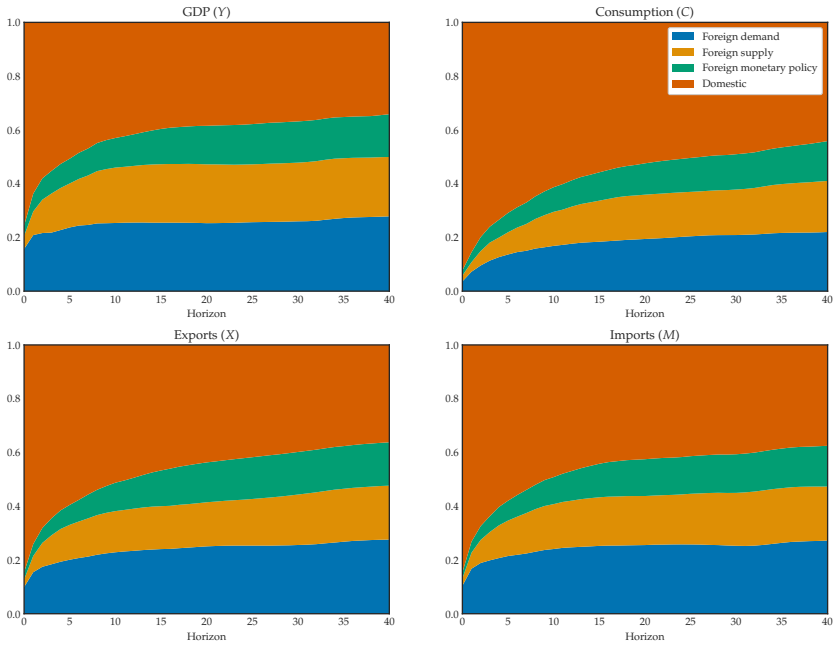


Figure 3: Forecast error variance decomposition

Note: The figure reports the forecast error variance decomposition of selected variables. The horizontal axis indicates the horizon, and the vertical axis indicates the share of variance explained.

2.4 Controlling for global factors

A potential threat to our identification strategy arises from the presence of "global" shocks that hit a large number of countries simultaneously, such as financial crises, shifts in global sentiments, or pandemics. If the small open economy was hit directly by a negative shock, rather than indirectly by a negative shock to its trading partners, this would have important implications for the appropriate way of modelling the shock. To address this concern, our baseline specification includes a control variable V_t capturing global factors in the form of the "global" industrial production index of Baumeister and Hamilton (2019). According to these authors, the countries included in their index account for 75 percent of estimated global GDP. One can think of this approach as using an instrument for global shocks in order to control for these.[4]

We have employed a broad set of alternative indicators of global economic factors as controls (results are reported in Appendix A.6). We consider activity-based measures in the form of the index of global real economic activity developed in Kilian

4. An alternative would be to use an instrument for country-specific foreign output, $Y^*_{j,t}$. This is the approach we take in our analysis of foreign fiscal consolidations; see Section 2.7.

(2009), the CPB World Industrial Production index developed for the European Commission, and OECD-wide GDP. The results are reported in Appendix Figures A.5 through A.7. In the first two cases, our results display only minor changes. When we include OECD-wide GDP, the results become weaker and in some cases insignificant. Most likely, this reflects that by construction this variable is strongly correlated with *foreign*, trade-weighted GDP ($Y^*_{j,t}$), making it very hard to distinguish between foreign and global shocks in this case.

We have also employed measures of global oil prices, commodity prices, and a dummy variable for the Global Financial Crisis (equal to 1 from 2008:Q4 to 2009:Q2), arguably the most salient example of a global shock in our sample period. Furthermore, we study a case where the weight of the US in the construction of foreign variables is set to zero to address any concern that the US could be driving our results. As seen from Figures A.8 through A.11, these changes do not materially affect our results.[5] Altogether, this supports our interpretation that the results are not mainly driven by global factors. To further support this conclusion, Section 2.7 reports corroborative evidence from narratively identified foreign fiscal shocks, which are unlikely to be driven by global factors.

2.5 Robustness

We conduct a variety of additional sensitivity checks to confirm the robustness of our empirical findings. First, we estimate responses separately for countries with fixed and floating exchange rate regimes. In both cases, the results are broadly consistent with those reported above (see Appendix Figures A.12 and A.13). For some variables, however, we find evidence of a shorter contraction followed by an expansion in floating-rate countries, consistent with the idea that exchange-rate flexibility can act as a shock absorber in response to foreign disturbances. Overall, these findings indicate that our results are not specific to any particular exchange rate regime.

We then turn to a series of changes to the empirical specification and the construction of the variables. These include using a structural VAR model instead of LP; changing the number of lags; employing a balanced sample of countries starting in 1996; using only the G7 economies to construct the foreign variables ($Y^*_{j,t}, \pi^*_{j,t}, i^*_{j,t}$); or using a common foreign economy based on shares of world GDP for all countries (i.e.,

5. An alternative approach would be to include time fixed effects in (2.1)-(2.4). However, this would be problematic, as it would eliminate much of the variation we wish to retain.

$Y^*_{j,t} = Y^*_t, \forall j$, and similar for $\pi^*_{j,t}$ and $i^*_{j,t}$). We also consider a specification in which domestic outcome variables are projected directly onto country-specific foreign output $Y^*_{j,t}$, without relying on sign restrictions. Finally, we supplement our baseline identification with the additional restriction that foreign demand shocks cannot exert a permanent effect on foreign output, following Blanchard and Quah (1989). The main takeaway from these exercises—which are reported in Appendix Figures A.14 through A.20—is that our main results are quite robust with respect to all the alterations we have considered, though with somewhat weaker results when adding more lags.

2.6 Effects of other shocks

While foreign demand shocks are the primary focus of this paper, we also examine the additional shocks identified in our procedure. As outlined in Section 2.1, these include a foreign supply shock and a foreign monetary policy shock.[6] By assumption, a negative foreign supply shock is characterized by a fall in foreign output accompanied by an increase in foreign inflation and the foreign interest rate. As shown in Figure 4, foreign output responds strongly and persistently to this shock, whereas the responses of inflation and the interest rate are brief (extending the sign restrictions beyond one quarter does not materially alter this result).

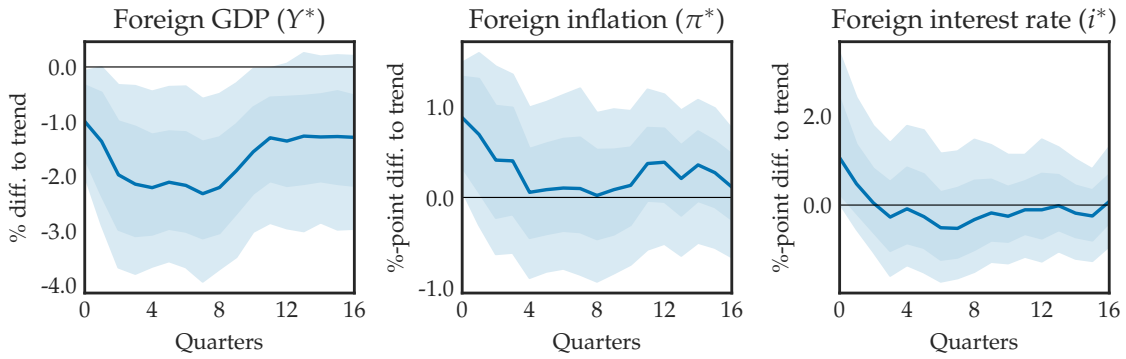


Figure 4: Effects of a foreign supply shock in the foreign economy

Note: The figure reports impulse responses of $Y^*_{j,t}$, $\pi^*_{j,t}$, and $i^*_{j,t}$ to a negative foreign supply 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).

6. Formally, we also identify a domestic "business cycle" shock. However, the only assumptions used to identify this shock are that it is orthogonal to all foreign variables and that it induces a positive response in the relevant domestic variable in the LP regression (e.g., output). Since these restrictions provide little basis for a structural interpretation, we do not analyze this shock further.

The corresponding responses of the domestic economy are presented in Figure 5. Mirroring the foreign recession, the small open economy experiences sizable and persistent declines in real activity, including output, employment, and consumption and its components. Somewhat surprisingly, domestic inflation and interest rates react only weakly and are mostly insignificant, while the real exchange rate appears to depreciate. We return to the effects of foreign supply shocks in Section 6.6, where we confront the empirical results with the predictions of our HANK and RANK models.

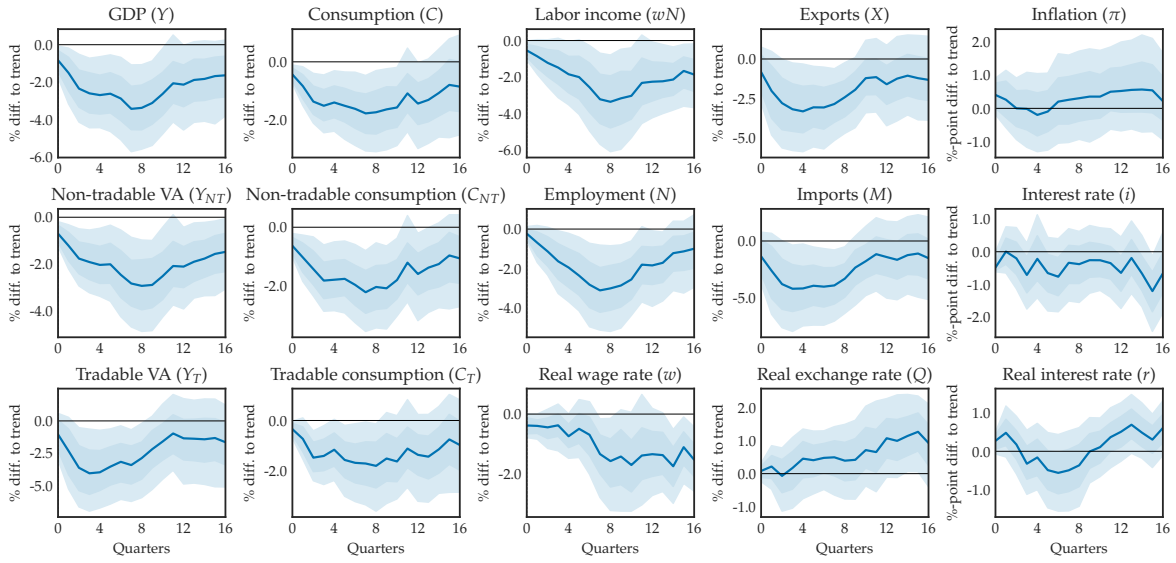


Figure 5: Effects of a foreign supply shock in the small open economy

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

We have also considered the effects of foreign monetary policy shocks, with results presented in Appendix Figures A.21 and A.22. This type of shock is identified as an increase in the foreign interest rate accompanied by declines in foreign output and inflation. We find that the drop in foreign output is modest and short-lived, while movements in the interest rate and especially inflation are more persistent. However, the responses of the domestic economy are generally insignificant, with wide confidence bands that make the results difficult to interpret. We can think of several potential explanations. First, the international transmission of monetary policy remains imperfectly understood, both empirically and theoretically (e.g., Iacoviello and Navarro, 2019; Miranda-Agrippino et al., 2020; Ilzetzki and Jin, 2021; Camara, 2025; and Boeck and Mori, 2025). This may be particularly relevant for our results, which reflect average spillovers across both large and small countries, and

over time.[7] Second, it is well known that monetary policy shocks identified through sign restrictions often yield wide confidence bands (e.g., Ramey, 2016). Partly in response to this, recent research has increasingly turned towards high-frequency identification strategies (e.g., Jarociński and Karadi, 2020), which tend to produce more tightly estimated and interpretable results. Taken together, these issues suggest that our results offer limited insight into the effects of foreign monetary policy shocks. A more comprehensive study of cross-country spillovers of monetary policy would require a high-frequency and/or narrative identification strategy, which would extend beyond the scope of this paper.

2.7 Evidence from identified fiscal consolidations

As a final step in our empirical analysis, we seek to corroborate our findings from Section 2.3 through an alternative identification strategy. In particular, we study a specific type of negative foreign demand shock in the form of fiscal consolidations in a given country's trading partners. To this end, we rely on the series of shocks developed by Guajardo et al. (2014). These authors take a narrative approach by studying contemporaneous policy documents to identify episodes of fiscal consolidation that are exogenous to current economic developments in the country in question, but instead are motivated by a desire to reduce prospective budget deficits. Based on evidence from 17 OECD countries, they find that such episodes lead to a large domestic contraction in output and consumption. This makes these shocks a relevant example of identified negative demand shocks that are unlikely to reflect global factors. We study the potential international spillovers of such episodes.

The annual shock series developed by Guajardo et al. (2014) has been widely used in subsequent work, e.g., by Broner et al. (2022), Gabriel et al. (2026), or Jordà and Taylor (2025). We use the updated shock series from Adler et al. (2024), who updated and expanded the sample to cover 21 OECD countries for the period 1978-2019 using the same methodology. The updated dataset contains 269 identified fiscal consolidations. The average magnitude of a consolidation episode in our sample is roughly 1 percent of GDP, though several episodes are considerably larger. We include both spending- and tax-based consolidations. Appendix A.1.4 reports the list of countries.

7. For example, the international transmission of U.S. monetary policy is known to be different from that of other countries (e.g., Miranda-Agrippino and Rey, 2020). There is also evidence that the international transmission of monetary policy has changed over time (e.g., Ilzetzki and Jin, 2021).

In line with our previous approach, we construct a trade-weighted measure of foreign fiscal consolidations, $FC^*_{j,t}$, for each country j in the group of 31 small open OECD economies. We then use this measure directly in our regressions, projecting foreign and domestic outcome variables on $FC^*_{j,t}$ (including lags and controls). In other words, this approach does not make use of sign restrictions. When constructing the foreign variables (e.g., $Y^*_{j,t}$), we now assign a weight of zero to countries not included in the fiscal consolidations data (since these countries by construction have a weight of zero in $FC^*_{j,t}$). We then run the following pooled LP regressions:

$$Z_{j,t+h} = \beta_h FC^*_{j,t} + \sum_{k=1}^{p} \delta_{h,k} Z_{j,t-k} + \sum_{k=1}^{p} \gamma_{h,k} FC^*_{j,t-k} + \xi_h D_{t+h} + \varepsilon_{j,t,h}, \tag{2.5}$$

where $Z_{j,t+h}$ now denotes any domestic *or* foreign outcome variable. We opt for $p = 1$ lag and otherwise perform the same data transformations as described above. Since a notable share of the fiscal consolidations in our sample occur during the European Debt Crisis, we include a dummy variable D_t equal to 1 for the years 2011-2013.

