Anchored in Troubled Waters: Monetary Unions and Uncertainty*

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Abstract

A monetary union shapes the impact of uncertainty on the economy: it does not alter the transmission of common uncertainty shocks, but significantly *dampens* the adverse effects of country-specific shocks. We establish this result based on time series data for 17 euro-area countries and 13 countries with flexible exchange rates. To rationalize it, we propose a model of a monetary union in which monetary policy responds to common shocks but not to country-specific ones, as each member country is small. The union dampens the effect of country-specific shocks by providing a nominal anchor in the face of country-specific uncertainty, thereby eliminating price level risk.

Keywords: Uncertainty shocks, exchange rate regime, monetary policy, Monetary union, price level risk, nominal anchor, euro area

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1 Introduction

Joining a monetary union has costs and benefits. The most significant benefit is often considered to be long-term or permanent: the elimination of a potential inflation bias through the 'nominal anchor' that the union provides (Alesina and Barro, 2002). Similarly, increased trade integration is a first-order benefit of a monetary union. On the other hand, costs are expected to materialize in a cyclical fashion because countries in a monetary union lack an independent currency and exchange rate flexibility vis-à-vis the other members of the union. This reduces their ability to cope with country-specific shocks, a central tenet of optimum currency area theory (Mundell, 1961). However, the distinction between permanent and cyclical implications of union membership only goes so far. For instance, as a monetary union fosters trade integration, it also alters business cycle co-movement and hence the incidence of country-specific shocks (Krugman, 1993).

Likewise, the nominal anchor provided by the union matters not only for inflation in the long run; it also shapes short-run fluctuations. We establish this point in the present paper by contrasting the effects of economic uncertainty and the associated price level risk on the euro area (EA) countries and on countries with flexible exchange rates. First, we present new evidence by estimating a structural Bayesian vector autoregression (VAR) on time series for 30 countries. Our main result is that the exchange rate regime does not matter for the effect of common uncertainty shocks, but it does matter for how country-specific uncertainty plays out. Somewhat surprisingly, the effect of country-specific shocks is much weaker in EA countries than in countries with floating exchange rates.

Second, to shed light on this result, we put forward a two-country model of a monetary union in which the domestic economy is small enough to have no influence on the common price level and estimate it by matching the empirical impulse responses to a common uncertainty shock. We evaluate the model predictions for the effect of a country-specific uncertainty shock: they are indeed weaker compared to a counterfactual in which we assume flexible exchange rates. The adjustment of the domestic price level explains this result. In a monetary union, it is anchored by the union-wide level, to which it converges to restore purchasing power parity. Therefore, increased uncertainty does not translate into long-run uncertainty about the price level—the union limits price level risk.

Our evidence is based on quarterly time-series data covering the period from the introduction of the euro in 1999 to 2022. We first estimate the VAR separately for each of the 30 countries in our sample, allowing for country-level heterogeneity. Only in a second step do we aggregate across country groups and compute results for the median EA economy and the median economy with flexible exchange rates ('floater'), drawing from the posterior distribution of the estimates for each set of countries. As indicators of economic uncertainty, we rely on the measure of *macroeconomic uncertainty* originally proposed by Jurado et al. (2015) and compiled for individual EA countries by Comunale and Nguyen (2025). Alternatively, when comparing EA countries and floaters, we use realized stock market uncertainty, as in Bloom's (2009) seminal work. Our main interest is to identify country-specific and common uncertainty shocks separately. To do so, we isolate the country-specific component in the uncertainty indicator for each country using principal component analysis and estimate the VAR with country-specific volatility ordered first and total volatility second. In this way, we allow total volatility to be driven by both types of shocks but restrict country-specific volatility to being driven only by country-specific uncertainty shocks.

Our first main result concerns the role of the exchange rate regime in the transmission of a common uncertainty shock: there is none. When we compare the adjustment of the median EA economy and the median floater to a common uncertainty shock, their responses are very similar. This result is consistent with the conventional wisdom: when all countries are exposed to the same shock, there is little scope for exchange rate adjustment. Regardless of the exchange rate regime, we find that a common uncertainty shock adversely impacts the economy, lowers inflation—as in previous work on 'closed' economies (e.g. Leduc and Liu, 2016)—and induces a decline in the policy rate. Our second result is that the exchange rate regime has a first-order effect on the transmission of country-specific uncertainty shocks. While they reduce economic activity in the median floater—just like common shocks—they hardly impact economic activity in the median EA economy at all. This result is surprising because floaters, not constrained by an exchange rate target, can adjust monetary policy in response to country-specific shocks, while EA countries cannot. Consistent with this notion, we find that the policy rate in EA countries is unresponsive to country-specific shocks—and yet, their economic activity remains well insulated from such shocks.

To understand this result, we develop a model of a monetary union that extends a variant of the model by Basu and Bundick (2017) to a two-country setting. The countries are isomorphic except in two key respects. First, "Home" is small and does not affect the rest of the union, while "Foreign" is large and operates as a de facto closed economy. Second, the countries differ in the incidence of shocks. There are uncertainty shocks specific to Home and common uncertainty shocks that affect both countries alike. In each case, the uncertainty shock widens the distributions from which supply and demand shocks are drawn without changing their mean. Monetary policy adjusts interest rates in response to union-wide inflation, for which Home is irrelevant due to its small size.

We solve the model using a third-order perturbation and—as it is not nested within the linear VAR—estimate it using an indirect inference approach. We simulate time series from the model and use them to estimate the (auxiliary) VAR model when matching the impulse response functions to common uncertainty shocks. As an external validation, we verify that the model predicts, consistent with the evidence, that country-specific uncertainty shocks have much weaker effects on countries in the monetary union. To understand how the monetary union shapes the transmission of both shocks, we compare the baseline scenario of a monetary union with a counterfactual in which Home operates outside the union and conducts monetary policy independently. In this case, the model correctly predicts that the effect of a country-specific shock is larger, while the effect of a common shock is unchanged relative to the baseline of union membership.

Thus, union membership is crucial for the transmission of country-specific uncertainty shocks, but not in the way traditionally expected. To see why, consider the transmission of the same shock when Home conducts its own independent monetary policy outside the union. Suppose, however, that instead of targeting inflation, Home adjusts interest rates to stabilize the domestic price *level*. In this case, the response to country-specific shocks is basically indistinguishable from what happens under union membership. This testifies to the importance of the union-wide price level as an effective nominal anchor in the transmission of country-specific uncertainty shocks. Intuitively, when monetary policy targets inflation under flexible exchange rates, the price level exhibits a unit root and can drift arbitrarily far from its initial value, introducing long-run price level risk. This risk is eliminated when Home is part of the monetary union.

Under union membership, the price level of the union provides a nominal anchor in the face of country-specific shocks due to purchasing power parity (PPP). While the model allows for sizable deviations from PPP in the short run, PPP holds in steady state, consistent with evidence for the EA (Bergin et al., 2017). Since the nominal exchange rate is irrevocably fixed in the monetary union, domestic prices must eventually converge back to the union level to restore PPP after a country-specific shock. In fact, the weaker condition of relative PPP is all that is required for the mechanism to operate. Note that the mechanism will also be at play when it comes to policy uncertainty, which impacts economic activity adversely (Mumtaz and Zanetti, 2013; Born and Pfeifer, 2014a; Fernández-Villaverde et al., 2015). Its adverse impact will also be reduced by the nominal anchor provided by the union—to the extent that it is country-specific.

We further analyze the impact of price level risk on the economy by decomposing the time-varying risk wedges due to uncertainty shocks in the spirit of Bianchi et al. (2023). We selectively shut off these wedges by solving variants of the model in which certain forward-looking equations are restricted to their log-linear approximation. Our simulation results suggest that the anchoring of price level expectations in a monetary union—and the resulting reduction of price level risk—is particularly important for households' saving decisions.

The paper is organized as follows. In the remainder of the introduction, we place the paper in the context of the literature and outline its contribution. The next section puts forward new time-series evidence on the impact of uncertainty shocks, contrasting the median EA country with the median floater. Section 3 develops our two-country model of a monetary union, which we estimate and use to run counterfactuals in Section 4. A final section concludes.

Related Literature. The idea that joining a monetary union removes the inflation bias by tying one's hands is already formalized by Giavazzi and Pagano (1988). Corsetti et al. (2013) and Groll and Monacelli (2020) show that this matters beyond the long run, as it affects the transmission of shocks more generally. Our analysis differs in that it provides actual time series evidence and contrasts the effects of common and country-specific uncertainty shocks, both in the data and in the model. Our finding that the effect of uncertainty shocks depends on expectations about the price level is related to recent evidence that the effect of uncertainty shocks depends on the disagreement of consumer expectations (Gambetti et al., 2025). More generally, we build on work that examines the macroeconomic effects of uncertainty, surveyed in Bloom (2014) and Castelnuovo (2023). This literature examines how the effects of uncertainty shocks are shaped by monetary policy (in a closed economy context), and how uncertainty plays out in the open economy. Against this background, our particular contribution is to highlight the importance of monetary policy in the open economy—and, in particular, the exchange rate regime—for the transmission of uncertainty shocks.

As such, our paper is related to three strands of the literature. First, there is work on the relevance of constraints on monetary policy for the transmission of uncertainty shocks (e.g. Johannsen, 2014; Caggiano et al., 2017; Nakata, 2017). Andreasen et al. (2024), Pellegrino et al. (2023), and Fasani and Rossi (2018) show that the conduct of systematic monetary policy greatly matters for the transmission of uncertainty shocks in closed economy models. This strand of the literature also explores the role of endogenous uncertainty (e.g. Plante et al., 2018).

Second, there is work that focuses on the international dimension of uncertainty shocks. Mumtaz and Theodoridis (2017) and Caggiano and Castelnuovo (2023) decompose uncertainty measures into global, regional, and country-specific factors. Albagli et al. (2024) and Georgiadis et al. (2024) study the role of exchange rates in the transmission of global uncertainty shocks. Lakdawala et al. (2021) study the spillovers of U.S. monetary policy uncertainty, while Meinen and Roehe (2017) investigate the effect of uncertainty shocks on EA countries. The transmission of interest-rate uncertainty shocks has also been studied extensively in small open economy models (Fernández-Villaverde et al., 2011; Born and Pfeifer, 2014b; Başkaya et al., 2013; Kollmann, 2016; Johri et al., 2022). In a parallel strand, the literature examines how uncertainty affects firms' export decisions (Handley and Limão, 2017; Carballo et al., 2022; Fernandes and Winters, 2021).

Finally, there is the question of whether and to what extent the exchange rate regime makes a difference in the transmission of shocks, both domestic and external (Bayoumi and Eichengreen, 1994; Broda, 2004; Giovanni and Shambaugh, 2008). The evidence presented in recent papers is inconclusive (Corsetti et al., 2021; Fukui et al., 2025), although there are cases where the exchange rate regime clearly matters, just like in our analysis—not only at the aggregate but also at the household level (Bayer et al., 2024; Born et al., 2013, 2024).

2 Time series evidence

In this section, we provide time series evidence on whether and, if so, how the exchange rate regime matters for the transmission of uncertainty shocks. Our sample starts in 1999Q1 with the launch of the euro and runs until 2022Q4. It comprises 32 countries, 19 of which are members of the EA and 13 countries that let their exchange rates float.

2.1 Data

Our sample includes all EA countries but Croatia (which joined only in 2023): Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Portugal, Slovakia, Slovenia, and Spain. Only 11 of these countries started the EA in 1999, the others joined later. For the latter countries, we only use observations from the period onward when their currency was irrevocably pegged to the euro in the run-up to accession. Our sample also encompasses the following countries that have a floating exchange rate: Australia, Brazil, Canada, Chile, Colombia, India, Israel, Mexico, New Zealand, Russia, South Africa, South Korea, and the United States. For these countries, we restrict observations to periods when they had a floating exchange rate. Appendix A provides details on the data coverage for each country.

We identify uncertainty shocks on the basis of two alternative proxies. First, we rely on the measure of macroeconomic uncertainty originally developed by Jurado et al. (2015) and compiled for individual EA countries by Comunale and Nguyen (2025). Specifically, we use their 12-month-ahead uncertainty proxy. Second, we rely on realized stock market volatility that we measure at monthly frequency by the annualized standard deviation of daily returns for a country's Datastream stock market performance index.[1]

We prefer the first measure on conceptual grounds. It is constructed using the time-varying forecast error variance of a large set of time series, which are, in turn, purged of predictability using a factor model. As a result, there is little risk that

[1] In principle, the implied volatility can be extracted from option prices. Although conceptually attractive, the data required for this approach are not consistently available across EA countries. In practice, implied and realized volatility co-move strongly. Their correlation of 0.88 in U.S. data (Born and Pfeifer, 2021) allowed Bloom (2009) to concatenate realized and implied volatility measures in his seminal study.

the measure is contaminated by first-moment shocks. Moreover, its construction based on the stochastic volatility of empirical forecast errors closely aligns with the notion of uncertainty that we entertain in our DSGE model below. This measure of macroeconomic uncertainty is available for all EA countries, but only from 2003Q3 onward. Moreover, there is no comparable proxy consistently available for all the floaters in our sample. Hence, we rely on realized volatility as an uncertainty proxy when we compare results for EA countries and floaters. When we zoom in on the EA, we instead resort to the preferred measure of macroeconomic uncertainty.

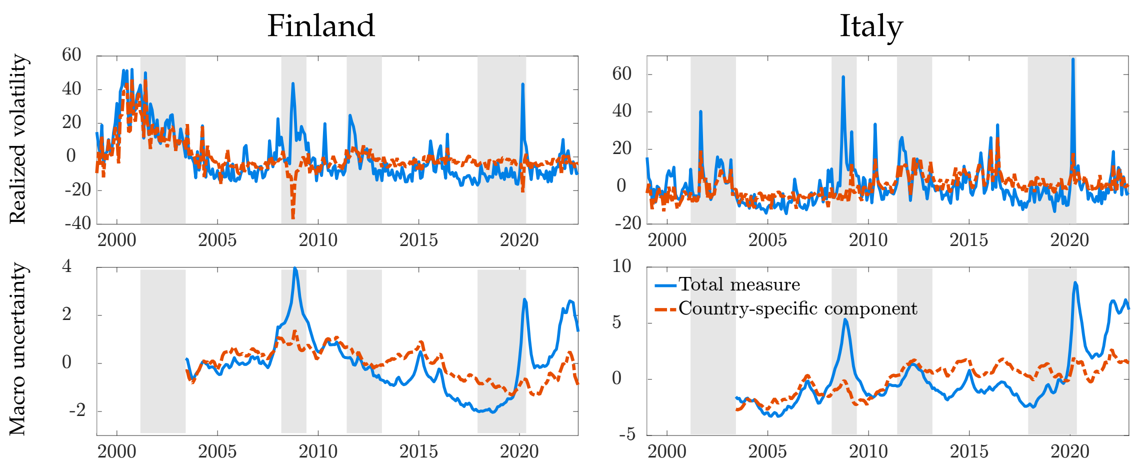
The notion of country-specific shocks is central to our analysis. As a first step in identifying these shocks, we isolate the country-specific component of the uncertainty proxy by employing a principal component approach. In the case of the measure of macroeconomic uncertainty, we obtain the country-specific component by removing the first principal component of the monthly measure compiled for all EA countries.[2] We proceed analogously for realized volatility, although in this case, we are able to compile the first principal component based on an even larger country panel.[3]

As an example, Figure 1 visualizes the uncertainty proxies for Finland (left column) and Italy (right column). The panels in the top row display the realized volatility, contrasting total uncertainty (blue solid line) with the country-specific component (red dashed line) over our sample period. The panels in the bottom row do the same for macro uncertainty. In both countries, total uncertainty captured by either proxy spiked during the 2008/09 financial crisis and at the onset of the COVID-19 pandemic in 2020. In both instances, the country-specific components did not increase, consistent with the notion that these were global events. In Finland, the country-specific component of realized volatility actually decreased in 2008/09, suggesting that the country was relatively less exposed to the financial crisis. However, the Finland-specific component of realized volatility was particularly high after the bursting of the dot-com bubble in the early 2000s, reflecting Nokia's prominent position in the Finnish economy and stock market.

[2]We exclude Cyprus from the sample, since its coefficient for the first principal component is negative such that its common component is inversely related to that of all other countries.

[3]For realized volatility, we lack consistent data coverage for Malta and Slovakia and thus exclude them from this part of the analysis. In addition to the 30 countries on which we estimate this VAR, the panel used for the PCA includes additional countries, some of which operate intermediate exchange rate regimes, see Appendix A for details.

Figure 1: Selected uncertainty proxies



Notes: Monthly total (solid blue line) and country-specific (dashed red line) uncertainty proxies for Finland (left column) and Italy (right column). Top row: realized volatility in percent (demeaned). Bottom row: macroeconomic uncertainty measure. Shaded areas mark EA recessions according to OECD indicators.

Similarly, the increase in both uncertainty proxies in Italy during the debt crisis in the 2010s was almost entirely driven by the country-specific component. Similar patterns emerge for all countries in our EA sample; see Figure B.1.[4]

For the estimation, we aggregate the monthly uncertainty series to quarterly frequency by averaging the observations of a given quarter. In addition to uncertainty proxies, the estimation below uses the log of real GDP per capita, inflation, and the policy rate. For EA countries, we use the Wu and Xia (2016) shadow rate as a proxy for the policy rate since the ECB was constrained by the zero lower bound for much of our sample period. Furthermore, we run specifications that also include the log of real per-capita consumption and investment for EA countries. Appendix A provides further details on the data.

[4]We also compare the macro uncertainty measure with the Economic Policy Uncertainty (EPU) index compiled by Baker et al. (2016) for selected EMU countries. For the four EA countries for which the EPU country index is available, it comoves considerably with the country-specific component of macro uncertainty, see Figure B.4. This suggests that country-specific macro uncertainty reflects country-specific uncertainty that is partly due to economic policy.

2.2 Time series framework

A distinct feature of our analysis is that we estimate the VAR model country by country in order to account for dynamic heterogeneity across countries (Pesaran and Smith, 1995; Canova and Ciccarelli, 2013). To exploit the panel dimension of our data, we then aggregate the results based on the posterior distribution of the estimated country-level impulse responses—for different groupings of countries, EA countries and floaters. For each country, we estimate the following VAR model:

$$Y_t = \mu_0 + \mu_1 D_t + \alpha_0 t + \alpha_1 t D_t + A(L) Y_{t-1} + \nu_t \ , \tag{2.1}$$

where Y_t is a column vector of endogenous variables, $A(L)$ is a lag polynomial of degree $p = 4$. D_t is a dummy variable equal to one starting with 2020:Q1 to account for shifts in the level and trend observed after the onset of the COVID pandemic; μ_0, μ_1 and α_0, α_1 capture constants and time trends, respectively. The reduced form innovations are $\nu_t \overset{iid}{\sim} \mathcal{N}(0, \Sigma)$.

To identify uncertainty shocks, we follow Baker et al. (2016) and others by employing a recursive scheme which orders the uncertainty indicators before the other variables included in the VAR.[5] That is, we assume a lower-triangular matrix B that maps structural shocks ε_t into reduced-form innovations ν_t, $\varepsilon_t = B\nu_t$ such that $\Sigma = BB'$. In the spirit of Basu and Bundick (2017) and Baker et al. (2016), who order the uncertainty proxy first, we put the country-specific component first, followed by total uncertainty, and then all other variables, with the shadow rate ordered last. We identify country-specific and common uncertainty shocks jointly, assuming that both shocks potentially drive total uncertainty, while the country-specific component is driven only by country-specific uncertainty shocks. We also allow uncertainty shocks to affect the other variables contemporaneously but exclude other shocks from affecting uncertainty within the quarter.