We first report the results for the foreign economy. In addition to $Y^*_{j,t}$, $\pi^*_{j,t}$, and $i^*_{j,t}$, we also report the responses of foreign government spending $G^*_{j,t}$ and foreign private consumption $C^*_{j,t}$ in order to validate the shock measure. As seen from Figure 6, a fiscal consolidation abroad leads to a significant decline in foreign public spending.[8] Next, we observe that such episodes are associated with a drop in foreign consumption and output, consistent with the results of Guajardo et al. (2014). Finally, we find that foreign inflation tends to decline, whereas foreign interest rates display an insignificant response. With the exception of the latter, these results confirm that fiscal consolidations "look like" negative demand shocks in the foreign economy, although with some noise, which is not very surprising, since in a given year most countries do not conduct a fiscal consolidation.

We turn next to our results for the domestic economy, which are reported in Figure 7. In line with our findings from Section 2.3, we observe that a negative demand shock abroad leads to a broad-based domestic recession in the small open economy, with significant declines in output, consumption, and employment, while imports and exports also tend to decline. We also observe a drop in both tradable and non-

8. Since this part of the analysis is based on notably fewer observations due to the use of annual data for a shorter sample and the fact that we only have data on fiscal consolidations in 21 out of 38 OECD member countries, we report 68 and 90 percent confidence bands in Figures 6 and 7.

tradable consumption. In other words, two of our three main empirical findings are confirmed in this case (with only one shock, we cannot perform a variance decomposition to verify the third of these). However, the responses of domestic inflation and interest rates now display small and insignificant movements. The muted response of domestic interest rates appears to mirror that of foreign interest rates. The real exchange rate again displays a modest response, except for a delayed appreciation after five years. Altogether, these results largely corroborate those presented above.

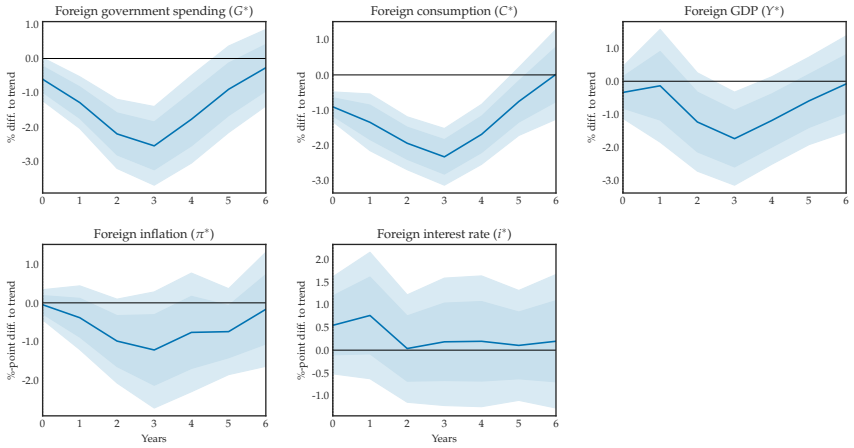


Figure 6: Effects of a fiscal consolidation in the foreign economy

Note: The figure reports impulse responses of $G^*_{j,t}$, $C^*_{j,t}$, $Y^*_{j,t}$, $\pi^*_{j,t}$, and $i^*_{j,t}$ to a fiscal consolidation. The shaded areas indicate 90 and 68 pct. confidence bands. We use Driscoll-Kraay standard errors (see Driscoll and Kraay, 1998).

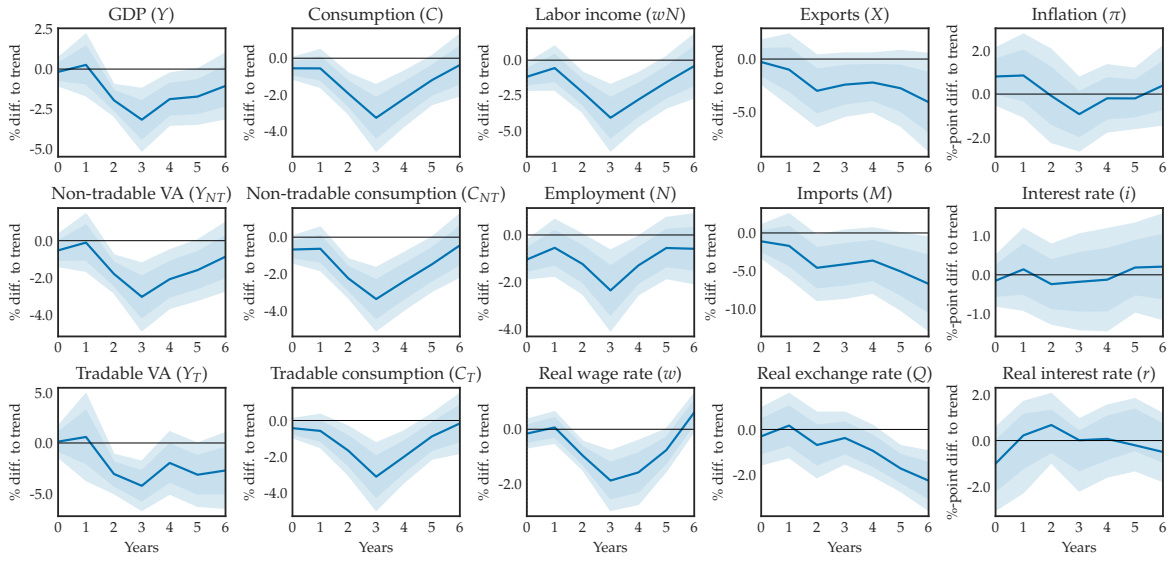


Figure 7: Effects of a fiscal consolidation in the small open economy

Note: The figure reports impulse responses to a fiscal consolidation. The shaded areas indicate 90 and 68 pct. confidence bands. We use Driscoll-Kraay standard errors (see Driscoll and Kraay, 1998).

We conduct two important robustness checks. In the first, motivated by the discussion in Section 2.4, we control for global economic activity by including the industrial production index of Baumeister and Hamilton (2019) employed above, although this is arguably less of a concern when using narratively identified shocks. As seen from Appendix Figure A.23, this does not lead to any notable changes in our results. Second, we account for the criticism of Alesina et al. (2019), who argue that some of the austerity episodes identified by Guajardo et al. (2014) should be treated as a single multi-year consolidation episode instead of several independent shocks. Thus, we replace $FC^*_{j,t}$ with the narrative series of Alesina et al. (2019).[9] The results show that this has only a small impact on our findings (see Appendix Figure A.24).

3 A stylized model of foreign demand shocks

To understand the effects of foreign demand shocks on domestic variables, we first introduce a stylized New Keynesian model of a small open economy, which allows for an analytical characterization of the main transmission mechanisms at work in the fully-fledged model we present in the next section.

The stylized model builds on the canonical model of Gali and Monacelli (2005), extended to feature household heterogeneity and incomplete financial markets, as in Bewley (1986), Imrohoroğlu (1989), Huggett (1993), and Aiyagari (1994). Market incompleteness implies that there is no risk sharing across households, nor across countries. Our stylized model is essentially equivalent to that of Auclert et al. (2021b), except for the assumptions regarding monetary policy. For comparison, we also consider an otherwise identical representative-agent (RANK) version of the model, featuring complete domestic financial markets, but no international risk sharing.[10]

The model consists of domestic households that have CES preferences over bundles of home and foreign goods with a home bias of $1 - \alpha \in (0, 1)$; domestic firms that produce the home good under perfect competition, facing sticky wages, and using a linear production technology with domestic labor as the only input; and a domestic

9. This also corresponds to the baseline shock series used by Gabriel et al. (2026), with the exception that these authors focus only on spending-based consolidations. Note that the dataset of Alesina et al. (2019) ends in 2014 and covers only 16 countries.

10. We do not treat the case of perfect international risk sharing. While a RANK model with this feature would be able to generate a positive co-movement between foreign and domestic consumption almost by construction, perfect international risk sharing is a very stark and empirically less plausible assumption, which creates other puzzles of its own (see, e.g., Corsetti et al., 2008).

central bank that follows a Taylor rule targeting domestic price inflation. Foreign consumption demand is exogenous, and we treat it as the "foreign demand shock" in this stylized setting.

We consider the linearized perfect foresight impulse response in discrete time, and let boldface variables refer to the time path, i.e. $\boldsymbol{X} = \{X_0, X_1, \dots\}$. We are interested in the response of domestic consumption, $\boldsymbol{C}$, to a drop in foreign consumption demand, $\boldsymbol{C}^*$. We focus here on the overall intuition, while a detailed exposition is provided in Appendix B.

Denote the real exchange rate by $\boldsymbol{Q}$, and define the *total* trade elasticity as $\chi \equiv \eta(1-\alpha) + \eta^*$, where η is the domestic consumers' elasticity of substitution between home and foreign goods, and η^* is the corresponding elasticity abroad. Then the market clearing condition for domestic production, $\boldsymbol{Y}$, can be written in terms of linearized deviations from steady state, $dY_t = Y_t - Y_{ss}$, as follows:

$$d\boldsymbol{Y} = (1-\alpha)d\boldsymbol{C} + \alpha d\boldsymbol{C}^* + \frac{\alpha}{1-\alpha}\chi d\boldsymbol{Q}, \tag{3.1}$$

where the first two terms capture domestic and foreign income effects, respectively, and the third term captures the substitution effect from changes in the real exchange rate. Domestic household labor income, $\boldsymbol{Y}^{hh}$, can be written, also in deviations from steady state, as

$$d\boldsymbol{Y}^{hh} = d\boldsymbol{Y} - \frac{\alpha}{1-\alpha}d\boldsymbol{Q}. \tag{3.2}$$

From the household budget constraint, we can write domestic consumption deviations as:

$$d\boldsymbol{C} = \boldsymbol{M}d\boldsymbol{Y}^{hh} + \boldsymbol{M}^r d\boldsymbol{r}, \tag{3.3}$$

where $\boldsymbol{M}$ is the matrix of intertemporal marginal propensities to consume, and $\boldsymbol{M}^r$ is the matrix of intertemporal effects on consumption of real interest rate changes.

Finally, we assume free capital mobility, which gives rise to a UIP condition. We can write this in real terms to obtain a relationship between the domestic real interest rate and the real exchange rate:

$$d\boldsymbol{r} = -\boldsymbol{G}^{r,Q}d\boldsymbol{Q}. \tag{3.4}$$

We can combine (3.4) with the model's New Keynesian Phillips curve and the Taylor

rule to obtain a relationship between domestic output and the real exchange rate:

$$d\boldsymbol{Q} = -\boldsymbol{G}^{Q,Y} d\boldsymbol{Y}. \tag{3.5}$$

The matrices $\boldsymbol{G}^{Q,Y}$ and $\boldsymbol{G}^{r,Q}$ are derived from the structural parameters of the model as shown in Appendix B. The implication of (3.4) is that high domestic real interest rates are associated with a future real exchange rate appreciation. Furthermore, we have found numerically that (3.5) implies a negative relationship between domestic output and the real exchange rate.

3.1 The response of aggregate consumption

Combining equations (3.1)–(3.5), we can show the following result:

Proposition 1. *The equilibrium response of domestic consumption ($d\boldsymbol{C}$) to a change in foreign consumption ($d\boldsymbol{C}^*$) is given by:*

$$d\boldsymbol{C} = \Big[\underbrace{\boldsymbol{M}}_{\text{Labor income}} + \underbrace{\frac{\alpha}{1-\alpha}\boldsymbol{M}\boldsymbol{G}^{Q,Y}}_{\text{Real income}} + \underbrace{\boldsymbol{M}^r \boldsymbol{G}^{r,Q}\boldsymbol{G}^{Q,Y}}_{\text{Intertemporal sub.}} \Big] \boldsymbol{G}^{Y,C^*} d\boldsymbol{C}^*, \tag{3.6}$$

with $\boldsymbol{G}^{Y,C^*}$ a known function of the structural parameters of the model.

Proof. See Appendix B.

For realistic parametrizations of the model, the entries of the matrix $\boldsymbol{G}^{Y,C^*}$ are such that domestic output declines in response to a negative foreign demand shock. Proposition 1 thus states that the consumption response to a foreign demand shock is driven by three channels.

The first channel captures direct income and multiplier effects from lower labor income. Consumption drops because domestic households have less income due to the drop in foreign demand.

The second channel captures effects of real exchange rate movements on consumption via household income. This is the "real income channel" emphasized by Auclert et al. (2021b): The decline in domestic inflation is associated with a depreciation of the real exchange rate, which reduces the real income of domestic households, forcing them to spend less on relatively more expensive imports and shrink their overall

consumption basket.[11]

The third channel captures intertemporal substitution effects from movements in the real interest rate: In the empirically plausible case where the substitution effect of changes in the interest rate is stronger than the income effect, the dominant entries in $\boldsymbol{M}^r$ are negative. This channel thus tends to drive up consumption, as the domestic central bank responds to the decline in domestic inflation by reducing the nominal interest rate, thus driving down also the real rate and inducing households to bring consumption forward in time.

Proposition 1 applies not only in our open-economy HANK model, but also in the RANK version of the model. When the marginal propensity to consume (MPC) out of current income is low, $\boldsymbol{M} \approx \boldsymbol{0}$, as in representative-agent models operating under the permanent income hypothesis, it holds that

$$d\boldsymbol{C} \approx \boldsymbol{M}^r \boldsymbol{G}^{r,Q} \boldsymbol{G}^{Q,Y} \boldsymbol{G}^{Y,C^*} d\boldsymbol{C}^*. \tag{3.7}$$

Since the dominant entries in each of the $\boldsymbol{G}$-matrices are positive, and those in $\boldsymbol{M}^r$ negative, as argued above, domestic consumption thus responds *positively* to a drop in foreign demand, in direct contrast to our empirical results. This reflects that intertemporal substitution plays a dominant role in the RANK model, as the low MPC effectively switches off the two other channels.

In contrast, the presence of high-MPC households in our HANK model implies that $\boldsymbol{M} \approx \boldsymbol{0}$ no longer applies. Instead, the first and second channels will dominate, provided that the average MPC is sufficiently high. This paves the way for the model to generate a negative response of domestic consumption, in line with the data. Furthermore, as we show using the full model in the next section, the negative response of aggregate consumption turns out to be crucial in obtaining a drop in consumption of both tradable and non-tradable goods, as well as in accounting for the importance of foreign demand shocks for fluctuations in domestic output.

We find it insightful to briefly consider the case of a fixed exchange rate. Under a peg, the relationship between the domestic output gap and the real exchange rate turns positive (i.e., the matrix $\boldsymbol{G}^{Q,Y}$ flips sign; see Appendix B). This implies that the

11. In the quantitative model we propose in the next section, the real income channel instead exerts a *positive* impact on the consumption response to a foreign demand shock. This happens since, in line with our empirical evidence in Section 2, the shock also affects the foreign interest rate and foreign inflation, leading instead to an *appreciation* of the real exchange rate. This indicates that the labor income channel is the key driver of the consumption response.