We use a shrinking prior of the Independent Normal-Inverse Wishart type (Kadiyala and Karlsson, 1997), with mean and precision derived from a Minnesota-type prior (Litterman, 1986; Doan et al., 1984). We write the vector of stacked

[5]Several alternative strategies for identifying uncertainty shocks have been proposed, based, for instance, on narrative restrictions, sign restrictions, external instruments, or disaster events (e.g. Piffer and Podstawski, 2018; Redl, 2020; Ludvigson et al., 2021; Baker et al., 2024). However, these approaches are more demanding regarding data and thus difficult to implement in our country panel. They also come with caveats (see, for instance, Kilian et al., 2025).

coefficients as $\beta = vec([\mu_0\ \mu_1\ \alpha_0\ \alpha_1\ A_1\ \ldots\ A_p]')$ and assume a normal prior: $\beta \sim N(\underline{\beta}, \underline{V})$. For its mean $\underline{\beta}$, we assume that the stochastic component of the variables follows a univariate AR(1)-model with mean of 0.9, while all other coefficients are 0. The prior precision $\underline{V}$ is a diagonal matrix with the highest precision for the first lag and exponential decay for the remaining lags. The cross terms are weighted according to the relative size of the error terms in each equation. At the same time, a rather diffuse prior is used for the deterministic and exogenous terms. The diagonal element corresponding to the jth variable in equation i is:

$$\underline{V}_{i,jj} = \begin{cases} \frac{\underline{a}_1}{r^2}, & \text{for coefficients on own lag } r \in \{1, \ldots, p\}\,, \\ \frac{\underline{a}_2 s_i^2}{r^2 s_j^2}, & \text{for coefficients on lag } r \in \{1, \ldots, p\} \text{ of variable } j \neq i\,, \\ \underline{a}_3 s_i^2, & \text{for coefficients on exogenous or deterministic variables}\,, \end{cases} \tag{2.2}$$

where s_i^2 is the OLS estimate of the error variance of an AR(p)-model with constant and trend estimated for the ith variable (see Litterman, 1986). We set $\underline{a}_1 = 0.1, \underline{a}_2 = 0.1$ and $\underline{a}_3 = 10^4$. The prior error covariance is assumed to follow $\underline{\Sigma} \sim IW\left(\underline{S}, \underline{\nu}\right)$, where $\underline{\nu} = 10$ are "pseudo-observations", corresponding to ≈ 10 percent of the observations, and $\underline{S}$ is the OLS covariance matrix.

Based on the (Raftery and Lewis, 1992) convergence diagnostic, we use 25,000 posterior draws from a Gibbs sampler, discarding the first 5,000 draws as a burn-in. Given the shortness of our sample, we prefer the 68% highest posterior density intervals (HPDIs) but report 90% HPDIs as well. As a practical matter, we z-score the data (including the trend) to avoid numerical problems arising from under-/overflow in the posterior computations involving sums of squares. We also impose a stability condition on our VAR by drawing from the conditional distribution for β until the modulus of all eigenvalues of the companion form matrix is less than 1.

Given the country-level posterior distributions, we synthesize the evidence by computing results for the 'median economy', following Degasperi et al. (2023): across the groups of EA countries and floaters, for each country, we take a random draw from the posterior distribution and compute the cross-country median of the statistic of interest, such as the impulse response function of a given variable to a given shock at a given horizon. Repeating this procedure 1,000 times yields the posterior distributions for the median EA country and the median floater.

2.3 Results

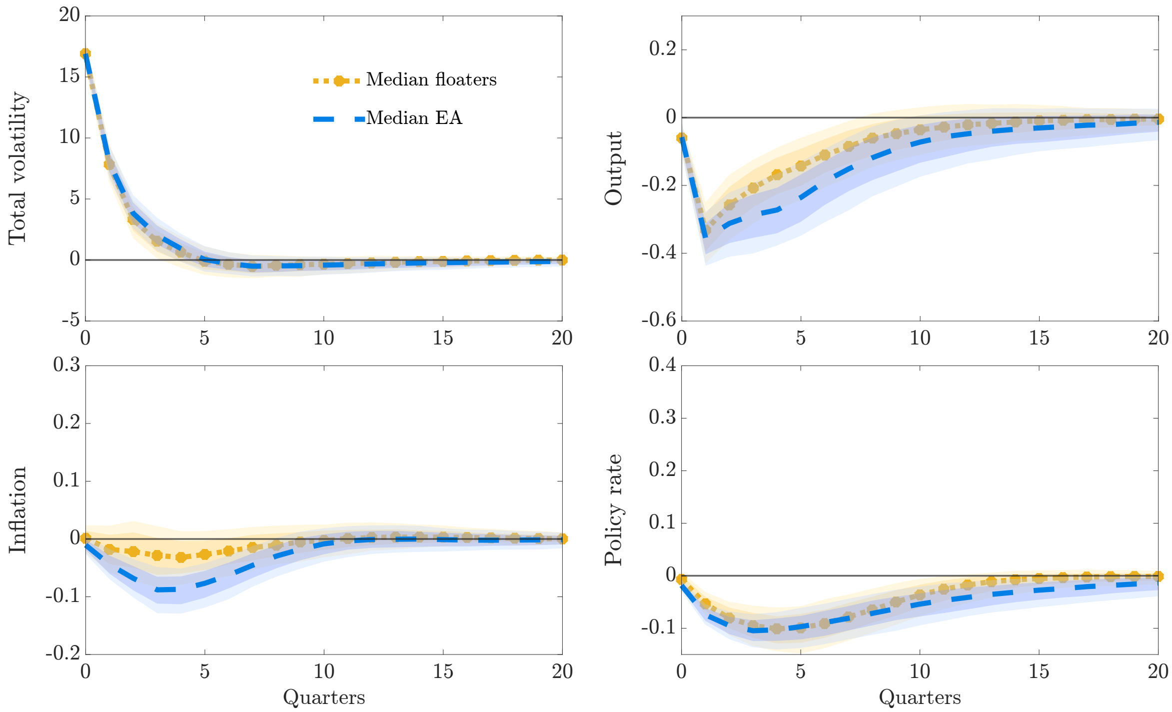
To set the stage, we first show results for a parsimonious VAR model that we estimate on 30 countries—17 members of the EA and 13 countries with flexible exchange rates. We proxy uncertainty with realized volatility and include five time series in the model: the country-specific component of realized volatility, total volatility, output, inflation, and the short-term interest rate. We show the adjustment to the common and the country-specific uncertainty shock.

We start with the common shock because it provides an important sanity check: theory suggests that the adjustment to a common shock should not differ systematically across exchange rate regimes for countries that are otherwise comparable. And indeed, this is precisely what Figure 2 shows as it compares adjustment dynamics to a common uncertainty shock in the median EA economy (dashed blue line) and in the median floater (dotted yellow line with octagonal markers). The shaded areas indicate 68% and 90% HPDIs. Here and in what follows, we normalize the size of the shock so that its impact on total volatility is the same as that of a country-specific one-standard-deviation shock in the median EA economy. The response of total volatility is shown in the top-left panel of the figure, measured as a percentage deviation from the unconditional mean, as in Basu and Bundick (2017). The horizontal axis measures quarters throughout.

The upper-right panel of Figure 2 shows the response of output, which declines sharply and recovers gradually afterwards. This pattern is virtually identical for the median EA economy and the median floater—the exchange rate regime makes no difference. The bottom-left panel shows that inflation declines in response to the shock, consistent with the results of Leduc and Liu (2016). Finally, looking at the bottom-right panel, we observe that the policy rate falls in response to the common uncertainty shock, also in the median EA economy—consistent with the notion that EA-wide monetary policy responds to a shock that is common to all countries in the EA. Overall, the pattern of adjustment is consistent with previous work based on aggregate data for the U.S. (Basu and Bundick, 2017).

Country-specific shocks are a different matter. In this case, the exchange rate regime is bound to have a first-order effect. As we shift focus and look at the adjustment induced by country-specific uncertainty shocks in Figure 3, we indeed observe notable differences in the median EA economy (solid red lines) and the median floater (solid green lines with plus-shaped markers). The figure

Figure 2: Adjustment to common uncertainty shocks in median economy

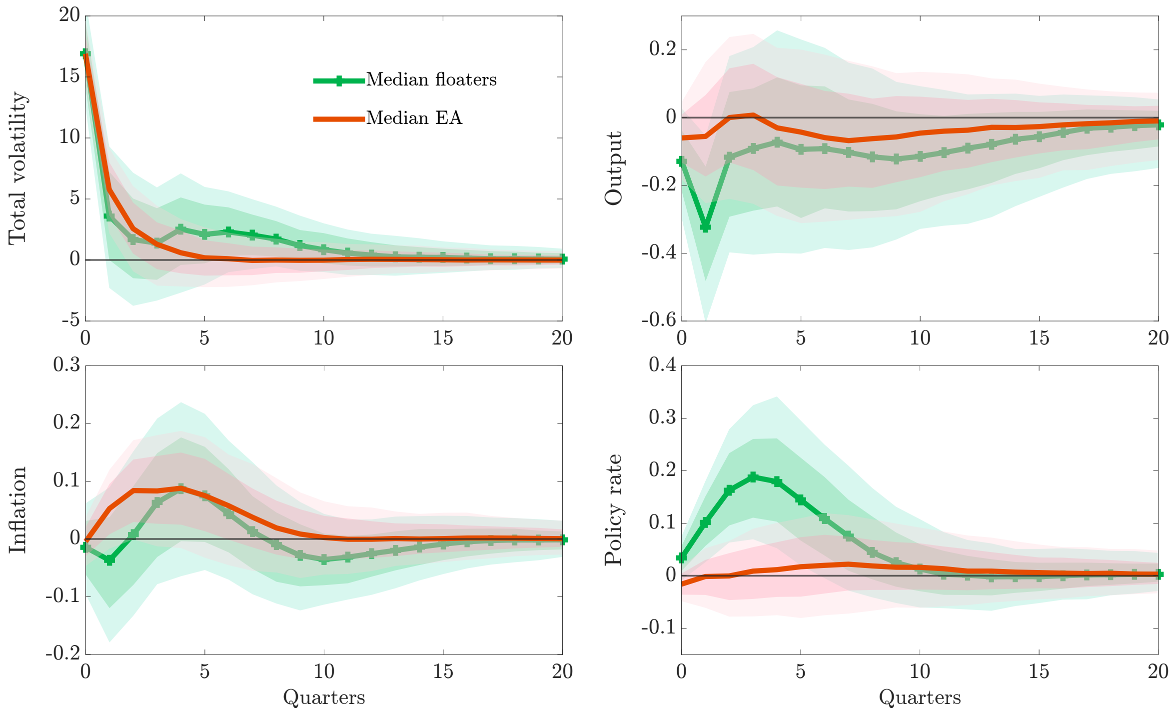


Notes: Impulse responses to common uncertainty shocks in median EA economy (blue dashed line) and median floater economy (yellow dotted line with octagonal markers). Shock size rescaled so that the median impact on total volatility equals that of one-standard-deviation country-specific uncertainty shock in the EA. Shaded areas indicate point-wise 68% (dark) and 90% (light) HPDIs, respectively. Horizontal axis measures time in quarters, vertical axis measures deviations from pre-shock level in percent, except for inflation and policy rate (ppts). Country-specific volatility is included in the VAR but not shown here.

is organized in the same way as Figure 2. The top-left panel shows the response of total volatility, which, upon impact, is normalized to be the same as for the common shocks.

Our main result concerns the response of output, shown in the top-right panel. Here, we observe a sharp, albeit transitory, decline in output for the median floater, comparable to the case of a common shock. Contrary to that, output does not move significantly in the median EA economy. This result is surprising given the received wisdom going back at least to Mundell (1961): after all, a country operating within a monetary union lacks the ability to adjust monetary policy in the face of country-specific shocks. Thus, if anything, one might have expected a

Figure 3: Adjustment to country-specific uncertainty shocks in median economy



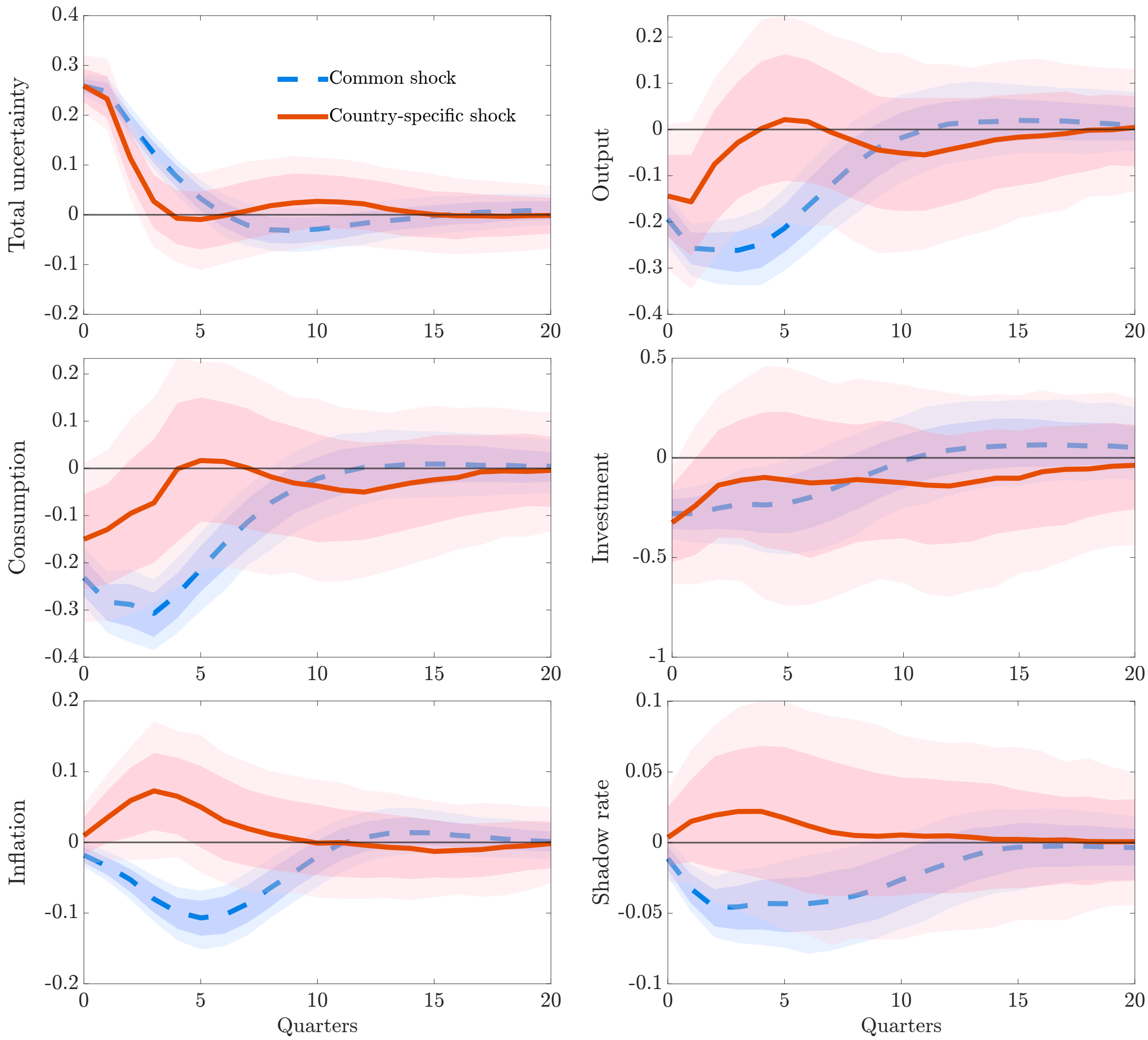
Notes: Impulse responses to country-specific uncertainty shocks in the median EA economy (red solid line) and median floater economy (green solid line with plus-shaped markers). Shock size rescaled so that the median impact on total volatility equals that of one-standard-deviation country-specific uncertainty shock in the EA. Shaded areas indicate point-wise 68% (dark) and 90% (light) HPDIs, respectively. Horizontal axis measures time in quarters, vertical axis measures deviations from pre-shock level in percent, except for inflation and policy rate (ppts). Country-specific volatility is included in the VAR but not shown here.

stronger impact of country-specific uncertainty shocks in the median EA economy. Yet, we find no significant output response.

The response of inflation, shown in the bottom-left panel, is quite similar in both cases. Finally, we note that the response of the policy rate in the median EA country is flat, supporting the notion that we are indeed capturing country-specific shocks to which the common monetary policy in the EA does not respond. Instead, the median floater raises its policy rate, possibly in response to the rise in inflation and suggestive of the monetary autonomy that floaters enjoy.

In the next step, we zoom in on the transmission of country-specific and common uncertainty shocks in the EA. For this purpose, we show results for

Figure 4: The adjustment to uncertainty shocks in median EA economy



Notes: Impulse responses to one-standard-deviation country-specific (solid red line) and equally-scaled common (dashed blue line) uncertainty shock. Shaded areas indicate point-wise 68% (dark) and 90% (light) HPDIs, respectively. Horizontal axis measures time in quarters, vertical axis measures deviations from pre-shock level in percent, except for inflation and the shadow rate (ppts). The country-specific component of uncertainty is included in the VAR, but not shown.

a VAR model that features two additional variables, namely consumption and investment. Importantly, in this case, we rely on the measure of macroeconomic uncertainty (rather than realized volatility), which is consistently available for the EA countries. The results are shown in Figure 4 and will serve as a vital input to identify some of our model parameters in Section 3 below. As before, the solid (red) line represents the adjustment to the country-specific uncertainty shock in the median EA economy. The dashed (blue) line shows the responses to a common shock, as in Figure 2.

Consistent with the results shown so far, we find that in the median EA economy output (top-right panel) declines much more strongly after a common than after a country-specific uncertainty shock. We find a similar pattern for consumption (middle-left panel) but no real difference for investment (middle-right panel). Importantly, the results from this larger VAR with our preferred uncertainty measure still show that the policy rate does not respond significantly to a country-specific shock.[6]

We also assess the (relative) importance of uncertainty shocks for business cycle fluctuations in the median EA economy. To do so, we perform a forecast error variance decomposition (FEVD) based on the extended VAR, computed using the same sampling approach as for the IRFs. We report the results in Table 1. Focusing on the FEVD at a business cycle frequency of 20 quarters, we find that the two uncertainty shocks together account for around 28 percent of the output fluctuations, with common shocks making a somewhat larger contribution. A similar pattern holds for consumption and investment. For the policy rate, country-specific shocks also appear to contribute to fluctuations. Note, however, that their effect on the shadow rate is generally insignificant, as Figure 4 shows.[7] In the appendix, we show the FEVD at the country level; see Figure B.9. As before, we find that the degree of heterogeneity at the country level is moderate. Table B.1 also shows the FEVD performed for the floaters in the parsimonious VAR. We find that the role of uncertainty shocks is roughly the same there, accounting for about 29 percent of output fluctuations.

[6]Figures B.5 and B.6 in the appendix show the impulse responses for each of the 17 EA countries. Similarly, Figures B.7 and B.8 show the corresponding results for the floaters.

[7]In the FEVD, we nevertheless find a non-zero contribution because, while the country-level shocks have partly opposite effects that average out for our 'median economy' impulse responses, this is not the case for the FEVD, which does not consider the sign of responses to shocks.

Table 1: Forecast error variance decomposition for median EA economy

	Country-specific uncertainty shock	Common uncertainty shock
Country-specific component	37.91 (33.51 , 42.86)	9.71 (7.63 , 12.30)
Total uncertainty	13.53 (11.14 , 16.23)	28.76 (25.36 , 32.46)
Output	11.26 (8.87 , 14.14)	16.78 (14.15 , 19.88)
Consumption	10.59 (8.40 , 13.52)	18.25 (15.47 , 21.49)
Investment	10.74 (8.51 , 13.42)	10.36 (8.20 , 12.93)
Inflation	9.87 (7.93 , 12.36)	15.06 (12.09 , 18.07)
Shadow rate	8.57 (6.46 , 11.12)	10.18 (7.83 , 13.00)

Notes: Contribution of country-specific (middle column) and common (right column) uncertainty shock to forecast error variance of each variable at horizon 20, in percent of total forecast error variance of that variable (with 68% HPDIs reported in parentheses). Based on 1,000 posterior draws.

2.4 Robustness

In what follows, we verify that our results for the EA are robust to a number of alternative specifications. We briefly discuss these specifications and, to economize on space, show the results in Appendix B. First, we address the concern that some countries in our sample are large enough to influence the common monetary policy in the EA by excluding the five countries that individually account for at least 5 percent of aggregate EA output (Germany, France, Italy, Spain, and the Netherlands) when computing the median economy impulse responses. We find no meaningful difference from the baseline results, see Figure B.10.