RANK version of the model (with $\boldsymbol{M} \approx \mathbf{0}$) actually generates the desired, negative response of domestic consumption, but for the "wrong" reason: With no changes in the foreign nominal interest rate, the domestic nominal interest rate also remains fixed, so the decline in domestic inflation leads to an increase in the real interest rate and a drop in consumption. In our full model in the next section—and in line with the data—foreign inflation also declines, and the foreign central bank responds by reducing the nominal interest rate, so that the negative responses of the nominal and real domestic interest rates are restored, and consumption in the RANK setup again displays a counterfactual increase.[12]

4 Model

We now turn to a quantitative business-cycle model of a small open economy. Building on the stylized model considered in the previous section, we now account for production of both tradable and non-tradable goods in the domestic economy. Moreover, we extend the production structure to incorporate inputs of (domestic and foreign) intermediate goods, which is frequently employed in existing studies to obtain positive business-cycle comovement across sectors and countries (see e.g. Huang and Liu, 2007 and Bouakez et al., 2009). A public sector conducts fiscal policy by setting the levels of government spending, taxes, and transfers.

4.1 Households

The economy consists of a continuum of households of unit measure, indexed by i. Households are permanently heterogeneous along two dimensions: The sector in which they work (tradable or non-tradable), and the level of their discount factor, β. We index these two states by s and k, respectively, and generally leave out the i index. The average discount factor is $\bar{\beta}$. We include a mean-zero discount factor shock ϵ_t^β, common across households. The composite discount factor for a household with permanent subjective discount factor β^k is denoted by $\beta_t^k = \beta^k \exp\left\{\epsilon_t^\beta\right\}$.

12. A similar case arises when the domestic economy is constrained by the zero lower bound on nominal interest rates. Also in that setting, the combination of a fixed nominal interest rate and a decline in inflation would lead to an increase in the real interest rate, and thus a drop in consumption in the RANK model. However, our empirical findings do not support this interpretation: First, we observe a clear decline in both nominal and real interest rates in the data, and second, we have verified that our main findings are robust to excluding the period in which such episodes were prevalent.

In real terms, the recursive consumption-saving problem of a given household is:

$$V_t^{s,k}(e_t, a_{t-1}) = \max_{c_t, a_t} \left(\frac{c_t^{1-\sigma}}{1-\sigma} - \nu \frac{L_{s,t}^{1+\frac{1}{\varphi}}}{1+\frac{1}{\varphi}} + \beta_t^k \mathbb{E}_t^e \mathbb{E}_t \left[V_{t+1}^{s,k}(e_{t+1}, a_t) \right] \right) \tag{4.1}$$

s.t.

$$c_t + a_t = (1 + r_t^a)\, a_{t-1} + (1 - \tau_t)\, w_{s,t} L_{s,t} e_t + T_t, \tag{4.2}$$

$$a_t \geq 0, \tag{4.3}$$

$$\ln e_t = \bar{e} + \rho_e \ln e_{t-1} + \epsilon_t^e, \quad \epsilon_t^e \sim \mathcal{N}\left(0, \sigma_e^2\right), \tag{4.4}$$

where σ is the inverse intertemporal elasticity of substitution, and φ is the Frisch elasticity of labor supply. $\mathbb{E}_t^e$ and $\mathbb{E}_t$ denote expectations over idiosyncratic and aggregate states, respectively. Each period, households choose the consumption bundle (c_t) and the level of savings (a_t) to maximize the expected discounted sum of lifetime utility, subject to a period budget constraint (4.2) and a no-borrowing constraint (4.3). Households can save in an asset yielding the return r_t^a. They earn real sector-specific labor income $w_{s,t} L_{s,t} e_t$, where $w_{s,t}$ is the wage rate, $L_{s,t}$ is hours worked by each household in sector s, and e_t captures the idiosyncratic part of earnings, which follows an AR(1) process in logs, as in (4.4). Note that labor supply is not chosen by the individual household, and thus not a choice variable in the consumption-saving problem. Instead, it is set by the labor union of which the household is a member, as described in Section 4.3. This ensures that all households within a given sector work the same number of hours, as is common in the HANK literature (see, e.g., De Ferra et al., 2020 or Auclert et al., 2024). Finally, T_t denotes lump-sum transfers from the government, and τ_t is a proportional labor income tax rate. Let $\mathcal{D}_t$ be the distribution of households over states $\{a_{t-1}, e_t, \beta, s\}$. Denoting aggregate consumption and assets by C_t and A_t, we have:

$$C_t = \int \tilde{c}_t \left(a_{t-1}, e_t, \beta, s\right) d\mathcal{D}_t, \tag{4.5}$$

$$A_t = \int \tilde{a}_t \left(a_{t-1}, e_t, \beta, s\right) d\mathcal{D}_t, \tag{4.6}$$

where $\tilde{c}_t$ and $\tilde{a}_t$ denote the optimal consumption and savings choices.

4.1.1 Portfolio choice

Total assets A_t owned by households are invested in a mutual fund, which can invest in three types of financial assets, implying the following balance-sheet relation:

$$A_t = B_t + \int p^D_{j,t} v_{j,t} dj + B^*_t, \tag{4.7}$$

where B_t and B^*_t denote domestic and foreign government bonds, respectively, and $v_{j,t}$ denotes the equity shares of domestic firm j priced at $p^D_{j,t}$, with $\int v_{j,t} dj = 1$. Domestic bonds pay the nominal policy rate i_t set by the central bank, and generate the real return $1 + r_t \equiv (1 + i_t)/(1 + \mathbb{E}_t \pi_{t+1})$, where π_{t+1} is the inflation rate. Firm shares pay dividends $D_{j,t}$ each period. Foreign bonds B^*_t pay the foreign interest rate i^*_t. $Q_t = E_t P^*_t / P_t$ is the real exchange rate, where P_t and P^*_t denote the domestic and foreign price levels, and E_t is the nominal exchange rate, defined as domestic currency units per foreign currency unit. The real return to foreign assets is then $(1 + r^*_t)\, \mathbb{E}_t Q_{t+1} / Q_t$. In the absence of aggregate uncertainty, and given that all assets are perfect substitutes, the real returns on each of the three assets will be equalized in equilibrium. Letting $r_t = \mathbb{E}_t r^a_{t+1}$ denote the ex-ante real return, we obtain the no-arbitrage conditions:[13]

$$1 + r_t = \frac{\mathbb{E}_t \left(D_{j,t+1} + p^D_{j,t+1} \right)}{p^D_{j,t}}, \tag{4.8}$$

$$1 + r_t = (1 + r^*_t)\, \frac{\mathbb{E}_t Q_{t+1}}{Q_t}. \tag{4.9}$$

The first condition equates the return on domestic bonds and stocks, while the second is a real UIP condition, stating that the expected real return on foreign and domestic assets must be equalized.

13. In the initial period following an unexpected (MIT) shock, it is generally not the case that $r_t = r^a_{t+1}$, so the no-arbitrage condition fails. In this period, the returns to assets is given by:

$$1 + r^a_t = (p^D_{j,t} + D_{j,t} + \frac{1 + i_{t-1}}{1 + \pi_t} B_{t-1}) / A_{t-1},$$

where we assume that households initially hold only domestic assets; $B^*_{ss} = 0$.

4.1.2 Complete markets and risk sharing: The representative-agent case

In addition to the model with incomplete markets, we also consider a complete-markets benchmark case. The assumption of complete markets with perfect risk-sharing and no preference heterogeneity implies the existence of a representative household, with aggregate consumption determined by a standard Euler equation:

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

As is well known, this type of small open economy model is not stationary. Following Schmitt-Grohé and Uribe (2003) and much of the subsequent literature, we therefore introduce a debt-elastic interest-rate premium $\iota_t = \iota\left(B_{t-1}^*\right)$, which enters only the household's Euler equation. Effectively, this generates an endogenous discount factor and is sufficient to ensure stationarity of the net foreign asset position.[14]

4.1.3 Consumption goods

Consumption is a CES aggregate of tradable ($C_{T,t}$) and non-tradable ($C_{NT,t}$) goods:

$$C_t = \left[\alpha_T^{\frac{1}{\eta_{T,NT}}} C_{T,t}^{\frac{\eta_{T,NT}-1}{\eta_{T,NT}}} + (1-\alpha_T)^{\frac{1}{\eta_{T,NT}}} C_{NT,t}^{\frac{\eta_{T,NT}-1}{\eta_{T,NT}}}\right]^{\frac{\eta_{T,NT}}{\eta_{T,NT}-1}}, \tag{4.10}$$

where the parameter $0 < \alpha_T < 1$ determines the expenditure share on tradable goods, and $\eta_{T,NT} > 0$ is the elasticity of substitution between the two goods. The CES formulation implies that the demand functions take the following forms:

$$C_{T,t} = \alpha_T \left(\frac{P_{T,t}}{P_t}\right)^{-\eta_{T,NT}} C_t, \tag{4.11}$$

$$C_{NT,t} = (1-\alpha_T) \left(\frac{P_{NT,t}}{P_t}\right)^{-\eta_{T,NT}} C_t, \tag{4.12}$$

where $P_t = \left[\alpha_T P_{T,t}^{1-\eta_{T,NT}} + (1-\alpha_T) P_{NT,t}^{1-\eta_{T,NT}}\right]^{\frac{1}{1-\eta_{T,NT}}}$ is the consumer price index (CPI), and $P_{T,t}$ and $P_{NT,t}$ are the prices of tradable and non-tradable goods. Tradables are, in turn, a composite made up of foreign and home goods, $C_{F,t}$ and $C_{H,t}$, bundled through a CES aggregator with share parameter $0 < \alpha_F < 1$, and elasticity of substi-

14. Although this is not required in the HANK model, which is stationary by design, we include it in both models for ease of comparison. The functional form of $\iota(B_{t-1}^*)$ is reported in Appendix C.

tution $\eta_{H,F} > 0$, resulting in the corresponding standard demand functions for home and foreign tradables, respectively.

4.2 Firms

We now turn to the production sector of the economy. The domestic supply side is composed of two sectors: A tradable and a non-tradable goods sector, $s \in \{T, NT\}$. In each sector, perfectly competitive wholesalers aggregate the different varieties supplied by the producers into a single final good.

4.2.1 Wholesalers

The representative wholesaler in sector s uses a CES production technology with elasticity of substitution $\epsilon^P > 0$, so the demand for output from producer j in sector s is given by (with $Z_{s,t}$ denoting gross output of sector s):

$$Z_{s,t}^j = \left(\frac{P_{s,t}^j}{P_{s,t}}\right)^{-\epsilon^P} Z_{s,t}. \tag{4.13}$$

4.2.2 Producers

The sectoral good $Z_{s,t}$ is produced using inputs of labor, $N_{s,t}$, and an intermediate goods bundle, $X_{s,t}$. Here $N_{s,t} = \int_{i \in s} e_{i,t} l_{i,s,t} di = s_s L_{s,t}$ is the sector's effective labor input, the efficiency-weighted sum of the hours $L_{s,t}$ each of its s_s households works; mean efficiency within a sector is one. In anticipation of a symmetric equilibrium within sectors, we drop the superscript j. Production is given by:

$$Z_{s,t} = \mathcal{Z}_s X_{s,t}^{\alpha_s^X} N_{s,t}^{1-\alpha_s^X} - F_s, \tag{4.14}$$

where $\mathcal{Z}_s$ is TFP, $0 \leq \alpha_s^X \leq 1$ is the share parameter for intermediate goods, and F_s is a fixed cost introduced to ensure a realistic valuation of the firm, given conventional levels of the markup. Each sector is characterized by monopolistic competition between a continuum of firms facing the demand function of wholesalers, (4.13). Firms choose $X_{s,t}$, $N_{s,t}$, and $P_{s,t}$ to maximize real dividends. The first-order conditions for factor inputs are presented in Appendix C. Firms' price-setting is subject to a Rotemberg adjustment cost of size θ_s^P. This gives rise to a sector-specific New-Keynesian

Phillips curve:

$$\pi_{s,t}\left(1+\pi_{s,t}\right)=\frac{\epsilon^{P}}{\theta_{s}^{P}}\left(mc_{s,t}-\frac{P_{s,t}}{P_{t}}\frac{1}{\mu_{s}}\right)+\frac{\mathbb{E}_{t}\pi_{s,t+1}}{1+r_{ss}}\left(1+\mathbb{E}_{t}\pi_{s,t+1}\right)\frac{\mathbb{E}_{t}Z_{s,t+1}}{Z_{s,t}}, \tag{4.15}$$

where $mc_{s,t}$ denotes the real marginal costs of firms in sector s.

4.2.3 Intermediate-good retailers

Within each sector $s \in \{T, NT\}$, the intermediate-good bundle $X_{s,t}$ is assembled by retailers operating in a perfectly competitive environment. The retailers have access to a CES technology:

$$X_{s,t}=\left[\Theta_{s\to s}^{\frac{1}{\eta_X}}X_{s\to s,t}^{\frac{\eta_X-1}{\eta_X}}+\Theta_{s'\to s}^{\frac{1}{\eta_X}}X_{s'\to s,t}^{\frac{\eta_X-1}{\eta_X}}+\Theta_{F\to s}^{\frac{1}{\eta_X}}X_{F\to s,t}^{\frac{\eta_X-1}{\eta_X}}\right]^{\frac{\eta_X}{\eta_X-1}}, \tag{4.16}$$

where $X_{s\to s,t}$ and $X_{s'\to s,t}$ denote input materials produced in sector s and s', respectively, and used as input for the intermediate-good bundle in sector s. The parameters $\Theta_{s\to s}$ and $\Theta_{s'\to s'}$ are the diagonal elements of a domestic input-output matrix. Likewise, $X_{F\to s,t}$ denotes intermediate inputs imported from the foreign economy (with weights $\Theta_{F\to s}$). $\eta_X > 0$ is the elasticity of substitution between input types.

4.2.4 Aggregates

Real value added (VA) in sector s (denoted $Y_{s,t}$) is defined as nominal VA deflated by the VA deflator $\mathcal{P}_t$:[15]

$$Y_{s,t}=\frac{P_{s,t}Z_{s,t}-P_{s,t}^{X}X_{s,t}}{\mathcal{P}_{t}}, \tag{4.17}$$

and aggregate VA (Y_t) as:

$$Y_{t}=\sum_{s}Y_{s,t}=Y_{T,t}+Y_{NT,t}. \tag{4.18}$$

15. The VA deflator is the ratio of nominal value added to value added at steady-state prices, $\mathcal{P}_t = \left[\sum_s \left(P_{s,t}Z_{s,t} - P_{s,t}^X X_{s,t}\right)\right] / \left[\sum_s \left(P_{s,ss}Z_{s,t} - P_{s,ss}^X X_{s,t}\right)\right]$.