Second, we consider the possibility that the milder effects of country-specific shocks are caused by fiscal stabilization. In theory, countries in monetary unions can resort to fiscal policy to stabilize country-specific shocks (e.g. Galí and Monacelli, 2008). To explore this hypothesis, we include real per capita government consumption as an additional variable in the VAR. The result is clear: we do not find that government spending increases in response to uncertainty shocks. It tends to fall, but the response is generally insignificant, see Figure B.11.

Third, we verify that our results do not depend on the choice of uncertainty measure. To do so, we re-estimate our extended euro area VAR using realized volatility as the uncertainty proxy.[8] In this specification, the difference between common and country-specific shocks is even more pronounced than in our baseline and only common shocks are accommodated by a significant monetary policy response, see Figure B.12.

Finally, we check the robustness of the floater response shown in Figures 2 and 3 by excluding the United States from the sample due to the unique position of the dollar as the dominant currency (Gopinath et al., 2020). As shown in Figures B.13 and B.14, this makes virtually no difference.

3 A model of monetary unions

To rationalize the empirical evidence presented in the previous section, we put forward a model of monetary unions that features two countries: Home and Foreign. Home is small and does not affect the rest of the union as in Galí and Monacelli (2005, 2008). The rest of the union ("Foreign") is a large economy that operates de facto as a closed economy but generates spillovers to Home. As we model uncertainty shocks, we build on the specification of Basu and Bundick (2017), but importantly, allow for country-specific and common uncertainty shocks in Home and assume that both affect the unconditional volatility of supply and demand shocks simultaneously. Our main interest is in how membership in a monetary union shapes the transmission of uncertainty shocks. For this purpose, we run a counterfactual with a flexible exchange rate, which we model explicitly throughout, assuming that it is permanently fixed in the union baseline. Home and Foreign are generally symmetric unless noted otherwise, and we focus the exposition on Home, delegating details and derivations to Appendix C.1.

Formally, we develop our two-country setup by assuming that a fraction $n \in [0, 1]$ of households and firms reside in Home and the rest in Foreign, with the global mass of firms and households normalized to unity. Later, we let $n \to 0$

[8]For this exercise, we use the largest available sample instead of only starting in 2003Q3 when the Jurado et al. (2015) measure becomes available.

as in Corsetti et al. (2021) so that Home is small. We use the subscripts 'H' and 'F' to refer to domestic and foreign variables in Home, and an asterisk to refer to variables in Foreign.

3.1 Households

For the representative household, following Epstein and Zin (1989) and Weil (1989), we assume preferences that allow risk aversion to be independent of the elasticity of intertemporal substitution.[9] Specifically, we write the household's expected lifetime utility recursively as

$$V_t = \max \left[(1-\beta_t) \left(\xi_{H,t} \xi_{C,t} C_t^{\varphi} (1-N_t)^{1-\varphi} \right)^{\frac{1-\sigma}{\theta_V}} + \beta_t \left(\mathbb{E}_t V_{t+1}^{1-\sigma} \right)^{\frac{1}{\theta_V}} \right]^{\frac{\theta_V}{1-\sigma}} . \tag{3.1}$$

Here, C_t is consumption, N_t is hours worked, and $\mathbb{E}_t$ is the conditional expectation operator. The parameter $\sigma \geq 0$ measures risk aversion, while ψ is the intertemporal elasticity of substitution with $\theta_V \equiv \frac{1-\sigma}{1-\psi^{-1}}$. $0 \leq \varphi \leq 1$ denotes the share of the consumption good in the consumption-leisure bundle. $\xi_{H,t}$ and $\xi_{C,t}$ denote Home-specific and common shocks to the discount factor, 'demand shocks' for short, which are specified below. The discount factor β_t decreases in the consumption-to-output ratio to ensure stationarity of the net foreign asset position. The foreign household has identical preferences, except for the absence of country-specific demand shocks. Appendix C.1 provides more details.

Households trade a domestic (currency) bond B_t, which pays the nominal interest rate R_t, and a foreign (currency) bond B_t^*, which pays R_t^*. The capital stock K_t is owned by the households, who decide on investment I_t and capital utilization u_t. They rent capital services $K_t^{serv} = u_t K_{t-1}$ to domestic firms and receive the rental rate r_t^K in return. Adjusting capital is subject to a quadratic adjustment cost parameterized by $\phi_k > 0$. The law of motion for the capital stock is given by

$$K_t = \left(1 - \delta_t(u_t) - \frac{\phi_K}{2} \left(\frac{I_t}{K_{t-1}} - \delta_0 \right)^2 \right) K_{t-1} + I_t \ , \tag{3.2}$$

where δ_0 is the steady state depreciation rate. The depreciation rate δ_t is time-

[9] We follow the specification in Basu and Bundick (2018), which does not lead to an asymptote in the model responses as the intertemporal elasticity of substitution approaches unity.

varying and depends on the rate of capital utilization u_t:

$$\delta_t(u_t) = \delta_0 + \delta_1 (u_t - 1) + \frac{\delta_2}{2} (u_t - 1)^2 , \quad \delta_0, \delta_1, \delta_2 \geq 0. \tag{3.3}$$

The household's period budget constraint is in domestic currency terms:

$$B_t + \mathcal{E}_t B_t^* + P_t C_t + P_t I_t \leq W_t N_t + D_t + r_t^K u_t K_{t-1} + R_{t-1} B_{t-1} + \mathcal{E}_t R_{t-1}^* B_{t-1}^* \, . \tag{3.4}$$

Here, P_t is the price of the final good defined below, $\mathcal{E}_t$ is the nominal exchange rate, defined as the price of foreign currency in terms of domestic currency (equal to unity in the monetary union), D_t are firm profits transferred to the households, and W_t is the wage.

The household maximizes (3.1), subject to the budget constraint (3.4), the law of motion for capital (3.2), and utilization costs (3.3). The first-order conditions for bonds can be combined into the familiar uncovered interest parity condition. The household in Foreign faces a nominal per-period budget constraint analogous to (3.4), but since Foreign acts as a closed economy from its point of view, it does not trade bonds of the Home country B_t.

3.2 Firms

Monopolistically competitive intermediate goods firms produce differentiated intermediate goods, traded across borders at prices that are sticky in the currency of the producer. A competitive final goods firm then uses a Dixit-Stiglitz technology to bundle these intermediate goods into a domestic composite $Y_{H,t}$ and an imported composite $Y_{F,t}$. These, in turn, are combined to produce final goods $\mathcal{F}_t$, which are used for consumption and investment:

$$\mathcal{F}_t = \left[(1-(1-n)v)^{\frac{1}{\eta}} \left(Y_{H,t}\right)^{\frac{\eta-1}{\eta}} + ((1-n)v)^{\frac{1}{\eta}} \left(Y_{F,t}\right)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} , \tag{3.5}$$

where $\eta > 0$ is the trade price elasticity and $0 \leq v \leq 1$ measures the import content of final goods. To the extent that $v < 1$, there is 'home bias.' We refer to the price of final goods as the 'consumer price index' (CPI). It is given by

$$P_t = \left[(1-(1-n)v) \left(P_{H,t}\right)^{1-\eta} + ((1-n)v) \left(P_{F,t}\right)^{1-\eta} \right]^{\frac{1}{1-\eta}} . \tag{3.6}$$

Here, $P_{H,t}$ is the domestic producer price index (PPI), and $P_{F,t}$ is the price of imports which, under the law of one price, is given by $P^*_{F,t}\mathcal{E}_t$, where $P^*_{F,t}$ is the foreign currency price of imports.

We define the real exchange rate $\mathcal{Q}_t$ as the price of foreign goods in terms of the domestic final good (so that an increase amounts to a depreciation): $\mathcal{Q}_t \equiv \mathcal{E}_t P^*_t / P_t$. Assuming that Home is small ($n \to 0$), expenditure minimization of final goods firms in Home and Foreign implies that the demand for a generic intermediate good $i \in [0, n]$ in Home, which sells at price $P_t(i)$, is given by

$$Y^d_t(i) = \left(\frac{P_t(i)}{P_{H,t}}\right)^{-\epsilon} \left(\frac{P_{H,t}}{P_t}\right)^{-\eta} \left[(1-v)\mathcal{F}_t + v\mathcal{Q}^{\eta}_t \mathcal{F}^*_t\right] \ , \tag{3.7}$$

where $\epsilon > 1$ is the elasticity of substitution between intermediate goods and $\mathcal{F}^*_t$ denotes the foreign final goods production.

To supply a differentiated intermediate good $Y^s_t(i)$, a generic monopolistically competitive firm i produces according to:

$$Y^s_t(i) = \left(K^{serv}_t(i)\right)^{\alpha} \left(A^H_t A^C_t N_t(i)\right)^{1-\alpha} - \Phi \ , \tag{3.8}$$

where $K^{serv}_t(i)$ are the capital services and $N_t(i)$ is the labor input. A^H_t and A^C_t denote Home-specific and common exogenous labor-augmenting technology, respectively. Their law of motion is specified below, and we will refer to technology innovations as 'supply shocks.' $0 \le \alpha \le 1$ parameterizes the capital share. The fixed costs of production Φ ensure that profits are zero in the steady state.

Intermediate goods firms are owned by domestic households and maximize the expected sum of discounted real profits $\frac{D_t(i)}{P_t}$,

$$\mathbb{E}_t \sum_{s=0}^{\infty} M_{t,t+s} \frac{D_{t+s}(i)}{P_{t+s}} \ , \tag{3.9}$$

subject to (3.7) and (3.8) by choosing $N_t(i), K^{serv}_t(i)$, and $P_t(i)$. $M_{t,t+s}$ denotes the real stochastic discount factor (see Appendix C.2). Real profits are given by

$$\begin{aligned} \frac{D_t(i)}{P_t} &= \frac{P_t(i)}{P_t} Y_t(i) - \frac{W_t}{P_t} N_t(i) - \frac{r^K_t}{P_t} K^{serv}_t(i) \\ &\quad - \frac{\phi_p}{2}\left(\frac{P_t(i)}{P_{t-1}(i)\Pi^{\gamma}_{H,t-1}\Pi^{1-\gamma}_H} - 1\right)^2 \frac{P_{H,t}}{P_t} Y^H_t \ , \end{aligned} \tag{3.10}$$

where $\phi_p > 0$ and $\Pi_{H,t}$ is PPI inflation. The last term is the Rotemberg (1982) price adjustment cost as a share of the domestic good Y_t^H, which depends on the inflation in firm i's price $\Pi_t(i) = \frac{P_t(i)}{P_{t-1}(i)}$ relative to a price indexing term that is a geometric weighted average of past and steady-state PPI inflation (see also, Bilbiie et al., 2014). The indexation parameter $0 \leq \gamma \leq 1$ measures the weight on past inflation. Profits D_t are rebated to the local households in a lump-sum fashion.

Foreign firms operate in an isomorphic environment, except for the fact that the export composite Y_t^H has infinitesimal weight in the composition of foreign final goods. The production function of Foreign firms is analogous to (3.8), but does not feature a country-specific component.

3.3 Monetary Policy

For the baseline model, we assume that Home operates in a monetary union with Foreign. Since it has zero weight ($n \to 0$), its economic conditions do not affect the 'union-wide' policy. Monetary policy sets the nominal interest rate R_t^* by following an interest rate rule, responding only to 'Foreign' inflation and output growth:

$$\frac{R_t^*}{R^*} = \left(\frac{\Pi_t^*}{\Pi^*}\right)^{\phi_{R\pi}} \left(\frac{Y_t^*}{Y_{t-1}^*}\right)^{\phi_{Ry}} + \sigma_M \varepsilon_t^M \, . \tag{3.11}$$

Here, R^* is the steady-state nominal interest rate, Π^* is the inflation target set by the central bank, and the parameters $\phi_{R\pi} > 1$ and $\phi_{Ry} \geq 0$ capture the responsiveness of the nominal interest rate to deviations of inflation from its steady-state value and to output growth, respectively. ε_t^M is a monetary policy shock specified below. If a monetary union is in place, the nominal exchange rate is fixed at unity, and interest rates are perfectly aligned:

$$\mathcal{E}_t = 1 \text{ and } R_t = R_t^*. \tag{3.12}$$

As a counterfactual, we consider the case of monetary autonomy, assuming an independent central bank sets the interest rate for Home, whose policy rule mirrors that of Foreign:

$$\frac{R_t}{R} = \left(\frac{\Pi_{H,t}}{\Pi_H}\right)^{\phi_{R\pi}} \left(\frac{Y_t}{Y_{t-1}}\right)^{\phi_{Ry}} , \tag{3.13}$$

with $\Pi_H = \Pi^*$, so that monetary policy has the same inflation target in Home and Foreign. The nominal exchange rate $\mathcal{E}_t$ then adjusts to clear the bond market.

3.4 Exogenous processes

The Home-specific and common demand shock and labor-augmenting technology processes are assumed to be AR(1) with stochastic volatility:

$$\xi_t^i = (1 - \rho_{pref}) + \rho_{pref}\xi_{t-1}^i + \sigma_t^i \varepsilon_t^{\xi_i} \tag{3.14}$$

$$A_t^i = (1 - \rho_A) + \rho_A A_{t-1}^i - \frac{\sigma_t^i}{\sigma_A}\varepsilon_t^{A_i} \tag{3.15}$$

$$\sigma_t^i = (1 - \rho_\sigma)\bar{\sigma} + \rho_\sigma \sigma_{t-1}^i + \sigma_\sigma \varepsilon_t^{\sigma_i}, \tag{3.16}$$

where $i \in \{H, C\}$. The $\varepsilon_t^j, j \in \{\xi_H, \xi_C, A_H, A_C, \sigma_H, \sigma_C\}$ shocks and the monetary policy shock ε_t^M in Equation (3.11) are standard normally distributed i.i.d. shock processes.[10] We refer to $\varepsilon_t^{\sigma_C}$ and $\varepsilon_t^{\sigma_H}$ as common and country-specific uncertainty shocks, respectively. These shocks simultaneously change the standard deviation of supply and demand shocks without affecting their mean. The relative standard deviation of supply shocks compared to demand shocks is a fixed multiple and determined by the scaling parameter σ_A.

3.5 Equilibrium

There is a symmetric equilibrium in which all intermediate good firms in each country charge the same price and use the same amount of inputs. In equilibrium, all goods and factor markets clear. Home bonds are in zero net supply in equilibrium. Home households can hold nonzero amounts of the Foreign bond, but since Home is infinitely small, it does not allow Foreign to have a non-zero net position. The resource constraint for Home implies that domestic output is used for consumption, investment, to pay for price adjustment costs, and for exports:

$$Y_t = (1 - \upsilon)\left(\frac{\mathcal{Q}_t}{\mathcal{S}_t}\right)^{-\eta}(C_t + I_t) + \frac{\phi_p}{2}\left(\frac{\Pi_{H,t}}{\Pi_H} - 1\right)^2 Y_t + \upsilon \mathcal{S}_t^{\eta} Y_t^*, \tag{3.17}$$

where $\mathcal{S}_t = P_{F,t}/P_{H,t}$ denotes the terms of trade.

[10]We use a level specification in both the level and volatility equations rather than a log-log specification to avoid the problem of non-existent moments implied by the latter (Andreasen, 2010).

Since Foreign behaves like a closed economy from its own point of view, the resource constraint there implies that all output is used for consumption, investment, and price adjustment:

$$Y_t^* = C_t^* + I_t^* + \frac{\phi_p}{2}\left(\frac{\Pi_t^*}{\Pi^*} - 1\right)^2 Y_t^* \,. \tag{3.18}$$

4 The transmission of uncertainty shocks

We now bring the model to the data and offer a structural account of the time series evidence established in Section 2. We focus on the median EA economy and estimate model parameters based on an indirect inference approach. We do this by estimating an auxiliary VAR on simulated data from the DSGE model. We pin down the model parameters by matching the auxiliary VAR responses to the common uncertainty shock with the empirical VAR responses shown in Figure 4. We then validate that the model's predictions following a country-specific shock are consistent with the evidence along this dimension as well. Finally, we examine the transmission of country-specific uncertainty shocks based on counterfactuals, assuming that Home enjoys monetary autonomy and allows its exchange rate to float freely.

4.1 Estimation

Prior to estimation, we fix a first set of parameters that are pinned down by long-run observations or poorly identified. In this respect, we mostly assume values in line with Basu and Bundick (2017, 2018), but make some adjustments where necessary to account for the open-economy dimension and the specificities of the EA. Table 2 shows these parameters. The capital share α is set to $1/3$, the discount factor β to 0.99, and the quarterly steady-state depreciation rate δ_0 to 0.025; δ_1 is set such that steady-state capital utilization is 1. We set the risk aversion parameter $\sigma = 100$ and the intertemporal elasticity of substitution $\psi = 0.5$, following Basu and Bundick (2018). The leisure share in the Cobb-Douglas utility bundle φ is set to imply a Frisch elasticity of 2.[11] For the intermediate goods elasticity of substitution ϵ, we assume a value of 11, corresponding to a steady-state markup of 10%. For the

[11] See Appendix A.2.1 of Born and Pfeifer (2021) for details.

Table 2: Parameters fixed prior to estimation

Parameter	Description	Value	Target / Source
α	capital share parameter	0.3333	standard value
β	discount factor	0.9900	4% interest rate per year
δ_0	depreciation rate steady state	0.0250	Basu and Bundick (2017)
δ_1	linear utilization cost	0.0351	steady-state utiliz. of 1
σ	risk aversion	100.00	Basu and Bundick (2018)
ψ	intertemp. elast. of subst.	0.5000	Basu and Bundick (2018)
φ	leisure share	0.2658	Frisch elasticity of 2
ϵ	intermed. goods subst. elast.	11.000	steady-state markup 10%
η	trade price elasticity	0.9000	Heathcote and Perri (2002)
Π_H/Π^*	steady state inflation	1.0000	no trend inflation
v	import share	0.4650	Gunnella et al. (2021)
ϕ_B	slope endog. discount factor	0.0010	small positive number
Φ	fixed costs	0.1111	steady-state profits of 0

trade price elasticity η, we use the point estimate of 0.9 reported by Heathcote and Perri (2002), which is also in line with the estimates of Christoffel et al. (2008). We assume the absence of trend inflation: $\Pi_H = \Pi^* = 1$. For the openness parameter v, we chose a value of 0.465, in line with the estimate of average EA openness by Gunnella et al. (2021). The slope of the endogenous discount factor ϕ_B is set to a small positive number, sufficient to ensure stationarity (Schmitt-Grohé and Uribe, 2003). $\Phi = 0.1111$ ensures zero profits in steady state. We set the persistence of *level* supply and demand shocks, ρ_A and ρ_{pref}, to 0.9.

There are eleven additional parameters that we estimate using a combination of impulse response function and moment matching. Since the empirical vector autoregression (VAR) is linear, but the model needs to be approximated at third order to generate effects of time-varying uncertainty, we rely on an indirect inference approach. We match the impulse responses to a common uncertainty shock from an auxiliary VAR estimated on simulated model data to their empirical VAR counterparts. Since the model's decision rules at higher order do not feature certainty equivalence, we pin down the ergodic distribution by matching the model-implied unconditional volatility of (log) output, consumption, and investment to the values observed in the data.

For our indirect inference approach, we solve the model for a given parameter vector θ using third-order perturbation techniques in Dynare 6.1 while pruning the decision rules (Adjemian et al., 2024). We then simulate 11,000 periods, discarding the first 1,000. Next, we use the VAR setup from Section 2 as the auxiliary model, that is, we estimate the same seven-variable VAR on the simulated data as we do on the actual data. The model equivalents for the country-specific and total components of macroeconomic uncertainty are σ_t^H and $\sigma_t^T = \sigma_t^H + \sigma_t^C$, respectively. To economize on computational time and because we use 100 times as many observations as the actual data, we estimate the auxiliary VAR using (asymptotic) frequentist methods.

The VAR is well defined because there are as many structural shocks in the model as there are variables in the VAR. The seven structural shocks are: two (country-specific and common) shocks to the level of demand, two to the level of supply, two uncertainty shocks, as well as a common monetary policy shock. To identify country-specific and common uncertainty shocks, we order the country-specific and total uncertainty measures σ_t^H and σ_t^T first in the auxiliary VAR. This ordering is consistent with the one in the empirical VAR. Since the responses to the uncertainty shocks are not sufficient for pinning down the ergodic distribution of the model variables, we also match the cyclical second moments of the logarithms of output, consumption, and investment in the model to the data. In the empirical data, we remove a log-linear trend for each country and compute the standard deviation. We then use the cross-country median of these statistics as the empirical target moments in Equation (4.1).