4.3 Labor supply and wage setting

Labor supply is determined by unions. In each sector, there is a continuum of unions, and each household i in that sector provides $l^j_{i,s,t}$ hours of work to union j in sector s. Total labor supply of household i is then $l_{i,s,t} = \int l^j_{i,s,t} dj$. Each union assembles individual labor supply to a union-specific task, $N^j_{s,t} = \int e_{i,t} l^j_{i,s,t} di$, and the sector's effective labor input $N_{s,t}$ is assembled from these union-specific tasks using a CES technology, with $\epsilon^W > 0$ denoting the elasticity of substitution between labor types. Union j in sector s maximizes the discounted stream of future utility of its members, net of a Rotemberg adjustment cost on nominal wages (see Appendix C for details). This problem yields a symmetric equilibrium in which all unions choose the same wage, and all households supply the same amount of labor, $L_{s,t} = N_{s,t}/s_s$. Thus, we obtain a sector-specific New Keynesian wage Phillips Curve, in which $L_{s,t}$ is hours per household as in (4.1) and (4.2):

$$\begin{aligned}\pi^w_{s,t}\left(1+\pi^w_{s,t}\right) = \frac{\epsilon^w}{\theta^w_s} L_{s,t}\left\{\nu L_{s,t}^{\frac{1}{\varphi}} - \frac{\epsilon^w - 1}{\epsilon^w}\frac{(1-\tau_t)\,W_{s,t}}{P_t} U'\left(C_{s,t}\right)\right\} \\ + \beta^U \mathbb{E}_t \pi^w_{s,t+1}\left(1+\mathbb{E}_t \pi^w_{s,t+1}\right).\end{aligned} \tag{4.19}$$

$U'\left(C_{s,t}\right) = \frac{1}{s_s}\int e_{i,t} u'\left(c_{i,s,t}\right) d\mathcal{D}_{s,t}$ denotes the average productivity-weighted marginal utility of consumption among households working in sector s, and β^U is the union's discount factor, which we set as the inverse of the steady-state real interest rate, $\beta^U = 1/(1+r_{ss})$; discounting at the real interest rate follows Hagedorn et al. (2019).

4.4 Monetary policy

As our baseline, we assume that the domestic economy maintains a floating exchange rate vis-a-vis the foreign economy. The domestic central bank conducts monetary policy according to a Taylor rule featuring interest rate smoothing:

$$i_t = \left(i_{ss} + \phi^\pi \pi^{PP}_t\right)(1-\rho^r) + \rho^r i_{t-1} + \epsilon^r_t, \tag{4.20}$$

where π^{PP}_t is the inflation rate of the domestic producer price index (PPI), defined as the Laspeyres index over $C_{H,t}$ and $C_{NT,t}$.[16] We follow Galí (2015) in assuming that

16. $PPI_t = (P_{H,t}C_{H,ss} + P_{NT,t}C_{NT,ss})/(P_{H,ss}C_{H,ss} + P_{NT,ss}C_{NT,ss})$, where we use the steady state as the base period.

the central bank responds to movements in the PPI instead of the CPI. The policy rule features no output-gap response. None of our results depend on these choices.

We also consider the case where the domestic economy maintains a fixed exchange rate towards the foreign economy. In this case, we replace the Taylor rule (4.20) with the condition that the nominal exchange rate remains fixed at all times:

$$E_t = E_{ss}. \tag{4.21}$$

4.5 The public sector

The public sector finances public consumption (G_t), transfers (T_t), and debt service using new bond issuance (B_t) and labor income taxes, $\tau_t \sum_s w_{s,t} N_{s,t}$. The period real budget constraint (measured in terms of the CPI) is:

$$B_t + \tau_t \sum_s w_{s,t} N_{s,t} = T_t + \frac{P_t^G}{P_t} G_t + \frac{1 + i_{t-1}}{1 + \pi_t} B_{t-1}, \tag{4.22}$$

where P_t^G is the public consumption deflator, which reflects the share of government spending going to domestic tradables ($G_{H,t}$) and non-tradables ($G_{NT,t}$), which we discuss in Section 5. Public consumption and transfers are treated as exogenous. We obtain a balanced budget in steady state by adjusting the tax rate, τ_t. Outside of steady state, discretionary fiscal policy and changes in interest expenses require financing. In the spirit of Hagedorn et al. (2019), we assume that the government finances deficits by issuing bonds for the first t_B quarters after a shock, i.e. for $t = 0, \ldots, t_B - 1$. From period t_B onwards, the government smoothly adjusts the tax rate τ_t to ensure that the level of public debt returns to the steady-state level. See Appendix C for details.

4.6 The foreign economy

The domestic economy is affected by foreign economic activity (through demand for domestic exports), prices (through international relative prices), and interest rates (through the UIP condition). Hence, we summarize the foreign economy as a sequence of foreign import demand, foreign inflation, and the foreign nominal interest rate, $\left\{ M_t^*, \pi_{F,t}^*, i_t^* \right\}$, which enter the set of domestic equilibrium conditions. This approach allows us to feed the estimated foreign demand shock, as studied in Section

2, directly into the model.[17]

The law of one price for foreign and domestic tradables implies that $P_{H,t} = E_t P^*_{H,t}$ and $P_{F,t} = E_t P^*_{F,t}$, where $P^*_{H,t}$ denotes the price of domestic tradables in foreign currency, and $P^*_{F,t}$ is the price of the foreign good in foreign currency. Foreign demand for domestic tradables is given by an Armington-type relation:

$$C^*_{H,t} = \alpha^* \left(\hat{p}^*_t\right)^{-\eta^*} M^*_t, \tag{4.23}$$

where $\alpha^* \in [0,1]$ is a scaling parameter, and $\eta^* > 0$ is the Armington elasticity. Following Drozd et al. (2021) and Boehm et al. (2023), we incorporate a dynamic export elasticity, which we obtain via a smoothed adjustment in the international relative price, $\hat{p}^*_t$:

$$\hat{p}^*_t = \left(\hat{p}^*_{t-1}\right)^{\rho^*} \left(\frac{P^*_{H,t}}{P^*_{F,t}}\right)^{1-\rho^*}, \text{ where } \hat{p}^*_{ss} = \frac{P^*_{H,ss}}{P^*_{F,ss}}. \tag{4.24}$$

When $\rho^* > 0$, the initial response of foreign demand to a change in relative prices is dampened, implying a smaller elasticity in the short run than in the long run, in line with the empirical evidence of Boehm et al. (2023).

4.7 Domestic market clearing

Equilibrium in the domestic economy is characterized by the two goods market clearing conditions:

$$Z_{NT,t} = C_{NT,t} + G_{NT,t} + X_{NT\to T,t} + X_{NT\to NT,t} + \Xi_{NT,t}, \tag{4.25}$$

$$Z_{T,t} = C_{H,t} + G_{H,t} + C^*_{H,t} + X_{T\to T,t} + X_{T\to NT,t} + \Xi_{T,t}, \tag{4.26}$$

where $\Xi_{s,t}$ collects all types of adjustment costs in sector s. We define net exports and the net foreign asset position as:

$$NX_t \equiv \frac{\mathcal{P}_t}{P_t} Y_t - C_t - \frac{P^G_t}{P_t} G_t - \frac{P_{H,t}}{P_t} \Xi_{T,t} - \frac{P_{NT,t}}{P_t} \Xi_{NT,t}, \tag{4.27}$$

$$NFA_t \equiv B^*_t = A_t - p^D_t - B_t. \tag{4.28}$$

17. A more structural approach would be to model the foreign economy as a standard three-equation small open economy, as in Galí (2015). We have found that this yields similar results.

(4.27) reflects that adjustment costs are included in value added, but absorb goods that are therefore not available for final use. (4.28) implies that we are abstracting from foreign investment in domestic assets. Asset market clearing holds by Walras' law, and implies the following balance of payments relation between net exports and the net foreign asset position (i.e., the current account):

$$NFA_t = NX_t + (1 + r_t^a)\, NFA_{t-1}.$$

4.8 Shocks and equilibrium

We consider only perfect-foresight shocks in the model.[18] As discussed above, we are interested in foreign demand (and later, supply) shocks consisting of the sequences $\left\{M_t^*, \pi_{F,t}^*, i_t^*\right\}$ obtained from our empirical analysis in Section 2. Later, we will also consider a domestic preference (or demand) shock ϵ_t^β, as well as shocks to the policy variables G_t, T_t, and ϵ_t^i. From the perspective of the domestic economy, the exogenous sequences are thus $\{M_t^*, \pi_{F,t}^*, i_t^*, \epsilon_t^\beta, G_t, T_t, \epsilon_t^i\}$, where the first three are those associated with foreign shocks.

Definition 1 (Domestic equilibrium)**.** *Given sequences for* $\{M_t^*, \pi_{F,t}^*, i_t^*, \epsilon_t^\beta, G_t, T_t, \epsilon_t^i\}$*, an initial household distribution over assets, earnings, discount factors and sectors* $\mathcal{D}_0(a, e, \beta, s)$*, and an initial portfolio allocation between foreign and domestic assets, a competitive equilibrium in the domestic economy is a path of household policies* $\{c_t(a, e, s), a_t(a_{t-1}, e, s)\}$*, distributions* $\mathcal{D}_t(a, e, s)$*, prices:*

$$\left\{E_t, Q_t, P_{s,t}, P_{H,t}, P_{F,t}, W_{s,t}, P_{s,t}^X, p_t^D, i_t, r_t, r_t^a\right\},$$

and quantities:

$$\{C_t, C_{s,t}, C_{H,t}, C_{F,t}, A_t, Z_{s,t}, Y_{s,t}, X_{s,t}, L_{s,t}, N_{s,t}, D_{s,t}, NFA_t, Y_t, T_t, \tau_t, G_t, B_t\},$$

such that all households and firms optimize, monetary and fiscal policies satisfy their respective rules/constraints, and the goods markets, (4.25) *and* (4.26)*, clear.*

18. Since we only study small shocks, the dynamics of the model are approximately linear, and the impulse responses are identical to those from a model with aggregate risk (Boppart et al., 2018).

4.9 Solution method

We solve the households' dynamic programming problem using the endogenous grid method of Carroll (2006). We use the "fake news algorithm" from Auclert et al. (2021a) to efficiently compute the Jacobian of the household problem around the deterministic steady state. We then proceed to solve for the full non-linear transition paths to each shock using Broyden's method.[19]

5 Calibration and model fit

We now describe our calibration and the fit of the model with the empirical evidence.

5.1 Calibration

The model is calibrated at a quarterly frequency. Our target is the average small open economy in our sample of OECD countries employed in Section 2. We calibrate the HANK and RANK models as similarly as possible. All parameters except those describing households' income and preferences are therefore identical across the two models. The parameter values are summarized in Appendix Table D.1 and Table D.2.

Preferences We set the elasticity of intertemporal substitution ($1/\sigma$) to 0.4. This value is well within the range of estimates commonly used in the literature. The implied interest-rate sensitivity of consumption in our HANK model is consistent with the two-asset HANK model of Kaplan et al. (2018), c.f. Appendix D.1. The Frisch elasticity of labor supply, φ, is set to a standard value of 0.5, consistent with the literature review by Chetty et al. (2011). These two parameters are the same in the RANK and HANK models.

We calibrate the average discount factor, $\bar{\beta}$, to obtain asset market clearing at a steady-state real interest rate of 2% annually. In the RANK model, the discount factor (β) is directly pinned down by our choice of the steady-state real interest rate. In both models, we calibrate the steady-state asset demand to match a quarterly wealth-to-income ratio of 10, which corresponds to the average among OECD countries over the period 1996-2019. We introduce discount-factor heterogeneity in the

19. The code is written in Python and based on the GEModelTools package.

HANK model in order to match the large MPCs estimated in micro studies. We assume that discount factors are uniformly distributed on $[\overline{\beta} - \Delta\beta, \overline{\beta} + \Delta\beta]$, where $\Delta\beta$ is the discount-factor dispersion. We calibrate $\Delta\beta$ to match an annual first-year MPC of 0.51, following the estimates from Fagereng et al. (2021), c.f. Appendix D.1.

Income process For the idiosyncratic income process, we set the standard deviation of innovations (σ_e) to 0.13, and the persistence (ρ_e) to 0.966, following the estimates in Floden and Lindé (2001). This yields an income process which is similar to the ones commonly used in the HANK literature (e.g., McKay et al., 2016, Guerrieri and Lorenzoni, 2017). We approximate the AR(1) process with a discrete Markov process using the method of Rouwenhorst (1995).

Domestic consumption baskets The CES share parameters α_F and α_T are based on OECD data on the composition of consumption. We fix the steady-state share of tradables in the consumption basket to match the average ratio across OECD countries, where we take consumption of non-durables and semi-durables to be tradables, and consumption of services to be non-tradables. We find that tradables make up 47% of the consumption basket; $\alpha_T = 0.47$. We set α_F (the share of foreign tradables in the tradable consumption basket of domestic households) to match the OECD average share of imports going to final consumption (29%). This yields $\alpha_F = 0.32$.

The elasticities of substitution, $\eta_{T,NT}$ and $\eta_{H,F}$, are less easily disciplined by the data. Evidence on the elasticity between tradable and non-tradable goods is sparse. Estimates of the elasticity of substitution between different varieties of goods are often around 3 to 5 (e.g., Feenstra et al., 2018), but given that the data used in these studies typically reflects tradable goods more than non-tradables, these estimates do not carry over to our case. Ostry and Reinhart (1992) and Akinci (2011) estimate the elasticity between tradables and non-tradables directly, and find it to be in the range of 0.5 to 1.5. We set $\eta_{T,NT} = 0.5$ as our baseline, and then consider a higher value as a robustness check. Regarding the elasticity of substitution between home and foreign tradables, we follow Boehm et al. (2023), who find a long-run elasticity of 2. We conduct robustness checks also for this parameter value.

Foreign economy The foreign interest rate is set to 2% per year. We set the size of the export market, α^*, to match the average of imports and exports to GDP across OECD countries, which is 42%. We set the export elasticity, η^*, to 2 and the export rigidity, ρ^*, to 0.9. These numbers imply a first-year elasticity of around 0.75, rising

to a long-run elasticity of about 2, in line with the empirical evidence reported by Boehm et al. (2023).