Formally, the point estimate $\hat{\theta}$ solves the following optimization problem:

$$\begin{aligned}\hat{\theta} \; &= \underset{\theta}{\operatorname{argmin}} \left(\Psi^{Aux}(\theta) - \Psi^{VAR}\right)' W \left(\Psi^{Aux}(\theta) - \Psi^{VAR}\right) \\ &\quad + \left(\chi^{Model}(\theta) - \chi^{data}\right)' V^{-1} \left(\chi^{Model}(\theta) - \chi^{data}\right) \quad .\end{aligned} \tag{4.1}$$

Here, Ψ^{VAR} is a column vector that stacks the impulse responses to a common uncertainty shock in the EA over the first 20 periods, as shown in Figure 4 above. As before, we normalize the size of the shock to one standard deviation.[12]

[12]As described in Section 2.3, we rescale the responses to a common uncertainty shock so that the impact on total uncertainty is the same as for a one-standard-deviation country-specific uncertainty shock. Since we impose in the model that common and country-specific uncertainty shocks impact

Table 3: Estimated model parameters

Parameter	Description	Point Estimate	Standard Error
ρ_σ	volatility shock autocorr.	0.9559	0.0090
$\bar{\sigma}$	uncond. level shock volatility	0.0158	0.0038
σ_σ	shock volatility	0.0042	0.0013
σ_A	scaling supply shock volatility	1.4134	0.5527
σ_M	monetary policy shock volatility	0.0008	0.0010
ϕ_K	capital adjustment costs	10.132	12.179
δ_2	quadratic util. costs	0.0000	0.0000
ϕ_p	price adjustment costs	367.49	404.61
γ	inflation indexation	1.0000	0.0000
$\phi_{R\pi}$	inflation feedback	1.0486	0.0445
ϕ_{Ry}	output feedback	0.0000	0.0000

Notes: Parameter estimates based on indirect inference. Third column shows point estimate. Fourth column shows bootstrapped standard errors.

Ψ^{Aux} contains the corresponding impulse responses that we obtain when we estimate the auxiliary VAR model on simulated data. We include the responses of output, consumption, investment, inflation, and the interest rate in Ψ^{VAR}.[13] W is a diagonal weighting matrix with the squared inverse of the width of the 68% HPDIs of the VAR responses on the diagonal. We put additional emphasis on matching the impact response by multiplying the weights of the first four quarters by 4^2. χ^{data} stacks the empirical standard deviations of the logarithms of output, consumption, and investment while $\chi^{Model}(\theta)$ contains the corresponding moments of the simulated data. Following Basu and Bundick (2017), V is a diagonal matrix containing 100 times the empirical unconditional variances of (log) output, consumption, and investment, obtained in the same way as the standard deviations. We bootstrap the standard errors by repeating the matching process for random posterior draws of the empirical VAR impulse responses.

Table 3 reports the results. Most parameters are precisely estimated, with the exception of the price and capital adjustment costs and the relative size of supply shocks. The volatility process exhibits a high degree of persistence. Its

our measure of total uncertainty σ_t^T equally, we use this rescaled version of the responses to a common shock in the matching process.

[13]We do not attempt to match the responses of σ_t^H and σ_t^T because the scaling of the measure of macro uncertainty is not easily comparable to the volatility measures in the model.

Table 4: Model fit: targeted standard deviations

Variable	Data	Model
Output	0.0394	0.0393
Consumption	0.0391	0.0511
Investment	0.1070	0.0748

Notes: Model fit of targeted standard deviations. Second column shows the cross-country median of the standard deviation of linearly detrended logged variables. Third column shows the standard deviation of the logged model variables at the point estimate.

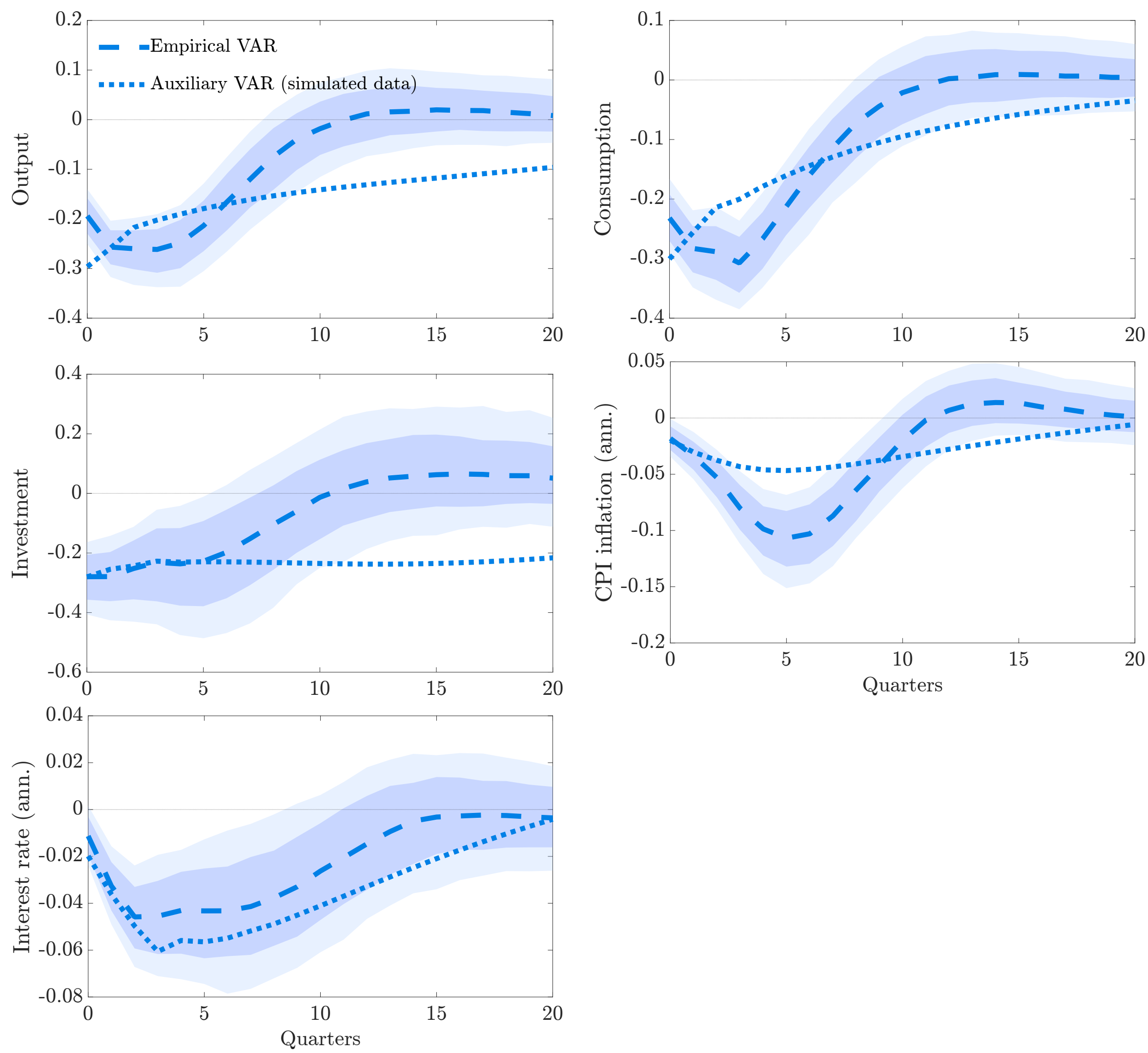
steady-state level of 0.0158 combined with the scaling parameter σ_A implies an unconditional standard deviation of supply (demand) shocks of about 1.1 (1.6) percent. The estimated size of the volatility shock of 0.0042 implies that a one-standard-deviation shock increases the volatility of supply and demand shocks by about 26 percent. The volatility of monetary policy shocks appears moderate at 0.08 percentage points. There is no curvature in the capital utilization costs ($\delta_2 = 0$), while investment adjustment costs are moderately high with $\phi_k = 10.132$. The parameter $\phi_p = 367.49$, which captures price adjustment costs, corresponds to a slope of the linearized New Keynesian Phillips Curve consistent with an average price duration between six and seven quarters, while $\gamma = 1$ implies full indexation to past inflation. We find that the central bank does not react strongly to inflation and not at all to output growth.

Table 4 shows the targeted second moments. The estimated model almost perfectly matches the unconditional standard deviation of output. Consumption volatility is slightly higher in the model than in the data, while the investment volatility is slightly overpredicted. Overall, the model delivers a good fit for the ergodic distribution.

4.2 Model performance

To assess the model performance, we first compare the empirical impulse responses with those of the auxiliary VAR estimated on simulated data. In this way, we verify that our model is able to reproduce the key features of the data—once they are examined through the lens of the auxiliary VAR. We then move on to several results based on the non-linear model solution.

Figure 5: Adjustment in EA countries—empirical vs. auxiliary VAR IRFs



Notes: VAR impulse responses to common uncertainty shock (normalized to one standard deviation) in a monetary union. Dashed line, reproduced from Figure 4: IRFs from empirical VAR estimated on actual time series; dotted line: IRFs from auxiliary VAR based on simulated data (point estimate). Horizontal axis: quarters, vertical axis: deviations from pre-shock level in percent, except for inflation and interest rate (ppts). Shaded area: pointwise 68%/90% (dark/light) HPDIs.

Figure 5 compares the responses from the two VARs. The dotted (blue) lines show those obtained by estimating the auxiliary VAR on simulated data at the point estimate. The dashed (blue) lines correspond to their empirical VAR counterparts already shown in Figure 4 above. As before, the shaded areas indicate pointwise 68% (dark) and 90% (light) HPDIs. We find that, even as the model is over-identified, its predictions, viewed through the lens of the auxiliary VAR, match the empirical responses quite well. As in the data, a common uncertainty shock has a sizable contractionary effect on the economy. Output, consumption, investment, and prices all fall. The model also matches the hump in the response of the interest rate and inflation, although the latter is less pronounced than in the data. Somewhat counterfactually, the auxiliary VAR predicts a very persistent decline in investment, while in the data, it becomes insignificant after about two years.[14]

We also compare the impulse responses of the non-linear model with those of the auxiliary VAR. They are very similar, see Figure C.1. This shows that when our nonlinear model is the data-generating process, the recursively identified VAR is able to uncover the true effect of uncertainty shocks rather well.

Moving on to the non-linear model approximated at third order, Figure 6 compares the predicted responses of a common (blue dashed line) and country-specific (red solid line) uncertainty shock in a monetary union.[15] The predictions are again quite consistent with the empirical VAR evidence uncovered in Figure 4: The effect of a country-specific shock tends to be markedly weaker than that of a similarly sized common shock. This is notable because the empirical responses to a country-specific shock were not targeted during the model estimation.[16]

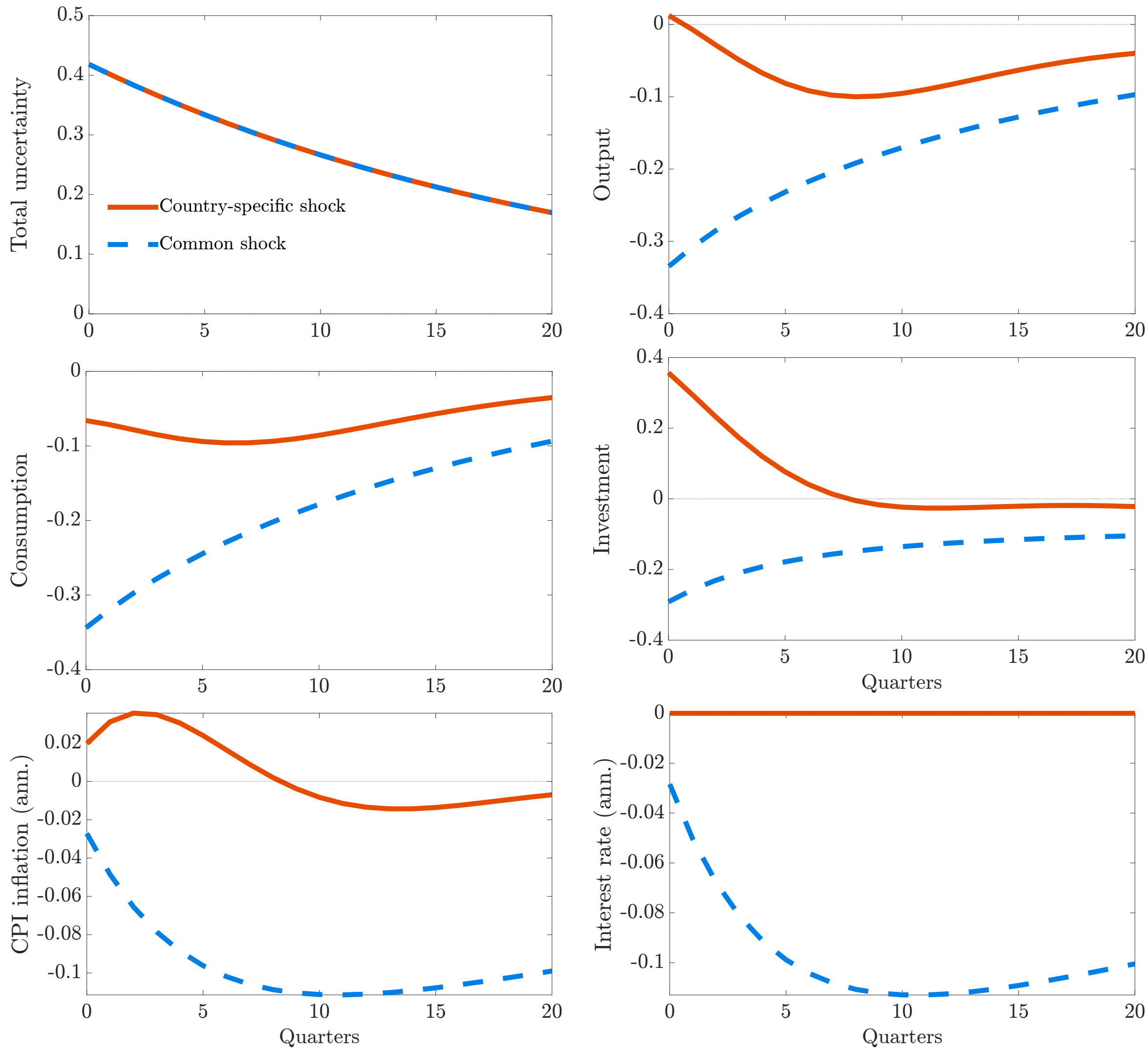
Turning to the bottom-right panel of Figure 6, we observe that the response of the interest rate to a country-specific shock is flat. This is because Home is a small country in the monetary union and has zero weight in the union-wide interest rate rule. In contrast, monetary policy lowers interest rates in response to a common uncertainty shock to dampen its recessionary impact. Still, as the responses in Figure 6 show, the monetary accommodation in response to the common shock is insufficient to insulate the economy from the shock: its recessionary impact is actually larger than that of a country-specific shock.

[14]The investment response from the non-linear model shown in Figure 6 matches the shape found in the data quite well.

[15]All impulse responses from the non-linear model are computed at the stochastic steady state.

[16]We also show a detailed comparison between the auxiliary-VAR responses and the empirical responses to a country-specific shock in Figure C.2 in the appendix.

Figure 6: Adjustment in monetary union—common vs. country-specific shock

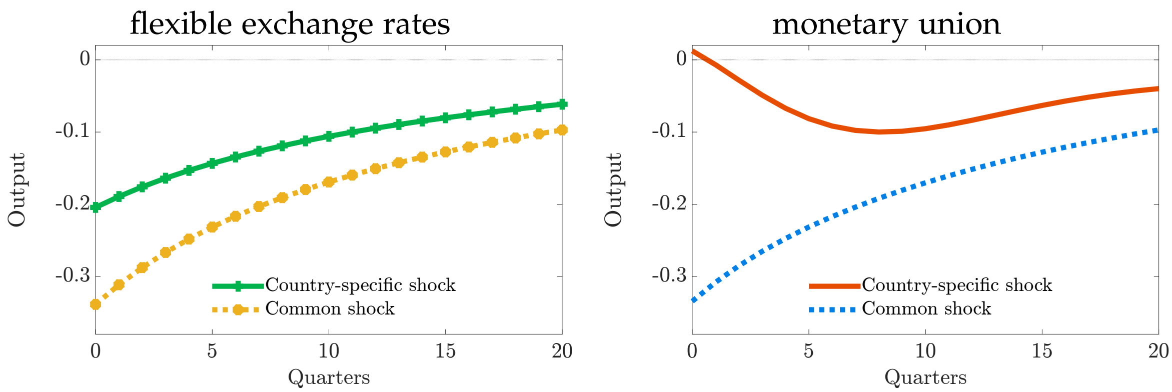


Notes: Model impulse responses to one-standard-deviation common (blue dashed line) and country-specific (red solid line) uncertainty shock in monetary union. Horizontal axis: quarters, vertical axis: deviations from stochastic steady state in percent, except for inflation and interest rate (ppts). IRFs are evaluated at the stochastic steady state and utilize the non-linear model.

4.3 Union vs. flexible exchange rates: the role of the anchor

Finally, we are able to shed light on our main finding: that the effects of country-specific uncertainty shocks are weaker for countries within a monetary union, despite the fact that countries outside the union enjoy monetary autonomy. To do

Figure 7: Output response to uncertainty shocks under ...



Notes: Responses to one-standard-deviation country-specific uncertainty shock (left panel: green solid line with plus-shaped markers, right panel: red solid line) and common uncertainty shock (left panel: yellow dotted line with octagonal markers, right panel: blue dotted line). Horizontal axis: quarters, vertical axis: responses in percentage deviations from the stochastic steady state. Left panel assumes flexible exchange rates and that monetary policy in Home follows rule (3.13).

so, we compare the adjustment dynamics in the union (baseline) with a counterfactual scenario in which Home operates outside the union, allowing the exchange rate to adjust freely in response to shocks and setting the interest rate according to the rule (3.13). This rule differs from the union-wide monetary policy rule only in that, with flexible exchange rates, monetary policy responds to domestic rather than union-wide developments (which are dominated by Foreign).

We focus on the output response, shown in Figure 7. The left panel shows the flexible exchange rate scenario, contrasting the effect of a common uncertainty shock (dotted yellow line with octagonal markers) and a country-specific shock (solid green line with plus-shaped markers). While both shocks are normalized to have the same effect on the volatility of supply and demand shocks in Home (i.e., the volatilities of $A_t^H A_t^C$ and $\zeta_t^H \zeta_t^C$), the maximum effect of the common shock is more than fifty percent larger. Intuitively, when the shock hits both Home and Foreign, there is a global contraction with adverse spillovers from Foreign (large) to Home (small).[17] Such spillovers are absent when the shock is Home-specific.

The adjustment under flexible exchange rates serves as a natural benchmark for understanding the adjustment dynamics when Home operates in a monetary

[17]Figure C.3 shows a Foreign-only shock that also reduces economic activity in Home.