Government For the monetary policy rule, we set a Taylor rule coefficient of 1.25 and an interest-rate smoothing parameter of 0.9. Regarding public consumption and debt, we set $G/GDP = 0.2$ and $B/GDP = 0.58$ annualized, as these are the average values in our data sample. For the debt dynamics in response to transitory shocks, we assume fully debt-financed fiscal policy for the first $t_B = 50$ quarters, with gradually increasing taxation afterwards to ensure that the public debt level returns to the steady-state level. The functional form for the tax rate, τ_t, is reported in Appendix C. Regarding the composition of government spending, we assume that 80% goes to the non-tradable sector, with the remaining 20% going to the domestic tradable sector, as documented by Cardi and Restout (2023).[20]

Production structure The supply side of our model is characterized by extensive input-output (IO) linkages. We discipline these using the OECD IO tables and the OECD STAN database, targeting average moments over the period 1990-2021. See Appendix D.1 for details. We proxy the non-tradable sector by the service sector, and the tradable sector by the industries in the STAN database. We calibrate the share of intermediate goods in production, α_T^X and α_{NT}^X, such that the expenditure share of intermediate goods is 81% and 57%, respectively, which are the averages across the countries in the STAN database. Finally, we assume that 30% of households are employed in the tradables sector to match the average *Trade-in-Employment* shares in the STAN database.

The input-output matrix of the model is given by:

$$\mathbf{\Theta} = \begin{array}{c} \\ T \\ NT \\ F \end{array} \begin{array}{c} \begin{array}{cc} T & NT \end{array} \\ \begin{bmatrix} 0.29 & 0.35 \\ 0.56 & 0.51 \\ 0.15 & 0.14 \end{bmatrix} \end{array},$$

where columns represent inputs, and rows output. According to the STAN database,

20. Considering a sample of 18 OECD countries, these authors report an average non-tradable share of public spending of 80%, and a domestic tradable share of 18%, while 2% is directed towards imports. We assume for simplicity that the public sector does not purchase foreign tradables.

the non-tradable sector obtains 51% of intermediate inputs from itself, while the corresponding number for the tradables sector is 29%. We use these numbers as the diagonal in $\mathbf{\Theta}$. We calibrate the share of imports in each sector ($\mathbf{\Theta}_{F,T}, \mathbf{\Theta}_{F,NT}$) to match i) a total import-to-GDP ratio of 42%; and ii) the ratio of imports in the tradable sector to imports in the non-tradable sector ($(X_{F\to T})/(X_{F\to NT}) = 1.26$). The remaining two parameters in $\mathbf{\Theta}$ are then obtained residually. Finally, we fix the elasticity of substitution between intermediate goods from different sectors, η_X, at 0.5, which is in the middle of the range found in the literature (e.g., Atalay, 2017; Boehm et al., 2019).

Markups and nominal rigidities We set the markup on final goods to 20% in both sectors, implying elasticites of substitution for final goods of $\epsilon_T^P = \epsilon_{NT}^P = 6$. We pick the Rotemberg price adjustment costs ($\theta_T^P, \theta_{NT}^P$) to match a Phillips curve slope of 0.1 in the non-tradable sector, and 0.2 in the tradable sector, following Nakamura and Steinsson (2008). For the wage Phillips curve, we set the markups equal to the final goods markups, $\epsilon_T^w = \epsilon_{NT}^w = 6$, as is common in the literature. We set the Rotemberg adjustment cost on wages to match a slope of 0.025, implying that wages are more sticky than prices, as in most of the existing HANK literature (see Broer et al., 2020). We calibrate the fixed costs F_T, F_{NT} such that the total supply of domestic assets equals the demand from households, and such that each sector's share of total profits matches its share of value-added.

5.2 Model fit

We are now ready to evaluate the ability of the calibrated model to account for the empirical effects of a foreign demand shock. To this end, we feed the model with smoothed versions of the estimated paths for foreign demand for domestic goods (i.e., foreign imports), foreign inflation, and the foreign nominal interest rate (these are reported in Appendix Figure D.3).[21] Figure 8 reports the responses to a foreign demand shock in the HANK and RANK models alongside our empirical re-

21. Using foreign imports as the measure of foreign import demand, M_t^* in (4.23), has two potential shortcomings. First, it neglects that changes in the real exchange rate could be driving some of the observed import response. Due to the muted response of the real exchange rate, this is not a problem in practice. Second, our measure of the foreign economy does not include all trading partners, and even with spillovers to these countries, total demand for domestic exports likely moves less than our measure of foreign imports. In practice, this is not a major concern as the RANK and HANK models are treated equally, and our fit of the domestic export response is good.

sults for the domestic economy from Section 2. Both models are able to account relatively well—qualitatively as well as quantitatively—for the responses of most variables, such as output, employment, exports, inflation, and nominal and real interest rates.[22]

This picture changes significantly, however, when we consider the response of consumption, including of both tradables and non-tradables (second column): While the HANK model can largely match the negative responses observed in the data for consumption and its components, the RANK model displays a counterfactual *increase* in each of these variables. To understand this difference, it is important to recall the analytical insights from Section 3: In the RANK model, the representative household raises current consumption via intertemporal substitution, whereas the presence of high-MPC households in the HANK model leads to a decline in consumption. We shed further light on this result in the next section.

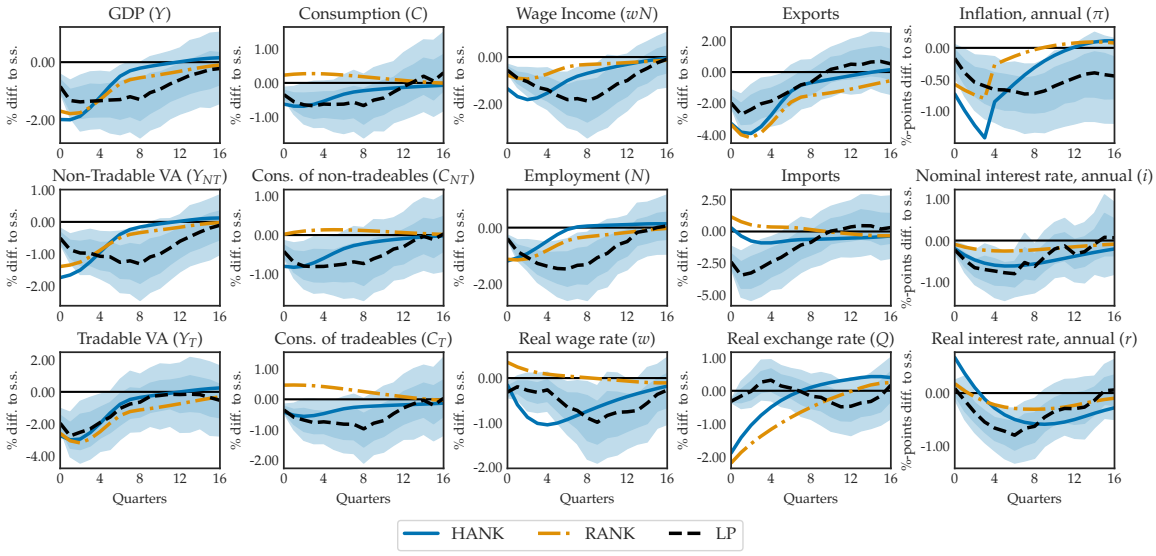


Figure 8: Response of the domestic economy to a foreign demand shock

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

Finally, neither model can account for the behavior of the real exchange rate. Both generate a sizeable appreciation, whereas in the data the real exchange rate remains largely unchanged. This discrepancy reflects the path of real interest rates: in both

22. The jump in inflation one year after the shock is due to the fact that we are reporting annual inflation rates to be consistent with the data.

models, the domestic real interest rate falls by less than its foreign counterpart.[23] The resulting appreciation boosts imports, helping to explain why both models fail to deliver the sharp fall in imports observed in the data.[24]

Capital formation We have also considered a model extension with capital formation and an earnings-based borrowing constraint (see Appendix E.1 for details). As noted in Section 2, investment drops markedly after a negative foreign demand shock. Since firms' earnings fall after the shock, the borrowing constraint reduces credit and generates an initial decline in investment (see Appendix Figure E.1). In the model, however, investment subsequently increases, unlike what we observe in the data. Thus, just as cash-flow-driven consumption—generated by high-MPC households—can account for the response of consumption, cash-flow-driven investment via an earnings-based borrowing constraint can help explain the initial response of investment, although additional frictions are needed to account for its persistence.

Fixed nominal exchange rate Our empirical investigation yielded little evidence that the transmission of foreign demand shocks differs markedly across exchange-rate regimes. We therefore find it worthwhile to evaluate the fit of our theoretical model also under a fixed nominal exchange rate. In Appendix Figure E.6, we report the results of a similar exercise as the one conducted above, i.e., where we feed the estimated paths of foreign variables into a version of our model with a currency peg.[25] We note that all of our main findings are confirmed, although the observed differences in consumption and its components between the HANK and RANK models are of a smaller magnitude. Consumption drops by less in the HANK model, since

23. The linearized UIP condition (4.9) solved forward yields $dQ_t = \sum_{k=0}^{\infty} \mathbb{E}_t \left(dr^*_{t+k} - dr_{t+k} \right)$.

24. The discrepancy between the empirical and model-implied real exchange rate responses is closely related to the "forward guidance exchange rate puzzle" discussed by Galí (2020). He shows 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. His proposed resolution is to introduce cognitive discounting (as in Gabaix, 2020) into the UIP condition. In Appendix E.2, we report results from a version of our model augmented in this way. This extension brings the real exchange rate response closer to the data and reduces imports, while leaving other variables largely unaffected.

25. We use the same smoothed series for foreign demand for domestic goods and foreign inflation as above. Since the UIP condition implies that foreign and domestic nominal interest rates are equalized under a peg, we simply use the estimated path for the *domestic* nominal interest rate in this case. In practice, these two series are not identical, since no country j in our sample has a fixed exchange rate towards *all* of the countries used in the construction of $i^*_{j,t}$.

this model underestimates the drop in employment and labor income, whereas it increases by less in the RANK model, since the real interest rate path is shifted up. For the remaining variables, the model entails a relatively good fit of the data.

6 Transmission of foreign demand shocks

We now return to our three main empirical findings from Section 2, assessing and explaining the ability of the HANK and RANK models to account for these facts.

6.1 The response of aggregate consumption

To analyze the drivers of the aggregate consumption response in more detail, we decompose it using the linearized consumption function studied in Section 3. In the fully fledged model, the analogue to equation (3.3) is given by:

$$d\boldsymbol{C} = \underbrace{\boldsymbol{M} d\boldsymbol{Y}^{hh}}_{\text{Disp. income}} + \overbrace{\boldsymbol{M}^{r} d\boldsymbol{r}}^{\text{Interest rate}} + \underbrace{\boldsymbol{M}^{v}\left(d\boldsymbol{r}^{\boldsymbol{a}} - d\boldsymbol{r}\right)}_{\text{Revaluation}}. \tag{6.1}$$

Recall that the first term represents the effects on consumption of disposable labor income, while the second term measures the effects of future expected real interest rates, thus primarily capturing intertemporal substitution effects. The third term represents the asset revaluation effect occurring in period 0 due to the fact that the ex-ante and ex-post returns on assets are not equalized for MIT shocks, as discussed by Auclert (2019).[26] $\boldsymbol{M}^{v}$ denotes the matrix of intertemporal effects on consumption from this channel. While this decomposition applies in both the HANK and the RANK model, the relative importance of the channels differs markedly across models. This is shown in Figure 9, which plots the three components from (6.1) following a foreign demand shock.

In the RANK model, the response of consumption is driven predominantly by the interest rate channel, with a lower real rate inducing the household to engage in intertemporal substitution to raise current consumption. In the HANK model, instead, the consumption response is driven predominantly by the decline in dispos-

26. This effect was absent in the stylized model of Section 3, since that model featured a zero net supply of bonds and no firm profits.

able labor income, which passes through to consumption in the presence of a large aggregate MPC. This confirms the insights from Section 3.

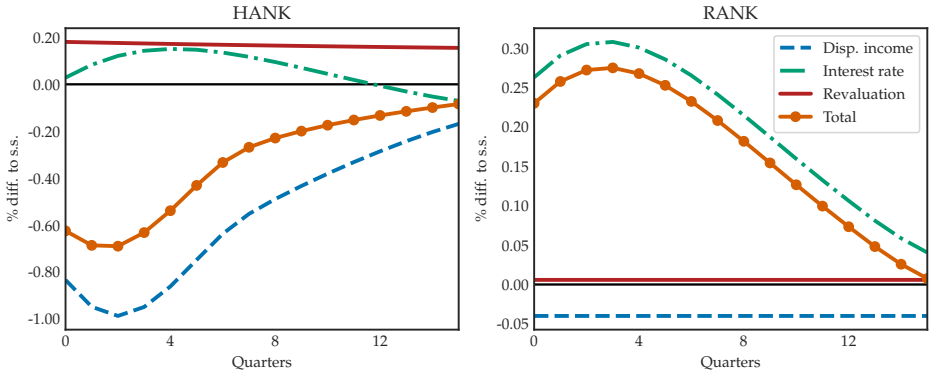


Figure 9: Decomposed consumption response to a foreign demand shock

Note: The figure shows the decomposed response of domestic consumption to a foreign demand shock according to (6.1).

Note that the intertemporal substitution channel is also operative in the HANK model, with the lower real interest rate exerting a positive effect on aggregate consumption, though this channel is clearly dominated by the labor income channel. Likewise, the latter is also present in the RANK model, where it exerts a small but very persistent contribution, reflecting the extensive consumption smoothing present in permanent-income models. The distinction between intertemporal substitution in RANK models and the labor income channel in HANK models plays a key role in the HANK literature; see, e.g., Kaplan et al. (2018), who offer a reinterpretation of the aggregate effects of monetary policy through the lens of a HANK model. Finally, the revaluation effect is practically non-existent in the RANK model, while it exerts a small but persistent, positive effect in the HANK model.[27]

27. Since the revaluation effect primarily affects households at the top of the wealth distribution (who act in a Ricardian manner and display low MPCs), the impact on consumption exhibits almost perfect smoothing even in the HANK model.

6.2 Consumption of tradables and non-tradables

To understand the consumption of tradables and non-tradables in more detail, we consider the linearized decomposition of the responses of these variables:

$$d\boldsymbol{C}_T = \underbrace{-\eta_{T,NT}\alpha_T d\left(\frac{\boldsymbol{P_T}}{\boldsymbol{P}}\right)}_{\text{Substitution effect}} + \underbrace{\alpha_T d\boldsymbol{C}}_{\text{Scale effect}}, \tag{6.2}$$

$$d\boldsymbol{C}_{NT} = \underbrace{-\eta_{T,NT}(1-\alpha_T)d\left(\frac{\boldsymbol{P_T}}{\boldsymbol{P}}\right)}_{\text{Substitution effect}} + \underbrace{(1-\alpha_T)d\boldsymbol{C}}_{\text{Scale effect}}. \tag{6.3}$$

The substitution effect in these equations refers to changes in the consumption of tradables and non-tradables induced by relative price changes. The scale (or income) effect represents consumption changes due to movements in the level of total consumption, as studied above. We report this decomposition in Figure 10.