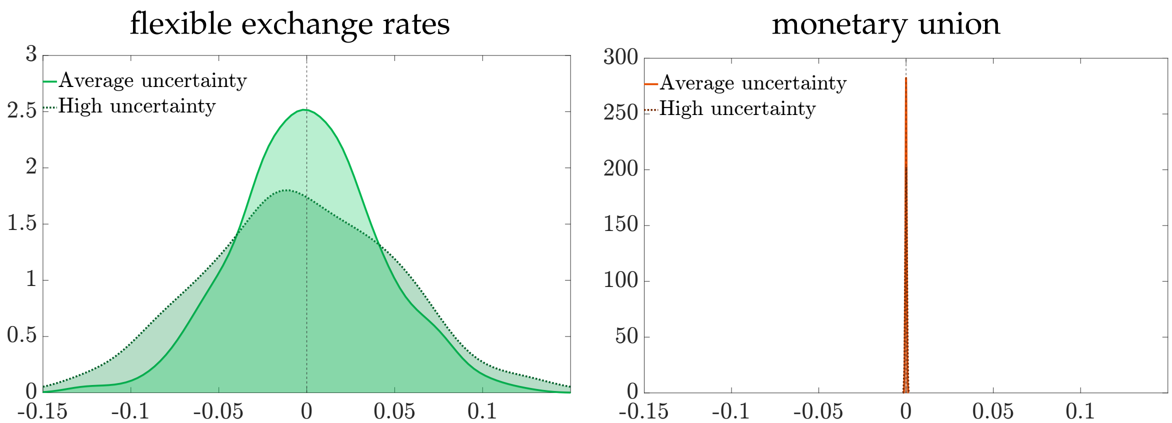
union. We consider this case in the right panel of Figure 7, reproducing the output responses already shown in Figure 6 above. The response to a common shock is the same as in the left panel. This result is consistent with the evidence for the median EA economy and the median floater, shown in Figure 2 and, as discussed above, is to be expected: When Home and Foreign are symmetric and exposed to the same shock, the exchange rate regime does not affect the outcome.

However, the exchange rate regime matters a great deal for how a country-specific shock plays out. When Home operates in a monetary union (right panel), the output response is considerably more muted than in the case of flexible exchange rates (left panel): While output falls immediately by 0.2 percent in the left panel and then slowly returns to its pre-shock level, the response in the right panel is more gradual and much more muted—again in line with the evidence. In other words, the model predicts not only that the effects of country-specific shocks are weaker in a monetary union than those of a common shock; it also predicts that they are much weaker than under flexible exchange rates, both predictions being consistent with the evidence established in Section 2 above. This result is remarkable because, in a monetary union, union-wide monetary policy cannot accommodate Home shocks.[18] After all, by joining the union, Home has given up its monetary autonomy in exchange for anchoring its price level to that of the union. This notion was formalized in earlier work by Giavazzi and Pagano (1988) and Alesina and Barro (2002) with a focus on how the anchor removes the inflation bias that raises average inflation independently of the business cycle.

However, it turns out that the nominal anchor also plays a crucial role in business cycle dynamics, in particular for the transmission of uncertainty shocks. To illustrate this, we compute the distribution of the price level 100 periods after a one-time shock to the *level* of demand, but for different initial uncertainty shocks. Figure 8 shows the results, contrasting the distribution with average uncertainty, that is, uncertainty at the unconditional mean when the level shock hits (light-shaded area), with the case where a simultaneous one-standard deviation uncertainty shock widens the shock distribution (dark-shaded area). The left

[18] According to the VAR evidence, monetary policy under a float raises interest rates in response to country-specific shocks. However, this alone does not explain why the contraction is larger there under a float. As we show in Figure C.4, monetary policy cuts interest rates in response to a country-specific uncertainty shock in our estimated model when Home operates under flexible exchange rates. And yet, economic activity contracts more than in the union case.

Figure 8: Simulated distributions of the long-run price level under ...



Notes: Kernel densities of long-run Home consumer price level after random one-time level demand shock drawn from distribution with average uncertainty (solid line) and widened distribution after one-standard deviation uncertainty shock (dotted line) under floating exchange rate (left panel) and in monetary union (right panel). We draw 1000 realizations of the level shock from its distribution and cumulate the inflation response to obtain the price level 100 periods after the shock.

panel illustrates how, assuming flexible exchange rates, increased uncertainty translates into greater price level risk, as the long-run distribution widens with the distribution of shocks. In contrast, the monetary union eliminates price level risk, as shown in the right panel. Since the domestic price level is anchored to the union-wide price level through purchasing power parity, it no longer exhibits a unit root. Consequently, the long-run distribution of the price level remains unaffected by the shock.[19]

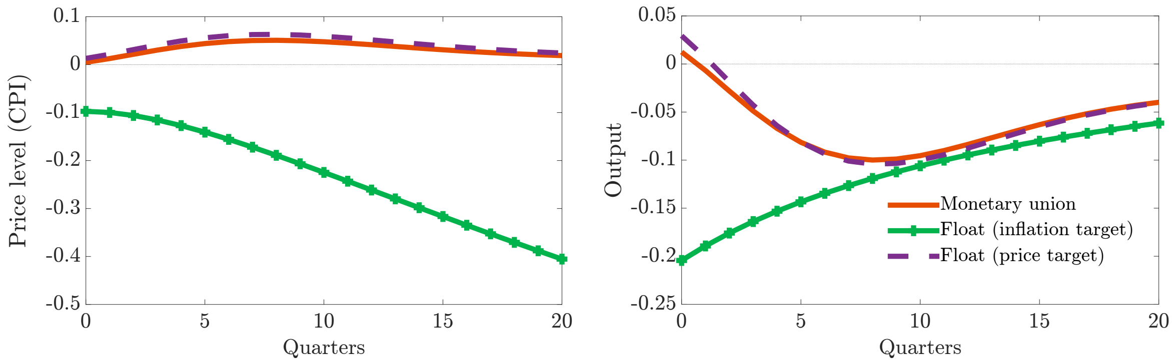
In light of this result, we consider an alternative scenario for monetary policy under a float: We assume that Home conducts an independent monetary policy, but targets the domestic price level instead of inflation. Specifically, it adjusts interest rates whenever domestic prices deviate from their steady-state level:

$$R_t = R \left(\frac{P_{H,t}}{P_H} \right)^{0.0001} . \tag{4.2}$$

This rule implies a very mild monetary response to the shock; in fact, there is

[19]Note that we show the distribution in period 100 after a one-time first-moment shock, when the distribution has collapsed almost to zero.

Figure 9: Effects of country-specific uncertainty shocks with alternative policies



Notes: Responses to country-specific uncertainty shock in a monetary union (red solid line), under flexible exchange rates with inflation targeting (green solid line with plus-shaped markers), and under flexible exchange rates with price level targeting (purple dashed line). Quarterly responses are in percentage deviations from the stochastic steady state.

hardly any visible interest rate response, as we show in Figure C.4 along with the response of additional variables. At the same time, however, the rule (4.2) is sufficient to anchor the price level in the long run—similar to what union membership does. We can see this in the left panel of Figure 9. The dashed (purple) line represents the case of flexible exchange rates when monetary policy follows the price level rule (4.2). It removes the unit root in the price level, and the adjustment mechanism is almost identical to what we observe for the monetary union, shown by the solid (red) line. This is true not only for the price level but also for output, shown in the right panel of the same figure. The inflation targeting case is shown by the solid (green) line with plus-shaped markers. Here, the price level features a unit root (left) and output falls much more, as discussed above.

In sum, membership in a monetary union anchors the price level in a way that is comparable to what happens when an independent monetary policy targets the price level—in either case, price level risk is eliminated in the long run. Note, however, that as far as the monetary union is concerned, this is only true for country-specific shocks: in this case, the price level temporarily deviates from that of the union, but it adjusts over time, ensuring that purchasing power parity is satisfied in the long run, consistent with the evidence (Bergin et al., 2017).[20]

[20]Computing the long-run response of the price level implied by the inflation response to a country-specific shock in the VAR (Figure 4), we find that it is not significantly different from zero.

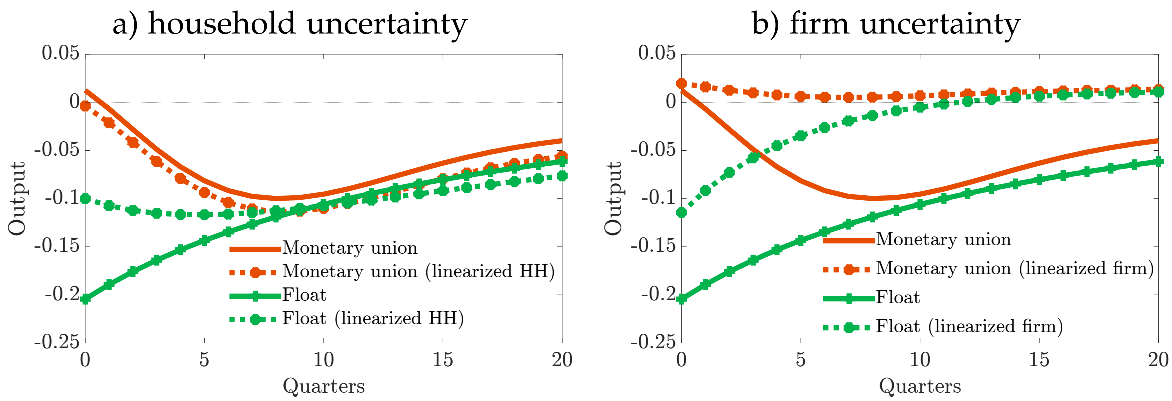
4.4 Households vs. firms

Price level risk is potentially important for both firm and household decisions because of precautionary saving and precautionary pricing (Born and Pfeifer, 2014a; Fernández-Villaverde et al., 2015; Basu and Bundick, 2017; Bianchi et al., 2023). To quantify the extent to which price level risk affects households and firms, we conduct further model simulations. They are centered on the insight that the effect of uncertainty shocks operates through time-varying, endogenous risk wedges that arise in forward-looking expectations equations. Intuitively, suppose that the probability distribution of shocks widens due to an uncertainty shock. In this case, the expected values in the optimality conditions of households and firms change due to Jensen's inequality—in contrast to what happens in a linear world. To identify the quantitatively important margins in this regard, we perform a decomposition à la Bianchi et al. (2023): We selectively shut off these endogenous risk wedges by solving variants of the model in which certain forward-looking equations are restricted to their log-linear approximation.

For our analysis, we split the overall effect of uncertainty shocks into two main categories: the household's consumption-saving decision and the firm's pricing decision. On the household side, we shut off the wedges associated with precautionary saving and price level risk embedded in the Euler equation and the investment risk wedge embedded in the first-order condition for capital. The results are shown in the left panel of Figure 10. It contrasts the results for the baseline scenario (solid lines), reproduced from Figure 9 above, with the results for when uncertainty plays no role in households' intertemporal decisions (dotted lines with octagonal markers). Recall that in the baseline, a country-specific uncertainty shock has much stronger output effects in the case of a floating exchange rate. We now see that consumption-saving wedges are predominantly responsible for this difference: While the response in a monetary union (red lines) is barely affected when removing household uncertainty, the response under a float (green lines) is reduced by more than half.

Next, we isolate the contribution of the endogenous risk wedge associated with the firm's pricing decision by contrasting the baseline response with the response when the wedge is eliminated in the right panel of Figure 10. In this case, the output effects of country-specific uncertainty shocks are substantially reduced relative to the baseline. However, the reduction is comparable for both the

Figure 10: Output effect of country-specific uncertainty without ...



Notes: Responses to country-specific uncertainty shock in a monetary union (red) and under a float (green) with inflation targeting. Solid lines show responses for baseline, broken lines show responses w/o uncertainty effect (log-linear approx. of selected equations only). Left panel: effect of uncertainty when risk in household's consumption-saving decision is removed (dotted lines with octagonal markers). Right panel: effect of uncertainty when risk associated with firms' pricing decision is removed (dotted lines with octagonal markers). Quarterly responses are in percentage deviations from the stochastic steady state.

float and monetary union cases. Thus, (long-run) price level risk is quantitatively less important for the adjustment on the firm side. To sum up, our simulation shows that the anchoring of price level expectations in a monetary union—and the resulting reduction in price level risk—is particularly important for households' saving decisions.

Finally, we note that the reduction in price level risk in the monetary union does not necessarily dampen the impact of all shocks. For instance, we find that a country-specific supply (level) shock has stronger adverse output effects in the monetary union than under a float, see Figure C.6. It is, therefore, possible that the containment of price level risk is particularly important for the transmission of uncertainty shocks. We leave it to future work, both empirical and in quantitative business cycle models, to explore this conjecture.

5 Conclusion

A monetary union provides a nominal anchor for the price levels of its members. This not only eliminates potential inflation biases but also reduces price level risk, as shown in this paper. As such, it also dampens the effects of country-specific uncertainty shocks within the monetary union, making them weaker than those experienced by countries with flexible exchange rates—in contrast to what the received wisdom suggests.

This is particularly relevant in a context of heightened uncertainty. While economic uncertainty is often heightened by global events, such as the Trump tariff shock in April 2025 or Russia's invasion of Ukraine, they tend to load differently on different countries (Federle et al., 2024), giving rise to country-specific uncertainty. In such an environment, the lack of monetary independence may prove less costly than is commonly perceived.

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Online Appendix

A Data appendix

In our euro area VARs, we use the following country-level data series:

1. Total and country-specific volatility: the average realized return volatility of the Datastream Country Market Total Return Index during the quarter, computed as the average annualized standard deviation of daily returns of the performance index (obtained from Datastream: `TOTMK*(RI)`); for the country-specific realized volatility, we remove the first principal component of the constructed volatility indices of a sample of 48 countries (see below). We use the alternating least squares (ALS) algorithm of the Matlab `pca`-function in the R2023a version to deal with missing values. We first conduct the PCA at the monthly frequency and then aggregate the resulting series to quarterly data.

2. Total and country-specific Jurado et al. (2015) uncertainty measure: 12-month-ahead macroeconomic uncertainty compiled by Comunale and Nguyen (2025). For the isolation of country-specific uncertainty, we remove the first principal component of that uncertainty index for all EA countries used in the second VAR and the corresponding robustness checks (see Table A.1).

3. log GDP: real GDP, Million euro, chain-linked volumes, reference year 2010 (Eurostat table `namq_10_gdp`, series `B1GQ`), divided by population

4. log Consumption: real personal consumption expenditures, Million euro, chain-linked volumes, reference year 2010 (Eurostat table `namq_10_gdp`, Household and NPISH final consumption expenditure series `P31_S14_S15`), divided by population

5. log Investment: real private investment, Million euro, chain-linked volumes, reference year 2010 (Eurostat table `namq_10_gdp`, series `P51G`), divided by population

6. Inflation: Harmonized index of consumer prices (annual rate of change), all-items HICP (Eurostat table `prc_hicp_manr`). We aggregate the monthly

data to quarterly frequency by using the geometric mean of all monthly observations within in a given quarter.

7. Policy rate: ECB interest rate for main refinancing operations / End of month (ECB Data Warehouse, `BBK01.SU0202`), complemented by the Wu and Xia (2016) shadow rate for the Euro Area

8. log Government spending: real final consumption expenditures of general government, Million euro, chain-linked volumes, reference year 2010 (Eurostat table `namq_10_gdp`, series `P3_S13`), divided by population

9. log Stock market index: Quarterly average of Datastream Country Market Total Return Index (`TOTMK*(RI)`), same as for volatility measures). We first average the daily values within each month and subsequently aggregate to quarterly averages.

To construct per capita values, we use Total population national concept, Seasonally and calendar adjusted data, Thousand persons (Eurostat table `namq_10_gdp`, series `POP_NC`).

We use seasonally and calendar-adjusted data for the national account series of countries where all series (apart from uncertainty proxies and the shadow rate) are available with these adjustments. For the other countries (Italy, France, Greece, Malta, Portugal), we use the Matlab `x13`-function of the `X-13 Toolbox for Seasonal Filtering`, version 1.58, to obtain seasonally adjusted series.

In the VARs, we use the countries as listed in Table A.1. The second column reports the first quarter with a consistent Euro peg according to their exchange rate classification. For the first VAR and corresponding robustness checks, we use this date as the sample start. The second VAR and the corresponding robustness checks only use data back until 2003Q3 when the Jurado et al. (2015) measure starts. The third and fourth columns indicate which countries are used in which VAR. Malta and Slovakia are dropped in the first VAR because the Datastream stock market measure is not consistently available. We exclude Cyprus from the second VAR because its coefficient for the first principal component of the Jurado et al. (2015) uncertainty measure is negative, leading to its common component being inversely related to that of all other countries.

Table A.1: EA countries: sample starting dates

Country	First Euro/peg quarter	First VAR	Second VAR
Austria	1999Q1	✓	✓
Belgium	1999Q1	✓	✓
Cyprus	2008Q1	✓	
Estonia	1999Q1	✓	✓
Finland	1999Q1	✓	✓
France	1999Q1	✓	✓
Germany	1999Q1	✓	✓
Greece	1999Q1	✓	✓
Ireland	1999Q1	✓	✓
Italy	1999Q1	✓	✓
Latvia	2009Q3	✓	✓
Lithuania	1999Q1	✓	✓
Luxembourg	1999Q1	✓	✓
Malta	2008Q1		✓
Netherlands	1999Q1	✓	✓
Portugal	1999Q1	✓	✓
Slovakia	2009Q1		✓
Slovenia	2007Q1	✓	✓
Spain	1999Q1	✓	✓

Notes: For countries that did not adopt the euro at its inception in 1999Q1, we use the first quarter after which Ilzetzki et al. (2022) consistently classify the country's exchange rate arrangement as a 2 ("Pre announced peg or currency board arrangement") or 1 ("No separate legal tender or currency union") in their fine classification.

PCA sample

For the principal component analysis, we use a sample of 48 countries made up of OECD members, participating partners, and countries negotiating OECD membership. Two exceptions are the OECD members Costa Rica, for which the Datastream stock market index is unavailable, and Iceland, whose stock market crash following the financial crisis in 2008-2011 significantly distorts all PCA outcomes.

Countries included in the PCA sample but in neither of the VARs are Argentina, Bulgaria, China, Croatia, Czechia, Denmark, Hungary, Indonesia, Japan, Norway, Peru, Poland, Romania, Saudi Arabia, Sweden, Switzerland, Turkey, and the United Kingdom. These countries either had pegged exchange rates for most or all of the sample duration or are European floaters not insulated from EA-wide shocks (see Corsetti et al., 2021)). Another exception is Japan, which we dropped from the VAR due to its 20 years at the zero lower bound, which creates stochastic singularity issues in the VAR once we include the policy rate.

Global float sample

In our global sample of countries with floating exchange rates, we use the following variables in addition to the country-specific and common component of realized stock market volatility:

1. log GDP: OECD quarterly national accounts data. Gross domestic product at market prices - output approach (subject `B1_GA`) measured in national currency, chained volume estimates, national reference year, quarterly levels, seasonally adjusted (measure `LNBQRSA`), when available, otherwise gross domestic product - expenditure approach (subject `B1_GE`) measured in national currency, constant prices, national base year, quarterly levels, seasonally adjusted (measure `VNBQRSA`), divided by population.

2. Inflation: OECD Data Archive. Indicator: `Inflation (CPI)`. Subject: `Total`. Measure: `Annual growth rate (%)`.

3. Policy rate: Central bank policy rate from the BIS data portal, data set `BIS WS_CBPOL 1.0`. To get quarterly values, we average over monthly observations.

To construct per capita values, we use OECD historical population data (table `HISTPOP`). To obtain quarterly values, we linearly interpolate the annual data.

In the VAR, we use the countries listed in Table A.2. The second column reports the sample periods for which all variables are available.

Dealing with Outliers

We have two cases of large outliers in the stock market data that significantly distort the decomposition into country-specific and common components. These distortions arise not only for the country with the outlier observation but also lead

Table A.2: Country sample periods global sample

Country	Sample periods
Australia	1999Q1-2022Q4
Brazil	1999Q1-2022Q4
Canada	2002Q3-2022Q4
Chile	1999Q4-2022Q4
Colombia	2005Q1-2022Q4
India	2013Q1-2022Q4
Israel	1999Q1-2022Q4
Mexico	1999Q1-2022Q4
New Zealand	1999Q1-2022Q4
Russia	2003Q1-2021Q3
South Africa	1999Q1-2022Q4
South Korea	1999Q2-2022Q4
United States	1999Q1-2022Q4

Notes: For each country, we report the periods where all variables are available and the country's exchange rate arrangement is classified as an 11 ("Moving band that is narrower than or equal to +/-2%") or higher by Ilzetzki et al. (2022). The only exception is Russia, where we also use 2013 and 2014 where it was classified as a 10 for most of the time.