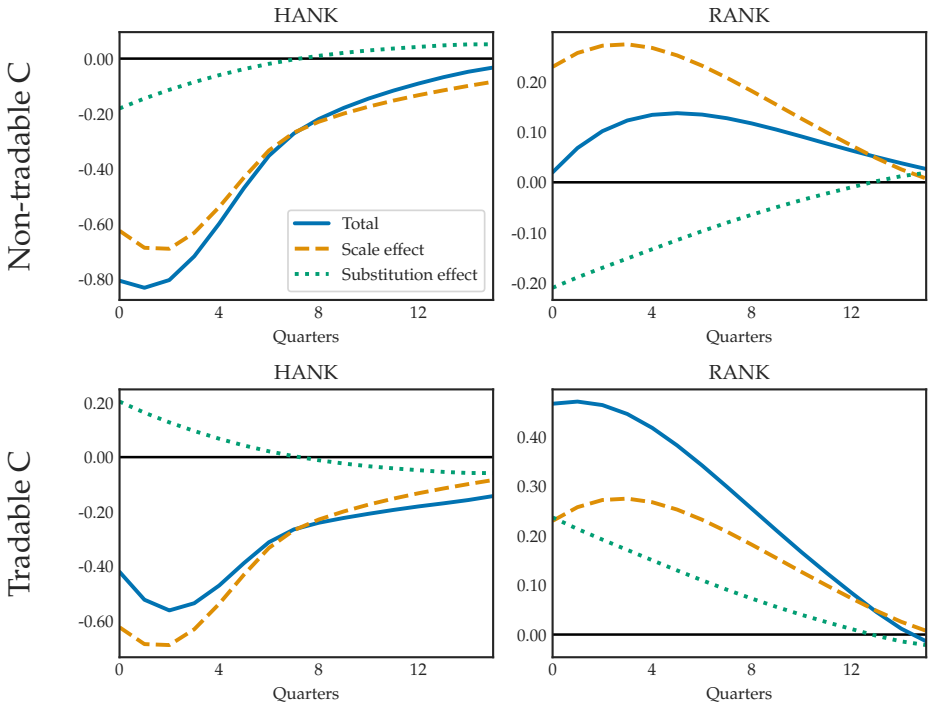


Figure 10: Decomposed response of consumption of tradables and non-tradables to a foreign demand shock

Note: The figure shows the decomposition of the responses of tradable and non-tradable consumption following a foreign demand shock according to equations (6.2) and (6.3).

The key message from the figure is that the different responses in the two models can largely be ascribed to the scale effect, as the blue and dashed orange lines tend

to follow each other closely. In the HANK model, this effect is large and negative, thus inducing the empirically observed drop in both tradable and nontradable consumption. The opposite is true in the RANK model, with the scale effect pushing both consumption types up. In both models, this effect dominates the substitution effect arising from the drop in the relative price of domestic tradable goods observed in response to the decline in foreign demand.

6.3 Can foreign demand shocks drive the business cycle?

We turn next to the third and final of our main empirical findings, the fact that—in the data—foreign demand shocks account for a large share of business-cycle fluctuations in output and other aggregate variables. We have documented above that the RANK model exhibits a negative correlation between domestic output and consumption, conditional on a foreign demand shock. Yet, the *unconditional* correlation of aggregate output and consumption is strongly positive in the data. For the 31 small open economies considered in Section 2, the average unconditional correlation between output and consumption is 0.69.[28] Effectively, this property rules out foreign demand shocks as potentially important drivers of business cycles in RANK models, consistent with the puzzling results of Justiniano and Preston (2010) and other estimated small open economy models. In our HANK model, in contrast, foreign demand shocks give rise to a positive comovement between output and consumption, in accordance with the unconditional observation.

Comovement of output and consumption Some key covariances from the data and the model can be considered to document these facts. In the first row of Table 1, we report the unconditional covariance of output and aggregate consumption in the data, as well as those of output with tradable and non-tradable consumption.[29] In the second row, we report the same covariances, but now *conditional* on identified foreign demand shocks. We then report the corresponding covariances—conditional on foreign demand shocks—from the HANK and RANK models in the bottom panel of the table. These numbers document that while the RANK model gets the sign

28. A similar argument applies to the correlation between domestic and foreign consumption, which in the RANK model is negative, conditional on a foreign demand shock, while, unconditionally, it is clearly positive in the data (0.40 in our sample).

29. We choose to focus here on covariances rather than correlations, since the former are informative of not just the sign, but also the magnitude of the comovement between two variables.

wrong, the HANK model can match the sign of the covariance between output and aggregate consumption, and account for more than 50% of its magnitude. By aligning the conditional covariance of output and consumption with its unconditional counterpart in the data, the HANK model thus paves the way for foreign demand shocks to play a quantitatively important role for domestic business cycles.

Table 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	6.24	7.37	4.97
RANK	-2.99	-1.25	-4.94

Note: The table reports the covariances of domestic output with domestic consumption or either of its sectoral components. The unconditional data moments refers to covariances of the filtered data series, whereas the conditional data moments are based on our estimated foreign demand shocks. The (conditional) model moments are computed from the model-based impulse responses displayed in Figure 8.

Correlated shocks To further substantiate this point, we consider an experiment in which we allow for shocks in the model to be correlated across countries. This is a common feature in calibrated open-economy models in the RANK tradition to obtain positive cross-country comovement of macroeconomic variables; see, e.g., Backus et al. (1992) or Kose and Yi (2006). We then determine the sequence of domestic demand shocks that must accompany a foreign demand shock for each model to match the empirical consumption response. This exercise allows us to quantify how much endogenous propagation of foreign demand shocks is generated by each model.

To this end, we consider a *domestic* demand shock in the form of a shock to the exogenous component of the households' discount factor (ϵ_t^β). We assume that a negative foreign demand shock coincides with a sequence of realizations of this shock over the first sixteen quarters, chosen so that the response of domestic aggregate consumption in the model matches that in the data quarter by quarter over that window. We do this for each of the HANK and RANK models and then ask how much of the comovement between the domestic economy and the foreign one each model ascribes to the domestic shock. Since the responses are close to linear, the covariance of a domestic variable with foreign output can be decomposed into a component coming

from the foreign shock and a component arising from the domestic shock. For domestic consumption, the HANK model attributes 70 percent of that covariance to the foreign shock and 30 percent to the domestic one, while in RANK the foreign shock in isolation produces a *negative* covariance, so the domestic shock has to account for more than 100 percent. In other words, the HANK model generates most of the required propagation of foreign shocks onto domestic consumption endogenously, while the RANK model relies on contemporaneous negative domestic shocks in order to match the data. Thus, the puzzling lack of comovement between domestic and foreign business cycles found by Justiniano and Preston (2010) is confirmed in the RANK model, while our HANK model can resolve this issue.

6.4 Fixed exchange rate

We have seen above that the responses of the domestic nominal and real interest rates play a crucial role in the RANK model. The counterfactual increase in aggregate consumption in that model can be attributed to the decline in the real interest rate, which in turn arises from the monetary policy response of the domestic central bank obeying the Taylor principle. This latter mechanism does not apply under a fixed exchange rate. We therefore revisit this case, as studied briefly at the end of the previous section, and evaluate whether this affects our results.

Under a peg, with $E_t = E_{ss}$ for all t, domestic monetary policy is dictated by the UIP condition, and the domestic real interest rate is therefore given by $dr_t = di_t^* - d\pi_{t+1}$. Thus, for the domestic real rate to decline, the foreign nominal interest rate needs to drop by more than domestic inflation. In Appendix Figure E.6, we document that this condition is satisfied in both the HANK and the RANK model, as both models display a decline in the real interest rate in response to a negative foreign demand shock, except for a short-lived initial increase. As a result, the positive response of consumption in the RANK model is confirmed under a fixed exchange rate.

This highlights the importance of modelling the foreign demand shock in line with the empirical evidence: Had we considered only a shift in the foreign demand component, M_t^*, keeping the remaining foreign variables fixed, we would not have captured the resulting decline in the foreign nominal interest rate i_t^*. This would have flipped the sign of the response of domestic consumption in the RANK model. When accounting for the empirical observation that also foreign inflation and the foreign interest rate drop, our HANK model can replicate the main empirical findings also

under a fixed exchange rate, while the RANK model cannot.[30]

6.5 Robustness

Our main findings are robust to a range of modelling choices and parameter values. We first compare the household specification in our baseline model to a two-asset HANK model and a two-agent (TANK) model. We describe the details of these models and report the associated responses of output and consumption in Appendix Figure E.9. As seen from the figure, the main conclusions are unchanged under each of these specifications, both of which feature a drop in aggregate consumption of a magnitude roughly similar to our baseline model.

We have also considered an alternative specification of the financing of public expenditures, with a tax rule as in Auclert et al. (2020), according to which the government adjusts the tax rate continuously: $\tau_t - \tau = \epsilon^B (B_{t-1} - B_{ss})/Y_{ss}$. The responses of output and consumption are reported in Appendix Figure E.10. Unsurprisingly, when the government relies more on higher taxes than on debt issuance to cover the shortfall of tax revenues after a negative foreign demand shock, the drop in consumption becomes somewhat larger in the HANK model, whereas this difference is inconsequential in the RANK model due to the presence of Ricardian equivalence. Thus, our main findings are unaffected.

We report the results of a further set of robustness checks in Appendix Figures E.11 through E.13. Notably, we show that having the central bank respond to consumer prices instead of producer prices does not change our findings, since foreign inflation also declines, thus reducing the domestic CPI. Likewise, since output drops, adding an output response to the Taylor rule does not change the sign of the interest-rate response. We also assess the robustness of our findings with respect to the values of the trade elasticities in the model, which are subject to some discussion in the existing literature. Since our findings generally emphasize income over substitution effects, they are not particularly sensitive to variations of these parameter values.

30. In Appendix E.3, we report a complete set of results from our model with a fixed exchange rate. All main takeaways are similar to those reported above for a floating rate.

6.6 Foreign supply shocks

We now shift our attention to foreign supply shocks and evaluate the extent to which our model can reproduce their effects. Following the same approach as in Section 5.2, we now feed the model with smoothed versions of the estimated responses of the foreign economy to a foreign supply shock (see Appendix Figure D.4). We then report the implied responses of the domestic variables in the HANK and RANK models against their empirical counterparts in Figure 11. Consistent with the data, both models generate a notable contraction in domestic GDP, foreign trade, and (to a lesser extent) employment. However, as with foreign demand shocks, they differ markedly in their ability to match the behavior of consumption and its sectoral components. The HANK model delivers a sizeable decline in consumption, consistent with the empirical response. In contrast, the RANK model produces a virtually flat response of both aggregate and sector-specific consumption. This divergence reflects the same mechanism discussed above: Although both models feature a substantial drop in wage income, only the HANK model maps this into a drop in consumption due to the differences in MPCs across the two models. In the RANK model, instead, consumption dynamics depend primarily on the path of the real interest rate, which remains close to zero and therefore induces a weak intertemporal substitution effect.

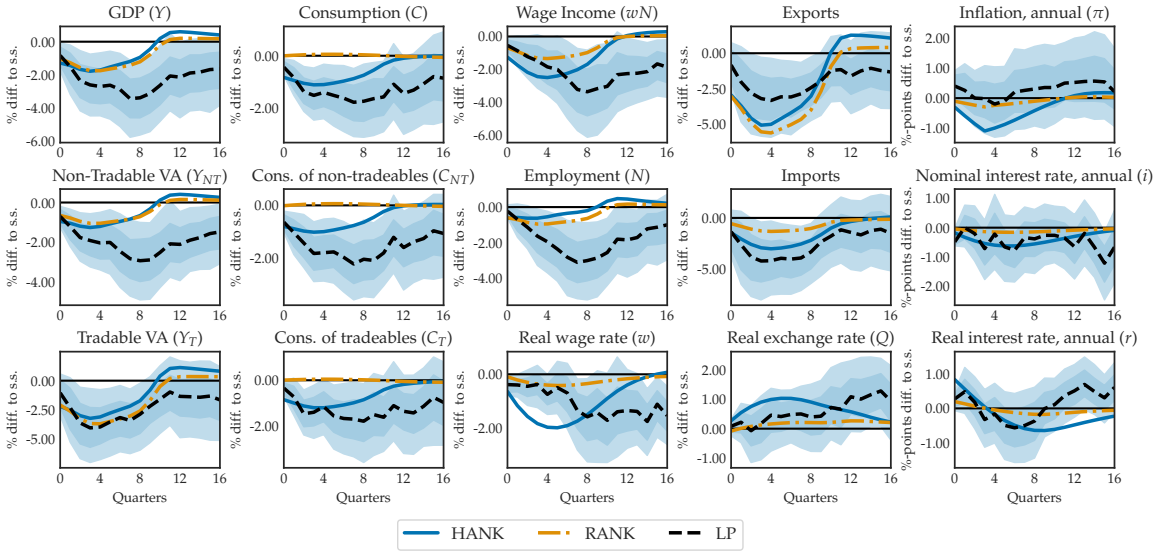


Figure 11: Response of the domestic economy to a foreign supply shock

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

Finally, although the HANK model generates somewhat more front-loaded move-

ments in some cases (e.g., the real wage and the real exchange rate), its predictions for most other variables remain broadly aligned with the empirical evidence. Taken together, the results in Figure 11 provide further validation of our HANK model, demonstrating that it can replicate both the qualitative patterns and the quantitative magnitudes associated with multiple types of foreign shocks. Moreover, applying the same logic as in Section 6.3, our findings suggest that foreign supply shocks are also likely to account for a sizeable share of business-cycle fluctuations in small open economies, consistent with our empirical findings (see Figure 3). This would reinforce the overall importance of foreign shocks, in line with the empirical evidence discussed in the introduction.

7 Implications for Stabilization Policy

When foreign demand shocks play an important role for business-cycle fluctuations in small open economies, as we have argued, it becomes relevant to study the implications of such shocks for stabilization policies. We therefore now turn to this question. Our analysis starts from the observation that for any given shortfall of foreign demand, the domestic government or central bank can always provide sufficient fiscal or monetary stimulus to stabilize *aggregate* domestic consumption. Against this backdrop, we study the ability of various policy tools to stabilize consumption of households working in each of the two domestic sectors. Our argument is that, all else equal, symmetric policies that stabilize consumption for households in the tradable and the non-tradable sectors roughly equally should be preferable.[31]

In the first row of Table 2, we consider the effects of a negative foreign demand shock scaled to generate a 1% cumulative drop in aggregate consumption. We then report the implied drop in consumption of households working in the tradable (C_T^{hh}) and non-tradable sector (C_{NT}^{hh}), respectively (columns 2-3), and the ratio between these two (column 4).[32] These numbers indicate that households in the tradable sector suffer the biggest drop in consumption, which is not too surprising, given that this

31. We leave an analysis of the optimal policy response to foreign demand shocks for future study. For a characterization of optimal fiscal and/or monetary policies in HANK models, see Acharya and Challe (2025) and Waldstrøm (2024) for open-economy analyses in one-sector models with a focus on different types of shocks, and Le Grand et al. (2026), McKay and Wolf (2026), Acharya et al. (2023), or Dávila and Schaab (2023) for closed-economy analyses.