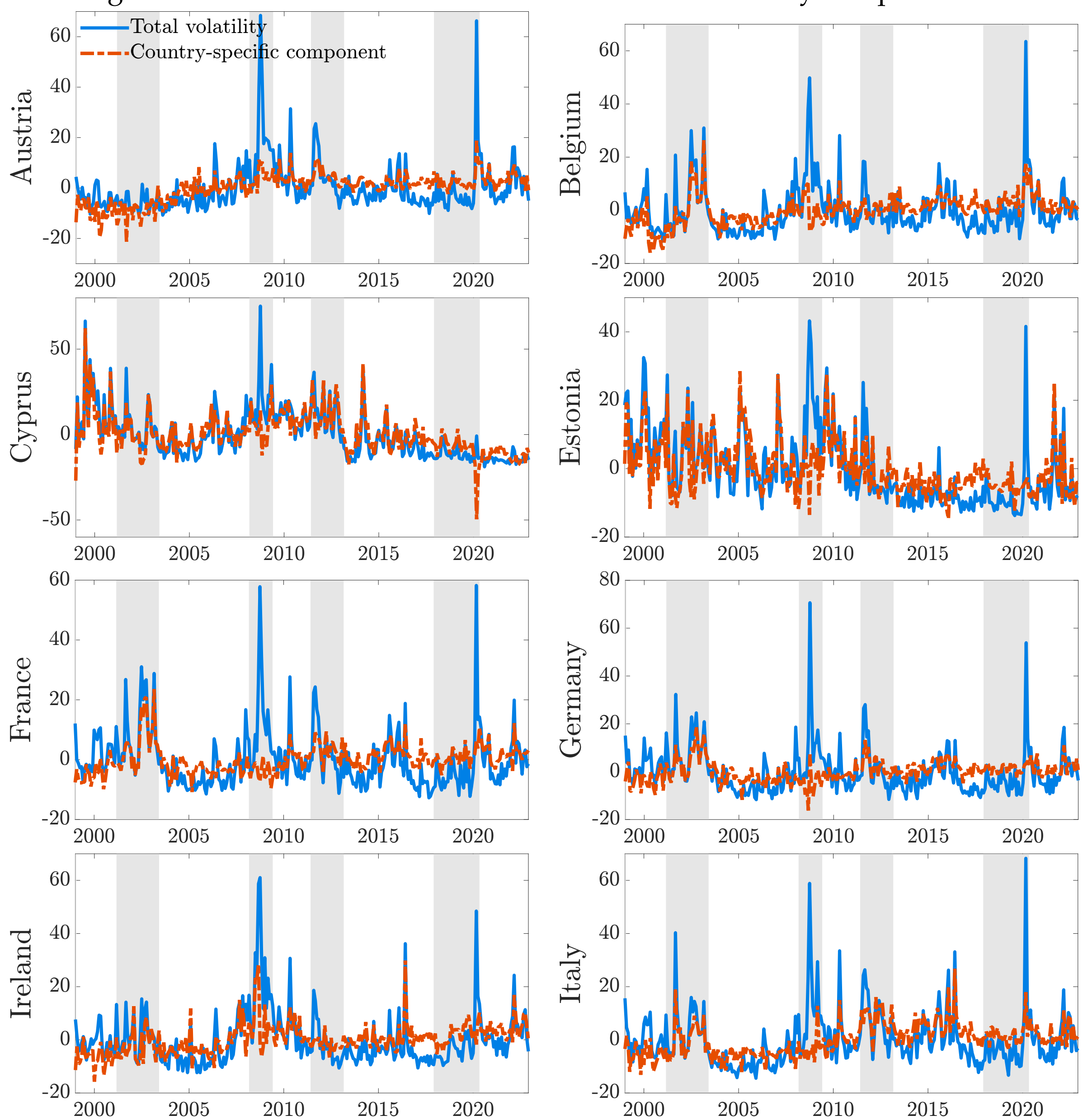
to the country-specific component being orders of magnitude larger (in absolute value) than in the period with the second-largest value for some other countries.

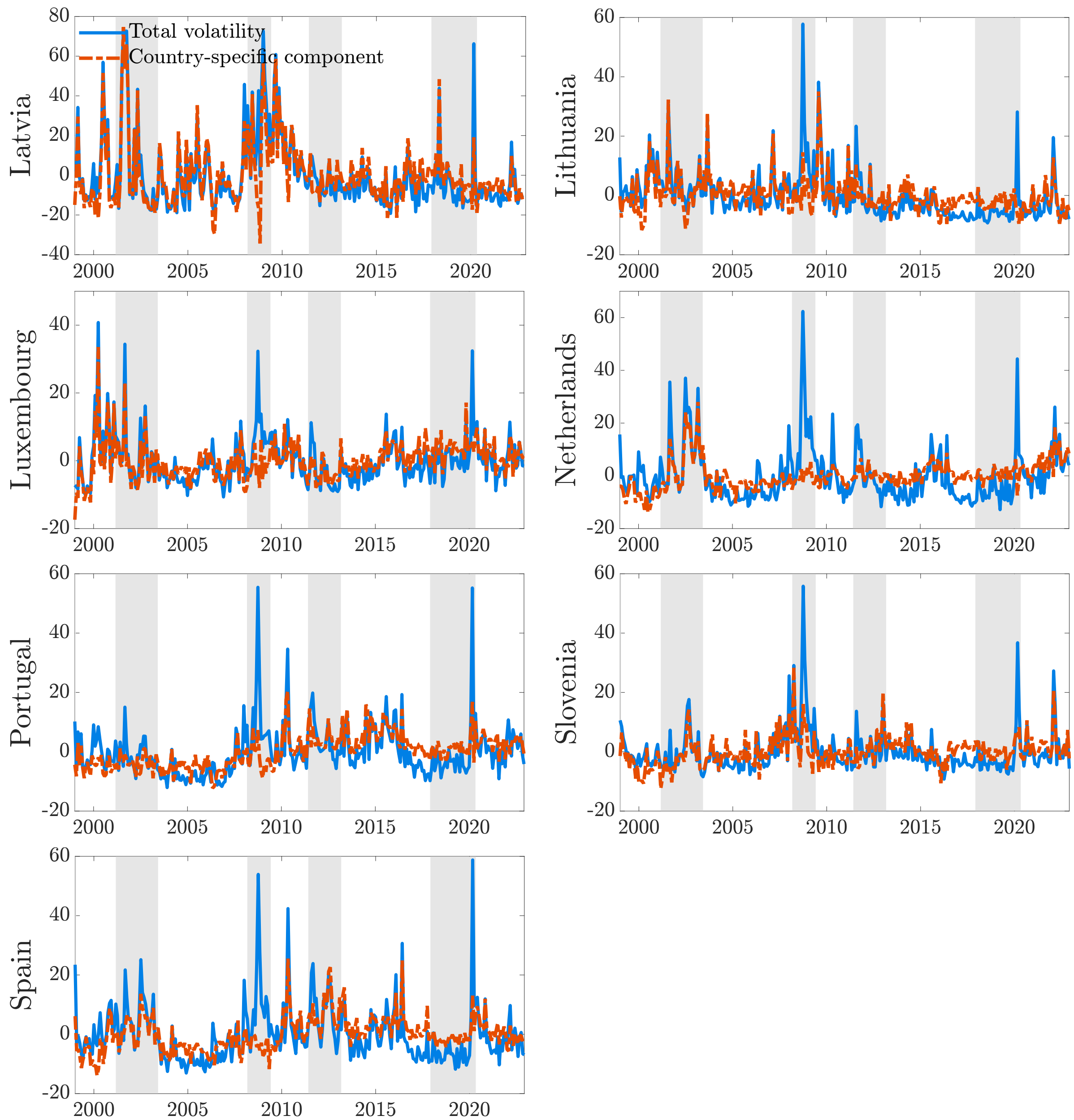
The first of these cases is a series of extreme spikes in annualized volatility for Latvia from August to October 2001. Since our VAR for Latvia only uses data starting in 2005Q3 and these observations are only used for computing the first PC, we winsorize the data and set the corresponding values to the next-highest value of Latvian volatility.

The second is a permanent drop in the performance index of Cyprus by around 2/3 of the index occurring between two daily observations in August 2020. We are unaware of any event that could explain this permanent drop and do not find a collapse like this in other available Cypriot performance indices. In contrast to the Latvian case above, we actually need the value of this observation for our VAR, so we add the value of the observed drop-off to all days after the 'crash' in the rest of the month. The monthly observation that is used in the PCA is then the annualized return volatility over these partly fixed daily observations.

B Further evidence

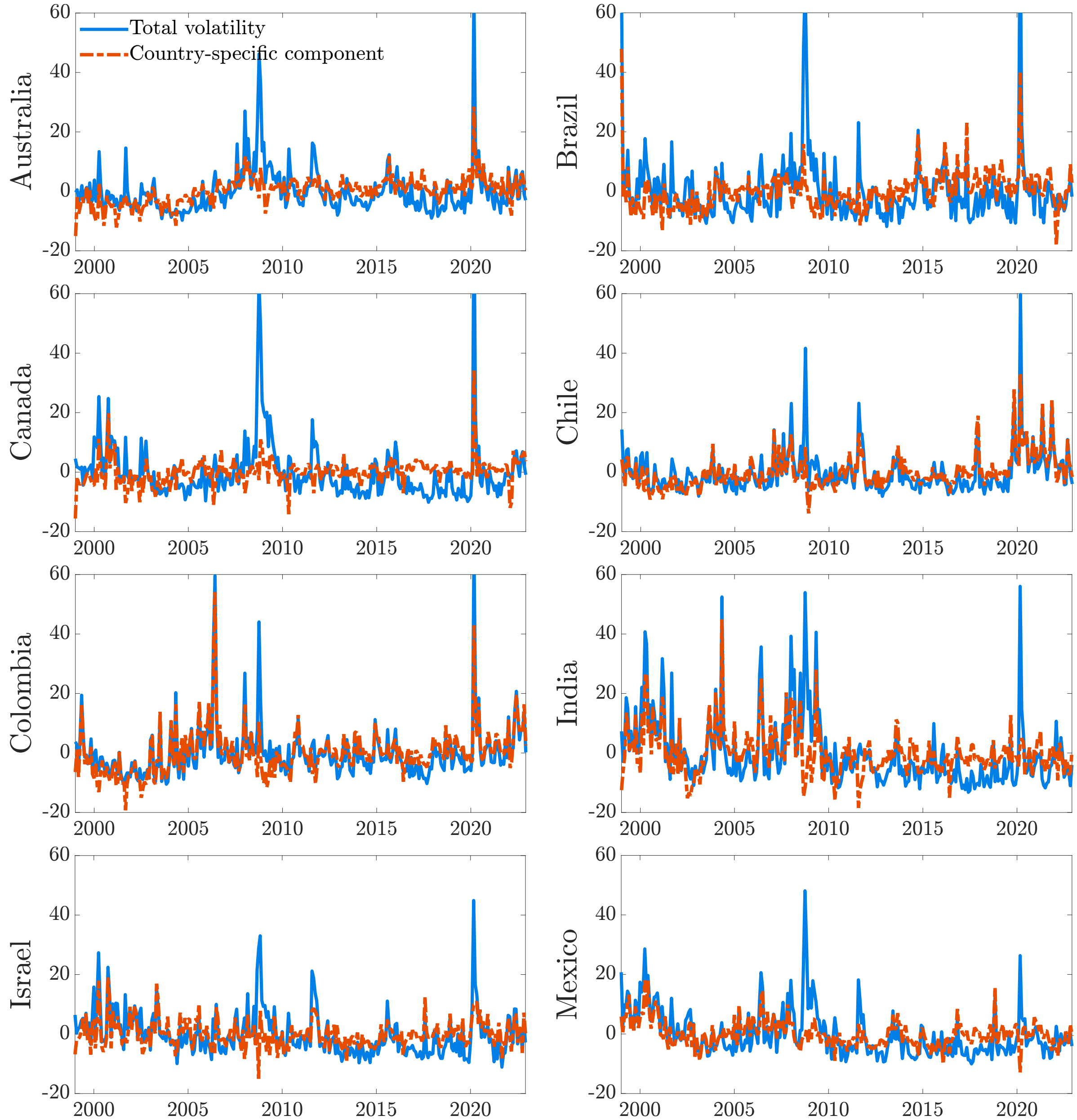
Figure B.1: Demeaned annualized stock market volatility components - EA

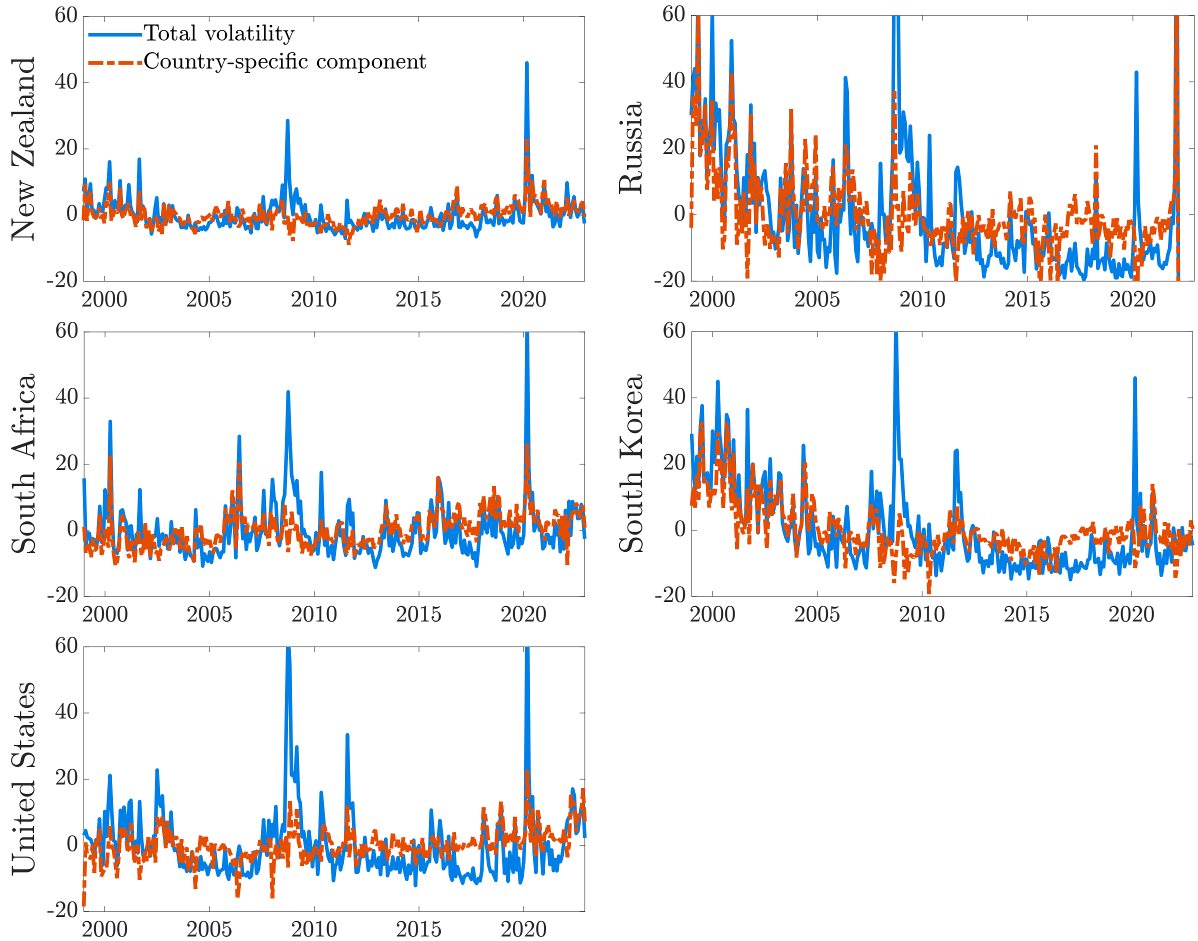




Notes: Monthly country-specific component (red dashed line) and total (blue solid line) realized volatility of annualized stock market returns in percent. All time series are demeaned. Shaded areas denote EA recession as dated by OECD-based recession indicators.

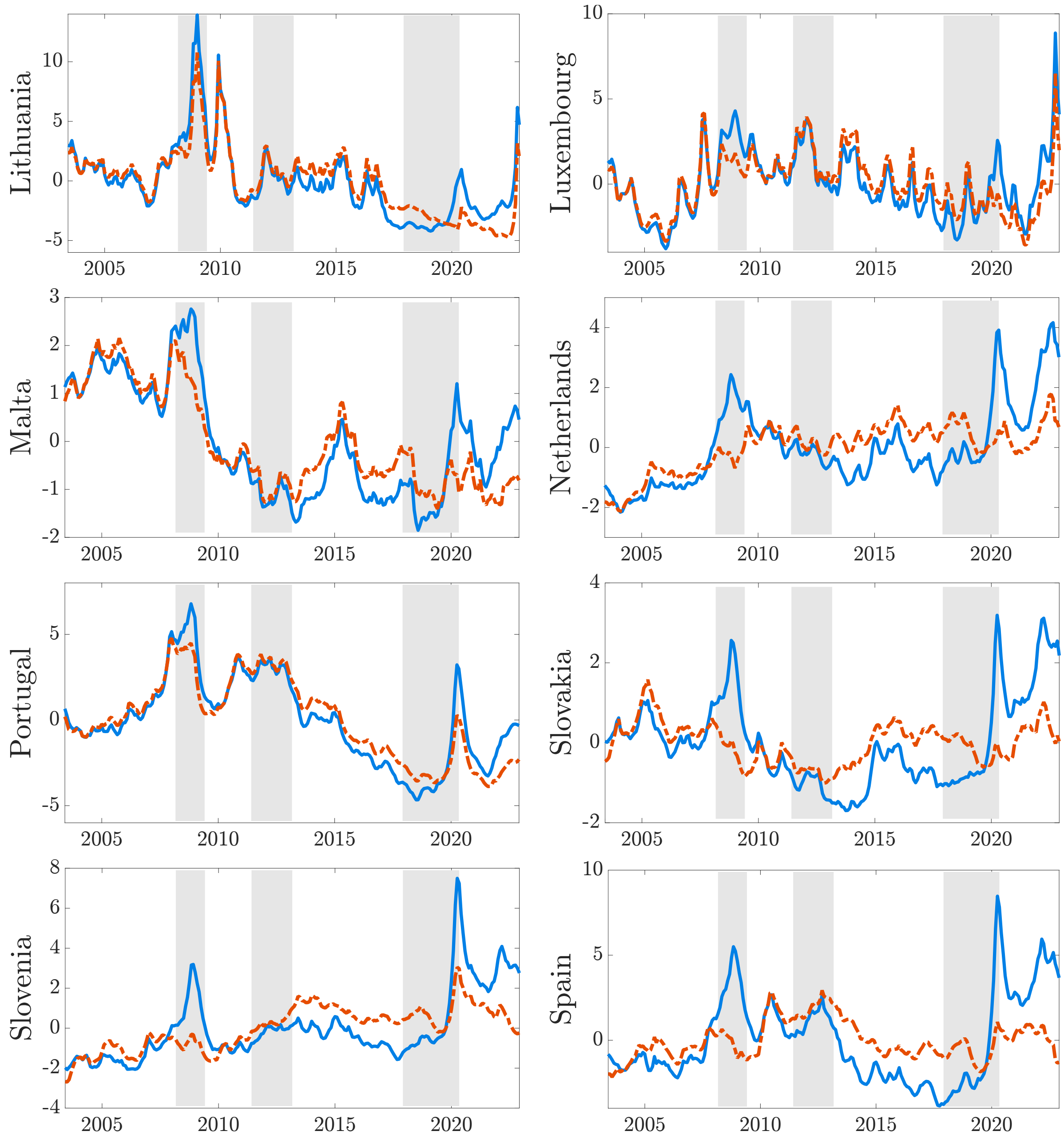
Figure B.2: Demeaned annualized stock market volatility components - floaters