32. In Appendix E.5 we report a table corresponding to Table 2, but focused on the responses of labor income instead of consumption. This does not alter the main message.

sector is most directly affected by a reduction in foreign demand.[33]

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

	Floating				Fixed			
	C	C_T^{hh}	C_{NT}^{hh}	$\frac{C_T^{hh}}{C_{NT}^{hh}}$	C	C_T^{hh}	C_{NT}^{hh}	$\frac{C_T^{hh}}{C_{NT}^{hh}}$
Foreign demand, β^*	-1.00	-1.14	-0.95	1.20	-1.00	-1.00	-1.00	1.00
Domestic demand, β	-1.00	-0.83	-1.06	0.78	-1.00	-0.83	-1.06	0.79
Public transfers, T	1.00	0.67	1.12	0.60	1.00	0.68	1.11	0.61
Public spending, G	1.00	0.23	1.28	0.18	1.00	0.26	1.27	0.20
Monetary policy, i	1.00	0.96	1.02	0.94	-	-	-	-
Nominal devaluation	-	-	-	-	1.00	1.17	0.94	1.24
Fiscal devaluation	-	-	-	-	1.00	1.10	0.97	1.14

Note: The domestic demand shock and all policy instruments follow AR(1) processes with a persistence of 0.75. Both demand shocks are scaled to generate a cumulative 1% *decrease* in aggregate consumption, and the policy instruments are scaled to exactly offset this. C is aggregate consumption and C_T^{hh} and C_{NT}^{hh} denote consumption of households employed in the tradable and non-tradable sectors, respectively. For all variables we report the cumulative effect over the first 16 quarters. The fiscal devaluation combines an increased VAT with a reduced payroll tax. Details are in Appendix E.5.

In comparison, the second row of Table 2 reports the corresponding numbers for a negative *domestic* demand shock (i.e., a shock to the discount factor, ϵ_t^β), which is assumed to follow an AR(1) process with a persistence of 0.75. This shock is seen to affect the non-tradable sector most strongly, in part because the tradable sector is less sensitive to domestic demand, and partly because the fall in domestic demand causes a decline in domestic inflation, which leads to a depreciation of the real exchange rate, and therefore an increase in foreign demand for domestic tradables.

7.1 Policy instruments under a floating exchange rate

We now consider three traditional policy instruments that may be used to offset foreign demand shocks: i) *Public transfers*, T_t, which are distributed equally among households in the two sectors; ii) *Government spending*, G_t, which flows predominantly to the non-tradable sector, as discussed in Section 5.1; iii) *Monetary policy*,

33. The effects of foreign demand shocks are significantly more symmetric across sectors than in the model of Guo et al. (2023), who find that households in the tradable sector are much more strongly affected. Importantly, they consider a foreign demand shock only in the form of a change in foreign demand for domestic goods, whereas we also account for the changes in foreign inflation and the foreign interest rate. Furthermore, their model does not feature input-output linkages in production.

implemented via changes in the exogenous component of the Taylor rule (4.20), ϵ_t^r. All three instruments are assumed to follow AR(1) processes with a persistence of 0.75, and are scaled to offset the cumulative drop in aggregate consumption entirely.

The effects are reported in rows 3 to 5 of Table 2. The effects of public transfers (row 3) largely mirror those of a domestic demand shock, making this a well-suited policy to combat such shocks. However, in the face of foreign demand shocks, transfers fail to stimulate consumption of households in the tradable sector sufficiently. The same is true—to a much larger extent—for government spending (row 4), due to the sectoral composition of G_t. Both fiscal instruments lead to an *appreciation* of the real exchange rate (see Appendix Figure E.14), which—instead of stabilizing—exacerbates the shortfall of foreign demand via expenditure switching.

In contrast, we find that monetary policy (row 5) is more successful at stabilizing consumption of households in both sectors, in large part because a monetary expansion leads to a *depreciation* of the real exchange rate and the terms of trade (see Appendix Figure E.14). This stimulates foreign demand for domestically produced tradables. Domestic demand for non-tradables is also stimulated, partly due to income and multiplier effects of higher foreign demand, and partly because of intertemporal substitution effects. Altogether, expansionary monetary policy therefore stimulates income and consumption of households in both sectors. In other words, monetary policy appears to be the most appropriate tool for combating foreign demand shocks.

7.2 Policy instruments with a fixed exchange rate

When we turn to the case of a fixed exchange rate (columns 5-8 of Table 2), the insights from above are largely confirmed: Foreign demand shocks now affect households in the two sectors almost symmetrically, while domestic demand shocks weigh more strongly on households in the non-tradable sector. Furthermore, while public transfers appear well-suited to combat domestic demand shocks, we observe that both T_t and (especially) G_t provide inadequate stimulus to the tradables sector (rows 3 and 4) when faced with foreign demand shocks also under a peg. This shortcoming can again be attributed to the fact that expansionary fiscal policies lead to an appreciation of the real exchange rate and the terms of trade, as discussed above.

The absence of an independent monetary policy under a currency peg therefore leaves domestic policymakers without any conventional instruments to offset foreign demand shocks. As shown in row 6 of Table 2, a devaluation of the nominal exchange rate would represent a way to provide adequate stimulus to both sectors,

similarly to a monetary expansion under a floating rate (see also Appendix Figure E.15). However, these results emerge under the unlikely assumption that full and immediate commitment to a one-off nominal devaluation is possible. In practice, there are a range of reasons why this type of policy may be infeasible or undesirable.

Fiscal devaluation A possible remedy discussed in the literature is to conduct a fiscal devaluation. In a representative-agent setup, Farhi et al. (2014) find that a fiscal devaluation—in the form of an increase in value-added taxes (VAT) and a reduction of payroll taxes—may successfully mimic the real effects of a nominal exchange rate devaluation. To investigate the effectiveness of a fiscal devaluation in our context, we introduce a VAT and a payroll subsidy into our baseline HANK model (see Appendix E.5 for details). We then conduct a fiscal devaluation scaled to fully offset the effect of a negative foreign demand shock on aggregate consumption.

The results are reported in the bottom row of Table 2. We find that a fiscal devaluation successfully stimulates consumption of households in both sectors, especially those in the tradables sector. The explanation is the following: A fiscal devaluation entails an increase in the payroll subsidy, which reduces the domestic cost of production. At the same time, a higher VAT affects international relative prices. This is because the VAT is levied on imported goods from the foreign country, whereas domestic exports are not subject to the VAT. Altogether, this leads to expenditure switching from foreign to domestic tradables by domestic and foreign consumers.

The left panel of Appendix Figure E.15 shows that a fiscal devaluation leads to a substantial *appreciation* of the real exchange rate, reflecting the increase in the domestic consumer price index directly resulting from a higher VAT at home. However, as indicated in the right panel of the figure, the introduction of a VAT breaks the proportionality between the real exchange rate and the terms of trade: the latter—which is defined as the ratio of the prices of imports and exports, $S_t = \frac{(1-\tau_t^v)P_{F,t}}{P^*_{H,t}E_t}$, with τ_t^v denoting the value-added tax rate, and therefore the relevant measure for expenditure switching—*depreciates* substantially, as the VAT makes domestic tradables cheaper relative to foreign tradables. In addition, the price of domestic non-tradables relative to tradables declines, stimulating economic activity also in the former sector. Thus, the bottom line is that a fiscal devaluation may be an effective way to offset a shortfall of foreign demand in countries without an independent monetary policy.

Effects on inflation Finally, we assess how well each policy stabilizes inflation. We report the responses of aggregate and sector-specific producer price inflation in Ap-

pendix Table E.3 and Appendix Figure E.16. Under a floating exchange rate, monetary policy is more effective than fiscal policy in stabilizing inflation, partly reflecting the different exchange-rate responses discussed above. Under a peg, domestic policies can stabilize inflation in the first two years after the shock but become less effective thereafter, as inflation must reverse to realign domestic prices with foreign prices. In both regimes, the two sectors display synchronized inflation dynamics.

8 Concluding remarks

In this paper, we have proposed a HANK model of a small open economy, and documented that this model can account for a set of empirical facts regarding the domestic response to a negative foreign demand shock. The key insight is that a strong direct labor income effect allows the model to match the observed negative response of aggregate consumption and its components. In contrast, in the absence of high-MPC households, a corresponding RANK model entails a counterfactual increase in domestic consumption, driven by intertemporal substitution. Since the HANK model implies a positive conditional comovement of output and consumption, in line with the unconditional comovement observed in the data, this model paves the way for foreign demand shocks to play a significant role in domestic business fluctuations, consistent with our empirical evidence.

The importance of foreign demand shocks poses a challenge for stabilization policies. Traditional fiscal policy tools such as public spending and transfers provide insufficient stimulus to the tradable sector. Monetary policy therefore plays a crucial role because of its ability to depreciate the terms of trade and stimulate both the tradable and non-tradable sector. These results constitute an important challenge for countries who cannot set monetary policy independently. We show that a fiscal devaluation may represent a good "substitute" for monetary policy.

Our findings call for further research in a number of directions. An important next step would be to study labor market dynamics in more detail. Introducing a search-and-match labor market would enable a new transmission mechanism where foreign demand shocks affect domestic unemployment and therefore idiosyncratic uncertainty. This would likely strengthen the overall transmission. On the other hand, a more detailed specification of the labor market with workers moving across sectors might make it less challenging to stabilize foreign demand shocks, as workers would choose to relocate. In ongoing work, we are exploring these and other avenues.

References

Acharya, Sushant, and Edouard Challe. 2025. "Inequality and Optimal Monetary Policy in the Open Economy." *Journal of International Economics* 155:104076.

Acharya, Sushant, Edouard Challe, and Keshav Dogra. 2023. "Optimal Monetary Policy According to HANK." *American Economic Review* 113 (7): 1741–1782.

Acharya, Sushant, and Paolo Pesenti. 2024. "Spillovers and Spillbacks." *NBER Working Paper 32245.*

Adler, Gustavo, Cian Allen, Giovanni Ganelli, and Daniel Leigh. 2024. "An Updated Action-based Dataset of Fiscal Consolidation." *IMF Working Paper 210.*

Adolfson, Malin, Stefan Laséen, Lawrence J. Christiano, Mathias Trabandt, and Karl Walentin. 2013. "Ramses II—Model Description." *Sveriges Riksbank Occasional Paper Series No. 12.*

Adolfson, Malin, Stefan Laséen, Jesper Lindé, and Mattias Villani. 2007. "Bayesian Estimation of an Open Economy DSGE Model with Incomplete Pass-through." *Journal of International Economics* 72 (2): 481–511.

Aggarwal, Rishabh, Adrien Auclert, Matthew Rognlie, and Ludwig Straub. 2023. "Excess Savings and Twin Deficits: The Transmission of Fiscal Stimulus in Open Economies." *NBER Macroeconomics Annual 2022* 37:325–412.

Aiyagari, S. Rao. 1994. "Uninsured Idiosyncratic Risk and Aggregate Saving." *The Quarterly Journal of Economics* 109 (3): 659–684.

Akinci, Ozge. 2011. "A Note on the Estimation of the Atemporal Elasticity of Substitution between Tradable and Nontradable Goods." Working Paper, Columbia University.

Alesina, Alberto, Francesco Giavazzi, and Carlo Favero. 2019. *Austerity: When it Works and When it Doesn't.* Princeton University Press.

Alpanda, Sami, Eleonora Granziera, and Sarah Zubairy. 2021. "State Dependence of Monetary Policy across Business, Credit and Interest Rate Cycles." *European Economic Review* 140:103936.

Arias, Jonas E., Juan F. Rubio-Ramírez, and Daniel F. Waggoner. 2018. "Inference Based on Structural Vector Autoregressions Identified With Sign and Zero Restrictions: Theory and Applications." *Econometrica* 86 (2): 685–720.

Atalay, Enghin. 2017. "How Important are Sectoral Shocks?" *American Economic Journal: Macroeconomics* 9 (4): 254–80.

Auclert, Adrien. 2019. "Monetary Policy and the Redistribution Channel." *American Economic Review* 109 (6): 2333–2367.

Auclert, Adrien, Bence Bardóczy, Matthew Rognlie, and Ludwig Straub. 2021a. "Using the Sequence-Space Jacobian to Solve and Estimate Heterogeneous-Agent Models." *Econometrica* 89 (5): 2375–2408.

Auclert, Adrien, Matthew Rognlie, Martin Souchier, and Ludwig Straub. 2021b. "Exchange Rates and Monetary Policy with Heterogeneous Agents: Sizing up the Real Income Channel." *NBER Working Paper 28872.*

Auclert, Adrien, Matthew Rognlie, and Ludwig Straub. 2020. "Micro Jumps, Macro Humps: Monetary Policy and Business Cycles in an Estimated HANK Model." *NBER Working Paper 26647.*

———. 2024. "The Intertemporal Keynesian Cross." *Journal of Political Economy* 132 (12): 4068–4121.

Backus, David K., Patrick J. Kehoe, and Finn E. Kydland. 1992. "International Real Business Cycles." *Journal of Political Economy* 100 (4): 745–775.

Baumeister, Christiane, and James D. Hamilton. 2019. "Structural Interpretation of Vector Autoregressions with Incomplete Identification: Revisiting the Role of Oil Supply and Demand Shocks." *American Economic Review* 109 (5): 1873–1910.

Bayer, Christian, Alexander Kriwoluzky, Gernot J. Müller, and Fabian Seyrich. 2024. "A $HANK^2$ Model of Monetary Unions." *Journal of Monetary Economics* 147:103579.

Bayer, Christian, Ralph Lütticke, Lien Pham-Dao, and Volker Tjaden. 2019. "Precautionary Savings, Illiquid Assets, and the Aggregate Consequences of Shocks to Household Income Risk." *Econometrica* 87 (1): 255–290.

Bellifemine, Marco, Adrien Couturier, and Rustam Jamilov. 2023. "The Regional Keynesian Cross." Working Paper, London School of Economics.

Benigno, Pierpaolo, and Federica Romei. 2014. "Debt Deleveraging and the Exchange Rate." *Journal of International Economics* 93 (1): 1–16.

Bergholt, Drago. 2015. "Foreign Shocks." *Norges Bank Working Paper 2015/15.*

Bewley, Truman. 1986. "Stationary Monetary Equilibrium with a Continuum of Independently Fluctuating Consumers." *Contributions to Mathematical Economics in Honor of Gérard Debreu*, 79–102.

Blanchard, Olivier J., and Danny Quah. 1989. "The Dynamic Effects of Aggregate Demand and Supply Disturbances." *American Economic Review* 79 (4): 655–673.

Boeck, Maximilian, and Lorenzo Mori. 2025. "Has Globalization Changed the International Transmission of U.S. Monetary Policy?" *Journal of International Economics* 157:104139.

Boehm, Christoph E., Aaron Flaaen, and Nitya Pandalai-Nayar. 2019. "Input Linkages and the Transmission of Shocks: Firm-level Evidence from the 2011 Tōhoku Earthquake." *Review of Economics and Statistics* 101 (1): 60–75.

Boehm, Christoph E., Andrei A. Levchenko, and Nitya Pandalai-Nayar. 2023. "The Long and Short (Run) of Trade Elasticities." *American Economic Review* 113 (4): 861–905.

Boppart, Timo, Per Krusell, and Kurt Mitman. 2018. "Exploiting MIT Shocks in Heterogeneous-agent Economies: The Impulse Response as a Numerical Derivative." *Journal of Economic Dynamics and Control* 89:68–92.

Bouakez, Hafedh, Emanuela Cardia, and Francisco J. Ruge-Murcia. 2009. "The Transmission of Monetary Policy in a Multisector Economy." *International Economic Review* 50 (4): 1243–1266.

Broer, Tobias, Niels-Jakob Harbo Hansen, Per Krusell, and Erik Öberg. 2020. "The New Keynesian Transmission Mechanism: A Heterogeneous-agent Perspective." *Review of Economic Studies* 87 (1): 77–101.

Broner, Fernando, Daragh Clancy, Aitor Erce, and Alberto Martin. 2022. "Fiscal Multipliers and Foreign Holdings of Public Debt." *Review of Economic Studies* 89 (3): 1155–1204.

Camara, Santiago. 2025. "Spillovers of US Interest Rates: Monetary Policy Information Effects." *Journal of International Economics* 154:104059.

Canova, Fabio. 2005. "The Transmission of US Shocks to Latin America." *Journal of Applied Econometrics* 20 (2): 229–251.

Cardi, Olivier, and Romain Restout. 2023. "Sectoral Fiscal Multipliers and Technology in Open Economy." *Journal of International Economics* 144:103789.

Carroll, Christopher D. 2006. "The Method of Endogenous Gridpoints for Solving Dynamic Stochastic Optimization Problems." *Economics Letters* 91 (3): 312–320.

Charnavoki, Valery, and Juan J. Dolado. 2014. "The Effects of Global Shocks on Small Commodity-Exporting Economies: Lessons from Canada." *American Economic Journal: Macroeconomics* 6 (2): 207–237.

Chen, Sihao, Michael B. Devereux, Kang Shi, and Juanyi Xu. 2023. "Consumption Heterogeneity and Monetary Policy in an Open Economy." *Journal of Monetary Economics* 140:1–15.

Chetty, Raj, Adam Guren, Day Manoli, and Andrea Weber. 2011. "Are Micro and Macro Labor Supply Elasticities Consistent? A Review of Evidence on the Intensive and Extensive Margins." *American Economic Review* 101 (3): 471–75.

Christiano, Lawrence J., Mathias Trabandt, and Karl Walentin. 2011. "Introducing Financial Frictions and Unemployment into a Small Open Economy Model." *Journal of Economic Dynamics and Control* 35 (12): 1999–2041.

Cloyne, James, Òscar Jordà, and Alan M. Taylor. 2023. "State-dependent Local Projections: Understanding Impulse Response Heterogeneity." *NBER Working Paper 30971.*

Corsetti, Giancarlo. 2007. "New Open Economy Macroeconomics." *CEPR Discussion Paper No. DP6578.*

Corsetti, Giancarlo, Luca Dedola, and Sylvain Leduc. 2008. "International Risk Sharing and the Transmission of Productivity Shocks." *Review of Economic Studies* 75 (2): 443–473.

Corsetti, Giancarlo, Keith Kuester, Gernot J. Müller, and Sebastian Schmidt. 2021. "The Exchange Rate Insulation Puzzle." *CEPR Discussion Paper No. DP15689.*

Dávila, Eduardo, and Andreas Schaab. 2023. "Optimal Monetary Policy with Heterogeneous Agents: Discretion, Commitment, and Timeless Policy." *NBER Working Paper 24280.*

De Ferra, Sergio, Kurt Mitman, and Federica Romei. 2020. "Household Heterogeneity and the Transmission of Foreign Shocks." *Journal of International Economics* 124:103303.

Driscoll, John C., and Aart C. Kraay. 1998. "Consistent Covariance Matrix Estimation with Spatially Dependent Panel Data." *Review of Economics and Statistics* 80 (4): 549–560.

Drozd, Lukasz A., Sergey Kolbin, and Jaromir B. Nosal. 2021. "The Trade-Comovement Puzzle." *American Economic Journal: Macroeconomics* 13 (2): 78–120.

Druedahl, Jeppe, Søren Hove Ravn, Laura Sunder-Plassmann, Jacob Marott Sundram, and Nicolai Waldstrøm. 2025. "Fiscal Multipliers in Small Open Economies With Heterogeneous Households." *IMF Economic Review* 73 (3): 654–707.

Eickmeier, Sandra. 2007. "Business Cycle Transmission from the US to Germany—A Structural Factor Approach." *European Economic Review* 51 (3): 521–551.

Fagereng, Andreas, Martin B. Holm, and Gisle J. Natvik. 2021. "MPC Heterogeneity and Household Balance Sheets." *American Economic Journal: Macroeconomics* 13 (4): 1–54.

Farhi, Emmanuel, Gita Gopinath, and Oleg Itskhoki. 2014. "Fiscal Devaluations." *Review of Economic Studies* 81 (2): 725–760.

Feenstra, Robert C., Philip Luck, Maurice Obstfeld, and Katheryn N. Russ. 2018. "In Search of the Armington Elasticity." *Review of Economics and Statistics* 100 (1): 135–150.

Feldkircher, Martin, and Florian Huber. 2016. "The International Transmission of US Shocks—Evidence from Bayesian Global Vector Autoregressions." *European Economic Review* 81:167–188.

Floden, Martin, and Jesper Lindé. 2001. "Idiosyncratic Risk in the United States and Sweden: Is There a Role for Government Insurance?" *Review of Economic Dynamics* 4 (2): 406–437.

Fornaro, Luca. 2015. "Financial Crises and Exchange Rate Policy." *Journal of International Economics* 95 (2): 202–215.

———. 2018. "International Debt Deleveraging." *Journal of the European Economic Association* 16 (5): 1394–1432.

Furlanetto, Francesco, Francesco Ravazzolo, and Samad Sarferaz. 2019. "Identification of Financial Factors in Economic Fluctuations." *The Economic Journal* 129 (617): 311–337.

Gabaix, Xavier. 2020. "A Behavioral New Keynesian Model." *American Economic Review* 110 (8): 2271–2327.

Gabriel, Ricardo Duque, Mathias Klein, and Ana Sofia Pessoa. 2026. "The Political Costs of Austerity." *The Review of Economics and Statistics* 108 (1): 145–161.

Gali, Jordi, and Tommaso Monacelli. 2005. "Monetary Policy and Exchange Rate Volatility in a Small Open Economy." *Review of Economic Studies* 72 (3): 707–734.

Galí, Jordi. 2015. *Monetary Policy, Inflation, and the Business Cycle: An Introduction to the New Keynesian Framework and Its Applications.* Princeton University Press.

———. 2020. "Uncovered Interest Parity, Forward Guidance and the Exchange Rate." *Journal of Money, Credit and Banking* 52 (S2): 465–496.

Giagheddu, Marta. 2020. "The Distributional Implications of Fiscal Devaluations." *SSRN Working Paper 3651258.*

Guajardo, Jaime, Daniel Leigh, and Andrea Pescatori. 2014. "Expansionary Austerity? International Evidence." *Journal of the European Economic Association* 12 (4): 949–968.

Guerrieri, Veronica, and Guido Lorenzoni. 2017. "Credit Crises, Precautionary Savings, and the Liquidity Trap." *The Quarterly Journal of Economics* 132 (3): 1427–1467.

Guo, Xing, Pablo Ottonello, and Diego Perez. 2023. "Monetary Policy and Redistribution in Open Economies." *Journal of Political Economy Macroeconomics* 1 (1): 191–241.

Hagedorn, Marcus, Iourii Manovskii, and Kurt Mitman. 2019. "The Fiscal Multiplier." *NBER Working Paper 25571.*

Hong, Seungki. 2020. "Emerging Market Business Cycles with Heterogeneous Agents." Working Paper, Columbia University.

Huang, Kevin X.D., and Zheng Liu. 2007. "Business Cycles with Staggered Prices and International Trade in Intermediate Inputs." *Journal of Monetary Economics* 54 (4): 1271–1289.

Huggett, Mark. 1993. "The Risk-free Rate in Heterogeneous-agent Incomplete-insurance Economies." *Journal of Economic Dynamics and Control* 17 (5): 953–969.

Iacoviello, Matteo, and Gaston Navarro. 2019. "Foreign Effects of Higher U.S. Interest Rates." *Journal of International Money and Finance* 95:232–250.

Ilzetzki, Ethan, and Keyu Jin. 2021. "The Puzzling Change in the International Transmission of U.S. Macroeconomic Policy Shocks." *Journal of International Economics* 130:103444.

Imrohoroğlu, Ayşe. 1989. "Cost of Business Cycles with Indivisibilities and Liquidity Constraints." *Journal of Political Economy* 97 (6): 1364–1383.

Jarociński, Marek, and Peter Karadi. 2020. "Deconstructing Monetary Policy Surprises—The Role of Information Shocks." *American Economic Journal: Macroeconomics* 12 (2): 1–43.

Jordà, Òscar. 2005. "Estimation and Inference of Impulse Responses by Local Projections." *American Economic Review* 95 (1): 161–182.

Jordà, Òscar, and Alan M. Taylor. 2025. "Local Projections." *Journal of Economic Literature* 63 (1): 59–110.

Justiniano, Alejandro, and Bruce Preston. 2010. "Can Structural Small Open-economy Models Account for the Influence of Foreign Disturbances?" *Journal of International Economics* 81 (1): 61–74.

Kaplan, Greg, Benjamin Moll, and Giovanni L. Violante. 2018. "Monetary Policy According to HANK." *American Economic Review* 108 (3): 697–743.

Kilian, Lutz. 2009. "Not All Oil Price Shocks are Alike: Disentangling Demand and Supply Shocks in the Crude Oil Market." *American Economic Review* 99 (3): 1053–1069.

Kose, M. Ayhan, and Kei-Mu Yi. 2006. "Can the Standard International Business Cycle Model Explain the Relation Between Trade and Comovement?" *Journal of International Economics* 68 (2): 267–295.

Le Grand, François, Alaïs Martin-Baillon, and Xavier Ragot. 2026. "Should Monetary Policy Care About Redistribution? Optimal Fiscal and Monetary Policy with Heterogeneous Agents." *Review of Economic Studies,* forthcoming.

Lubik, Thomas A., and Frank Schorfheide. 2007. "Do Central Banks Respond to Exchange Rate Movements? A Structural Investigation." *Journal of Monetary Economics* 54 (4): 1069–1087.

McKay, Alisdair, Emi Nakamura, and Jón Steinsson. 2016. "The Power of Forward Guidance Revisited." *American Economic Review* 106 (10): 3133–58.

McKay, Alisdair, and Christian K. Wolf. 2026. "Optimal Policy Rules in HANK." *Review of Economic Studies,* forthcoming.

Mendoza, Enrique G. 2010. "Sudden Stops, Financial Crises, and Leverage." *American Economic Review* 100 (5): 1941–1966.

Miranda-Agrippino, Silvia, Tsvetelina Nenova, and Hélène Rey. 2020. "Global Footprints of Monetary Policies." Working Paper, London School of Economics.

Miranda-Agrippino, Silvia, and Hélene Rey. 2020. "US Monetary Policy and the Global Financial Cycle." *Review of Economic Studies* 87 (6): 2754–2776.

Mumtaz, Haroon, and Paolo Surico. 2009. "The Transmission of International Shocks: A Factor-Augmented VAR Approach." *Journal of Money, Credit and Banking* 41:71–100.

Nakamura, Emi, and Jón Steinsson. 2008. "Five Facts About Prices: A Reevaluation of Menu Cost Models." *The Quarterly Journal of Economics* 123 (4): 1415–1464.

Oskolkov, Aleksei. 2023. "Exchange Rate Policy and Heterogeneity in Small Open Economies." *Journal of International Economics* 142:103750.

Ostry, Jonathan D., and Carmen M. Reinhart. 1992. "Private Saving and Terms of Trade Shocks: Evidence from Developing Countries." *IMF Economic Review* 39 (3): 495–517.

Ottonello, Pablo. 2021. "Optimal Exchange-rate Policy under Collateral Constraints and Wage Rigidity." *Journal of International Economics* 131:103478.

Plagborg-Møller, Mikkel, and Christian K. Wolf. 2021. "Local Projections and VARs Estimate the Same Impulse Responses." *Econometrica* 89 (2): 955–980.

Ramey, Valerie A. 2016. "Macroeconomic Shocks and Their Propagation." In *Handbook of Macroeconomics*, 2:71–162. Elsevier.

Rouwenhorst, K. Geert. 1995. "10 Asset Pricing Implications of Equilibrium Business Cycle Models." *Frontiers of Business Cycle Research*, 294–330.

Rubio-Ramírez, Juan F., Daniel F. Waggoner, and Tao Zha. 2010. "Structural Vector Autoregressions: Theory of Identification and Algorithms for Inference." *Review of Economic Studies* 77 (2): 665–696.

Schmitt-Grohé, Stephanie, and Martın Uribe. 2003. "Closing Small Open Economy Models." *Journal of International Economics* 61 (1): 163–185.

Uhlig, Harald. 2005. "What Are the Effects of Monetary Policy on Output? Results from an Agnostic Identification Procedure." *Journal of Monetary Economics* 52 (2): 381–419.

Waldstrøm, Nicolai. 2024. "Supply Shocks and Household Heterogeneity in Open Economies: Implications for Optimal Monetary Policy." Working Paper, University of Copenhagen.

Zhou, Haonan. 2022. "Open Economy, Redistribution, and the Aggregate Impact of External Shocks." *SSRN Working Paper 3902121.*