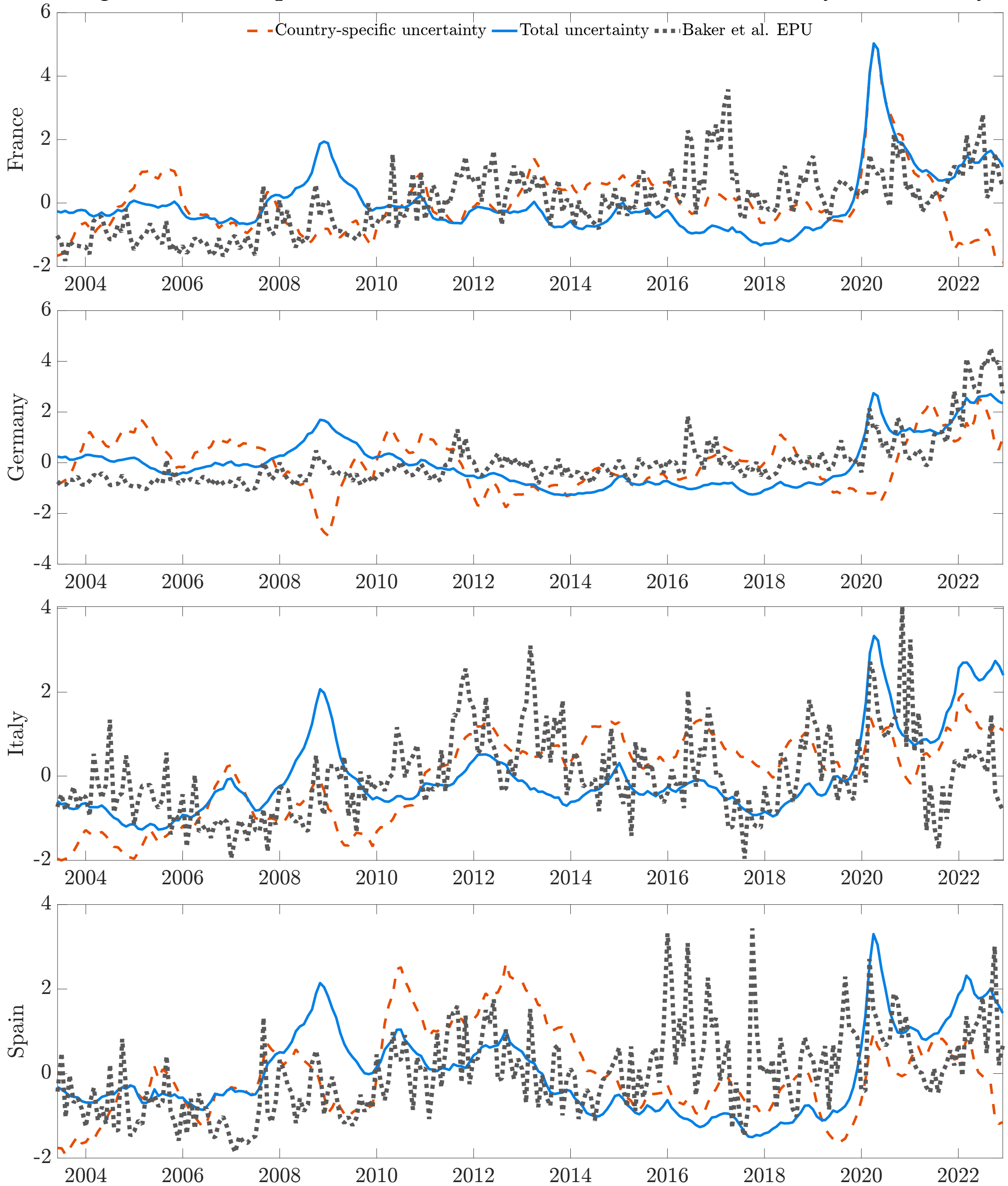
Notes: Monthly country-specific component (red dashed line) and total (blue solid line) realized volatility of annualized stock market returns in percent. All time series are demeaned.

Figure B.3: Demeaned macroeconomic uncertainty components



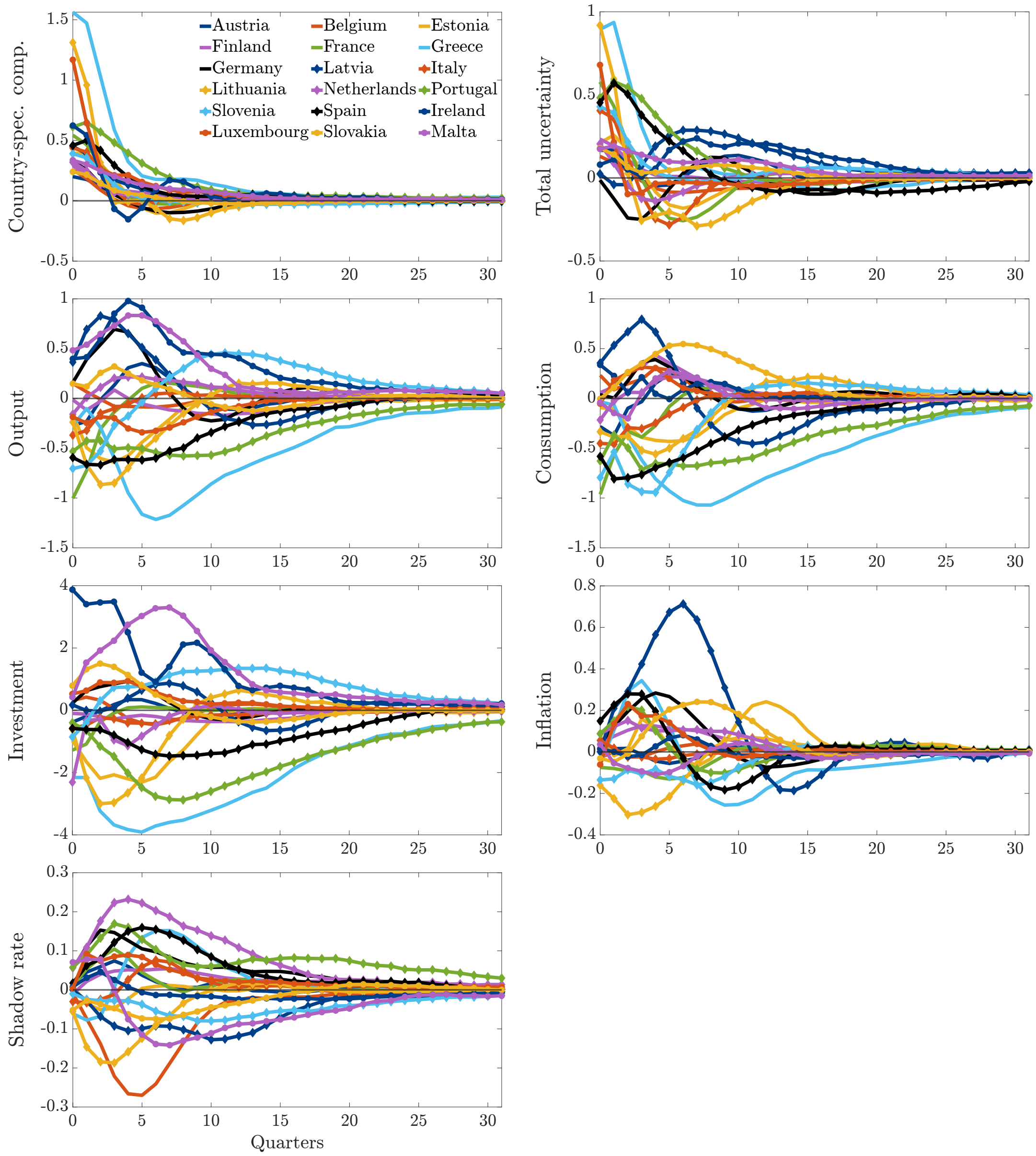
Notes: Monthly country-specific component (red dashed line) and total (blue solid line) one-year-ahead macroeconomic uncertainty measure (Comunale and Nguyen, 2025). All time series are demeaned. Shaded areas denote EA recession as dated by OECD-based recession indicators.

Figure B.4: Comparison to Baker et al. (2016) Economic Policy Uncertainty



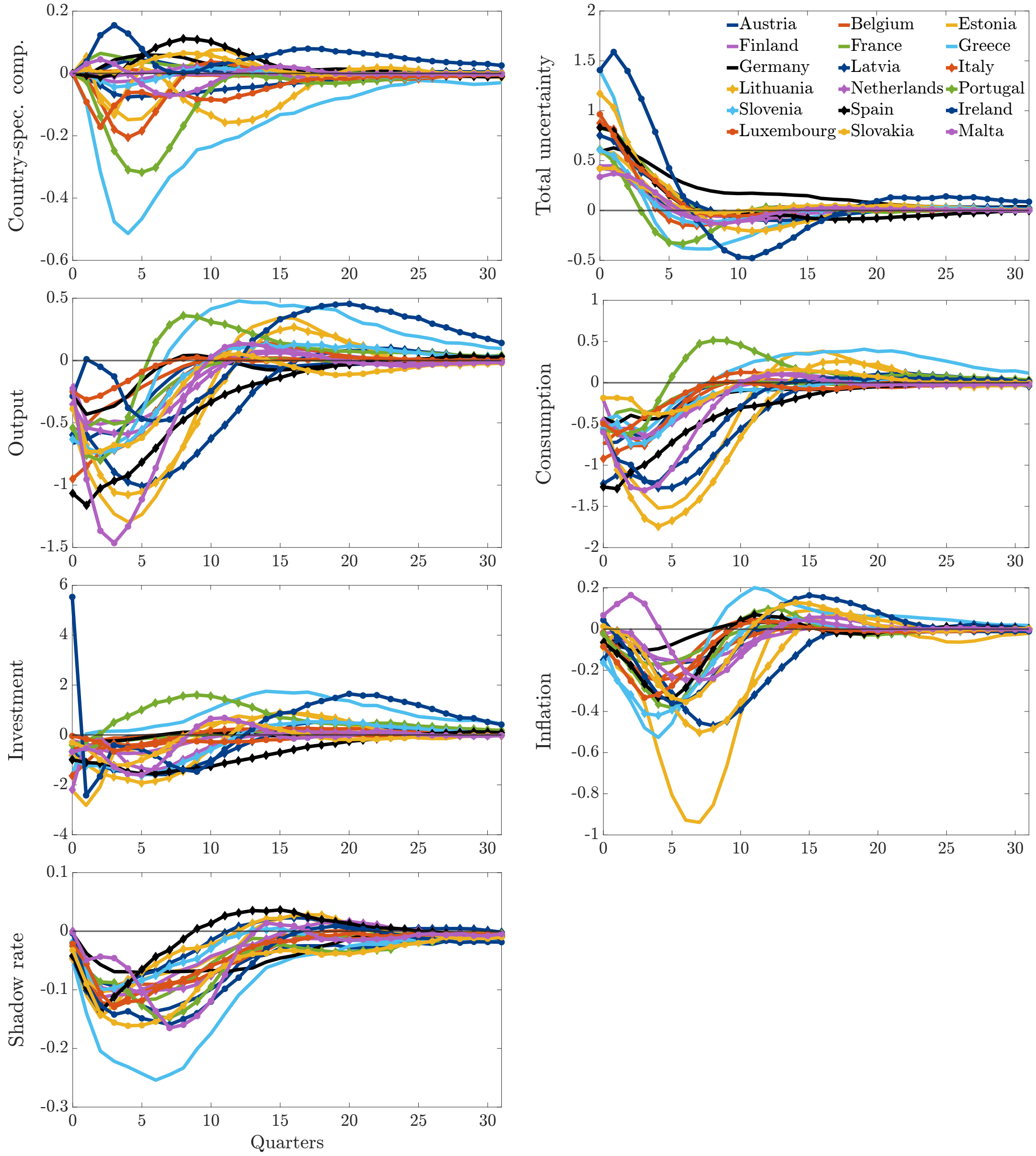
Notes: Comparison of country-specific (red dashed line) and total macroeconomic uncertainty (blue solid line) measures with Baker et al. (2016) economic policy uncertainty index (grey dotted line), when available. All time series are z-scored.

Figure B.5: IRFs to country-specific uncertainty shock: country-level evidence (EA sample)



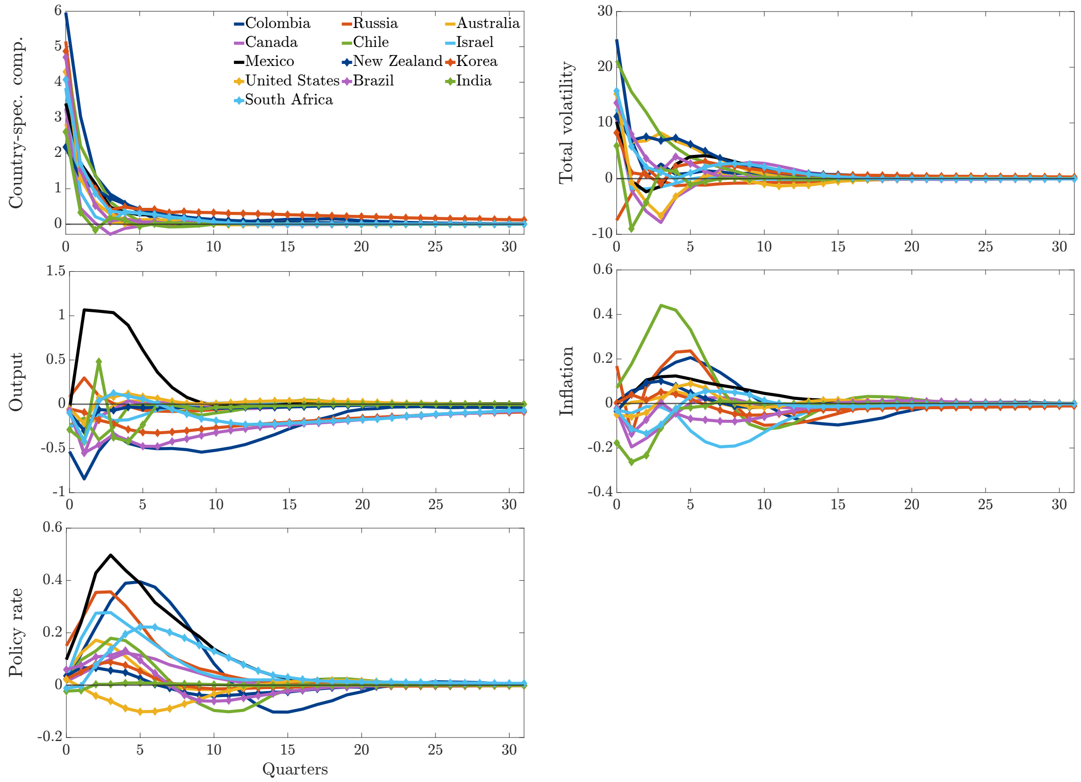
Notes: (Unnormalized) IRFs to one-standard-deviation country-specific uncertainty shock. Deviations in percent, except for country-specific component, inflation, and the shadow rate, which are in ppts.

Figure B.6: IRFs to common uncertainty shock: country-level evidence (EA sample)



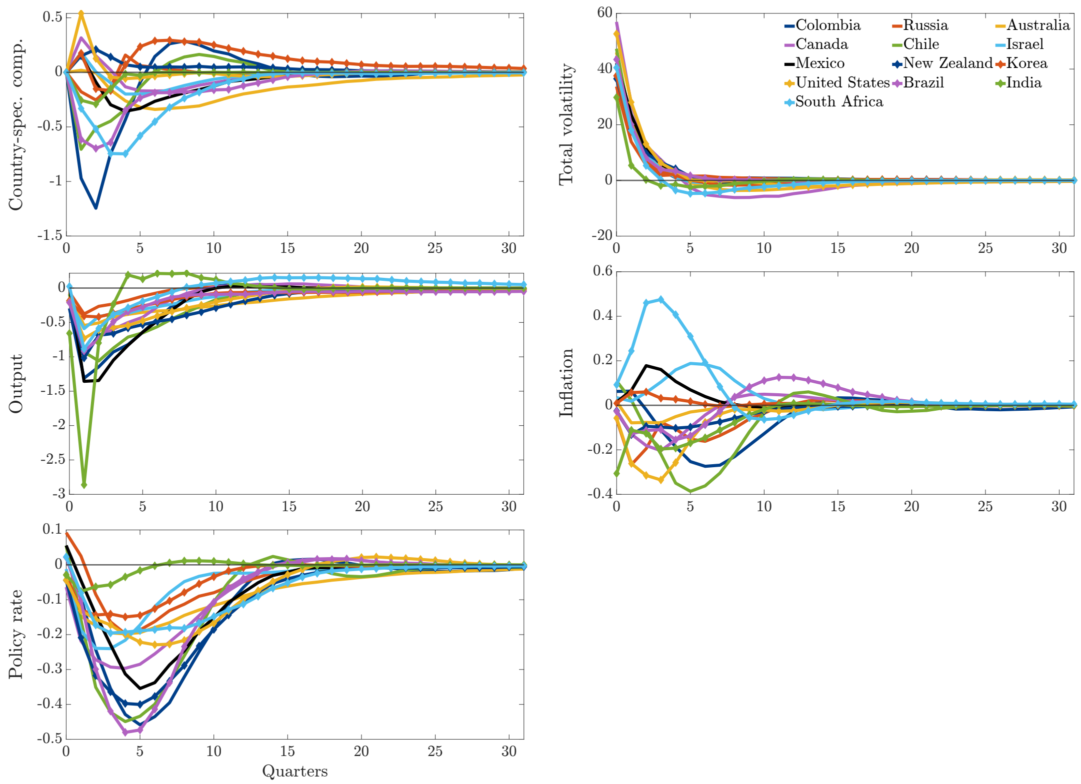
Notes: (Unnormalized) IRFs to one-standard-deviation common uncertainty shock. Deviations in percent, except for country-specific component, inflation, and the shadow rate, which are in ppts.

Figure B.7: IRFs to country-specific uncertainty shock: country-level evidence (floaters sample)



Notes: (Unnormalized) IRFs to one-standard-deviation country-specific uncertainty shock. Deviations in percent, except for country-specific component, inflation, and the policy rate, which are in ppts.

Figure B.8: IRFs to common uncertainty shock: country-level evidence (floaters sample)



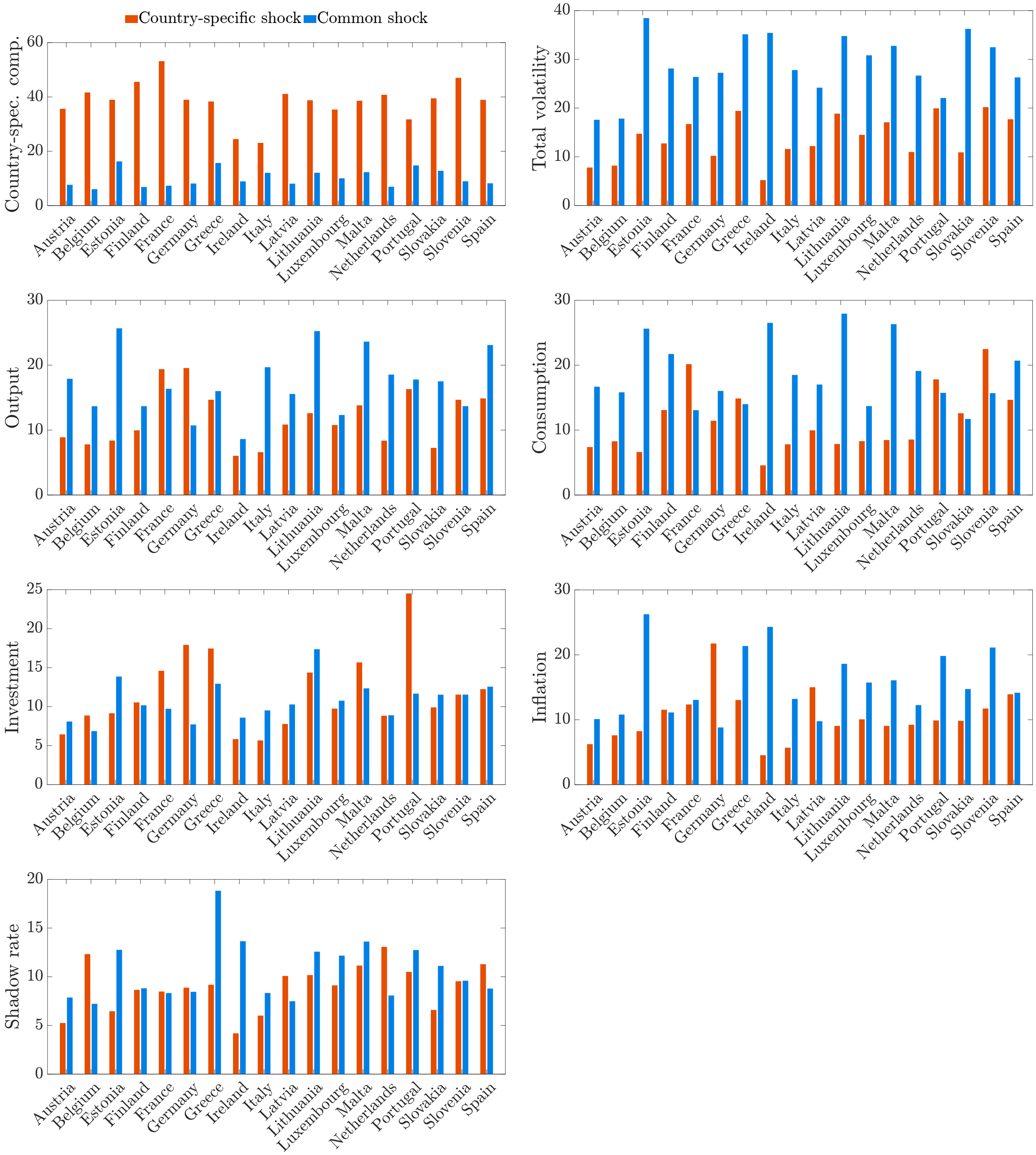
Notes: (Unnormalized) IRFs to one-standard-deviation common uncertainty shock. Deviations in percent, except for country-specific component, inflation, and the policy rate, which are in ppts.

Table B.1: Forecast error variance decomposition for median economy among global floaters

	Country-specific uncertainty shock	Common uncertainty shock
Country-specific component	73.92 (68.95 , 78.46)	7.55 (5.65 , 10.35)
Total volatility	13.64 (11.11 , 16.77)	64.15 (59.75 , 68.30)
Output	9.52 (6.87 , 12.80)	19.38 (14.69 , 25.02)
Inflation	8.7 (6.29 , 11.55)	11.63 (8.31 , 15.55)
Shadow rate	10.2 (6.99 , 13.85)	18.90 (13.67 , 24.44)

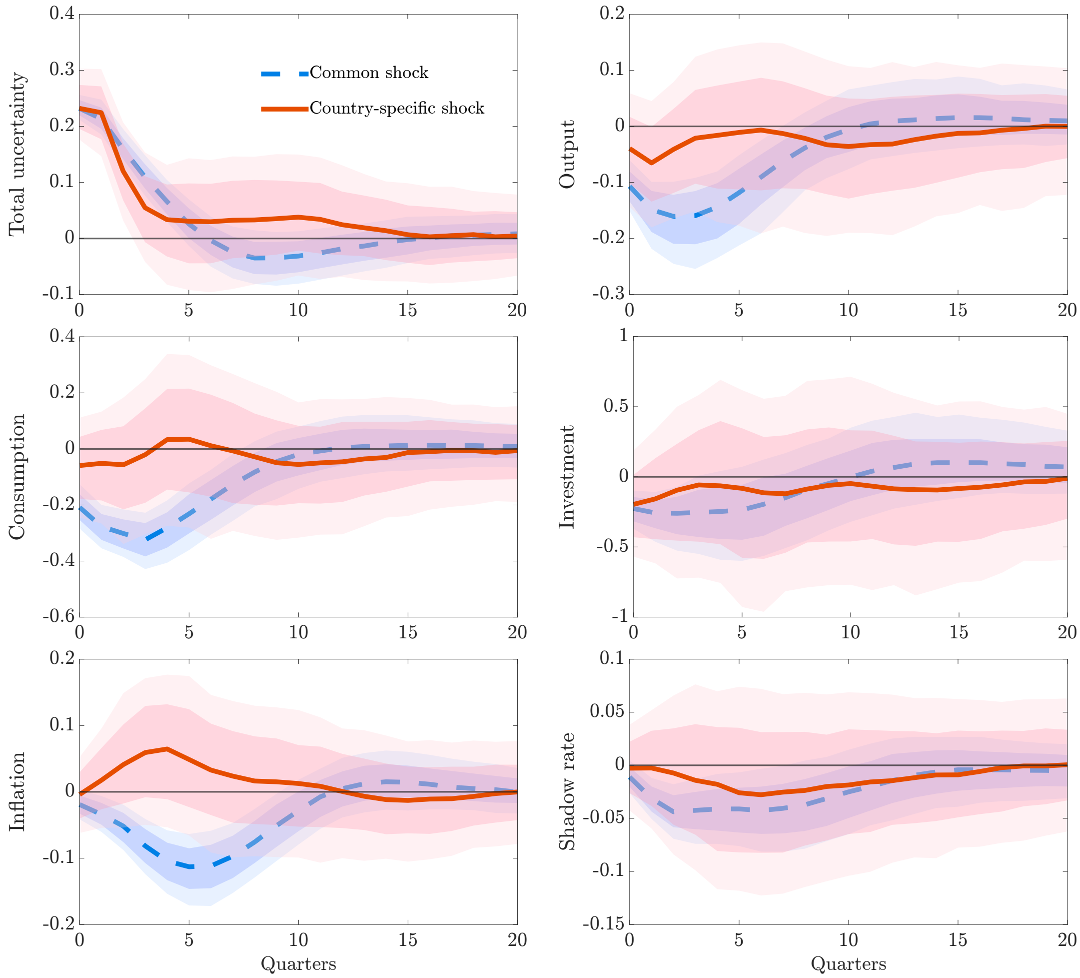
Notes: Contribution of country-specific (middle column) and common (right column) uncertainty shock to forecast error variance of each variable at horizon 20, in percent of total forecast error variance of that variable (with 68% HPDIs reported in parentheses).

Figure B.9: Forecast error variance decomposition at horizon 20



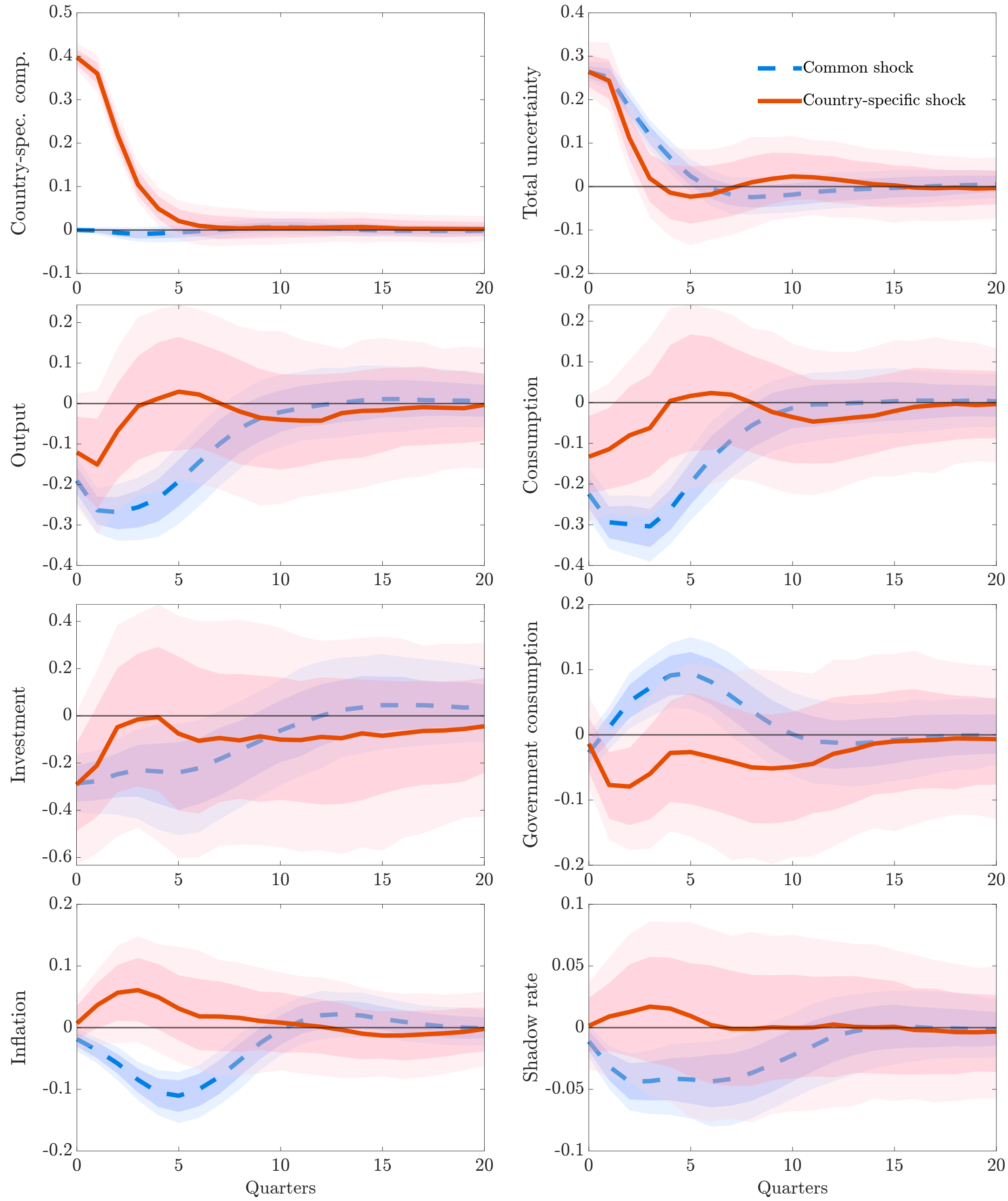
Notes: Median contribution of country-specific (red) and common (blue) uncertainty shock to forecast error variance of each variable at horizon 20 as percent share of total forecast error variance of that variable. Results are median FEVD values for each country across 1,000 random draws from the posterior distribution.

Figure B.10: VAR robustness: small EA countries only



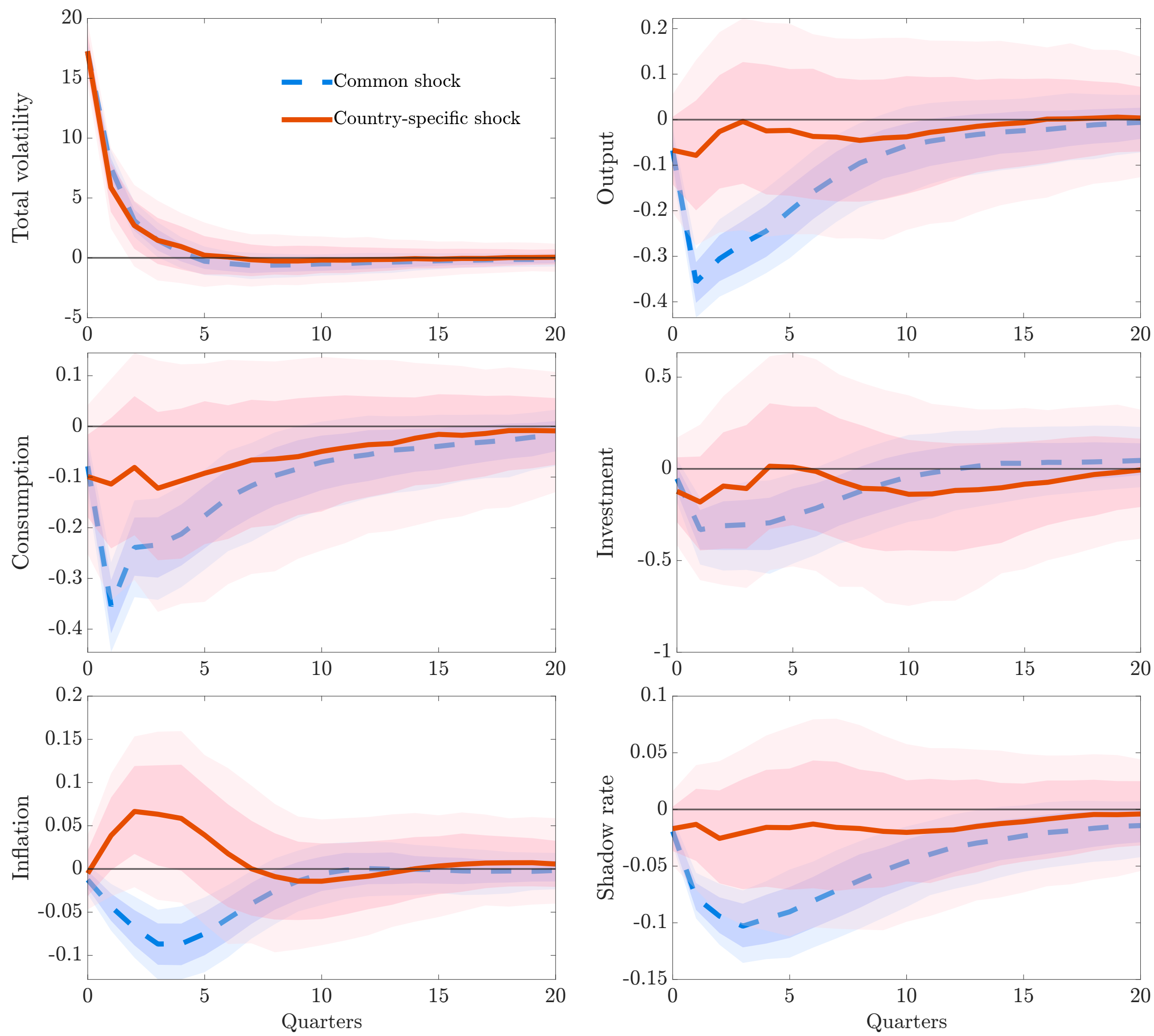
Notes: Sample only consists of countries that each make up less than 5 percent of aggregate output in the EA (excludes Germany, France, Italy, Spain, Netherlands). IRFs to one-standard-deviation country-specific (red solid lines) and equally-sized common (blue dashed lines) uncertainty shock. Shaded bands are pointwise 68% (dark) and 90% (light) HPDIs, respectively. Horizontal axis measures time in quarters, vertical axis measures deviations from pre-shock level in percent, except for uncertainty, inflation and the shadow rate (ppts). Country-specific uncertainty is included in the VAR, but not shown here.

Figure B.11: VAR robustness: include government spending



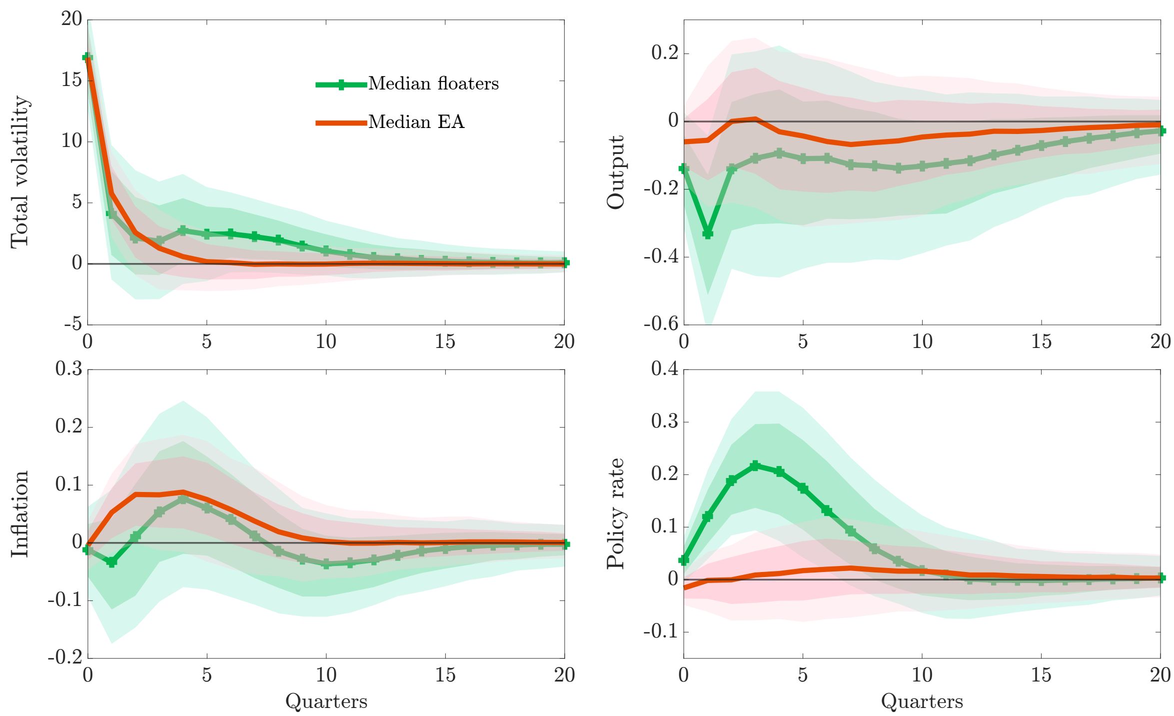
Notes: VAR includes real per capita government consumption as additional variable. IRFs to one-standard-deviation country-specific (red solid lines) and equally-sized common (blue dashed lines) uncertainty shock. Shaded bands are pointwise 68% (dark) and 90% (light) HPDIs, respectively. Horizontal axis measures time in quarters, vertical axis measures deviations from pre-shock level in percent, except for country-specific and total uncertainty, inflation, and the shadow rate (ppts).

Figure B.12: VAR robustness: VXO as uncertainty measure



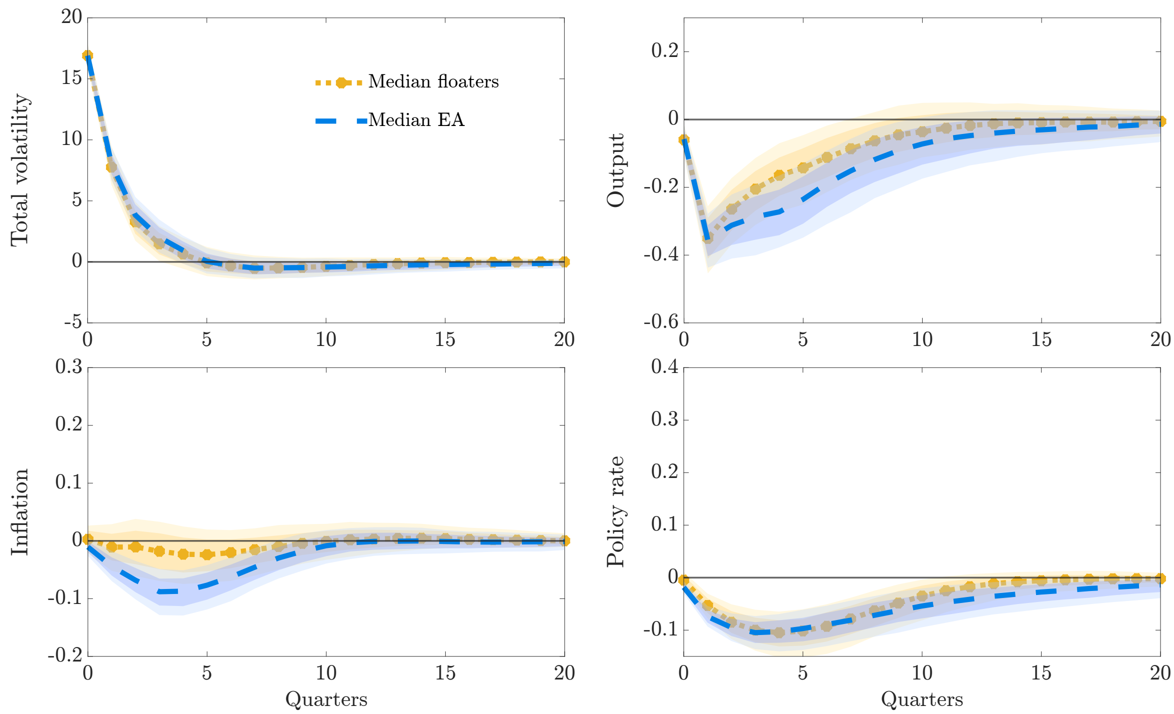
Notes: Stock market volatility used as proxy for uncertainty as in five-variable VAR. IRFs to one-standard-deviation country-specific (red solid lines) and equally-sized common (blue dashed lines) uncertainty shock. Shaded bands are pointwise 68% (dark) and 90% (light) HPDIs, respectively. Horizontal axis measures time in quarters, vertical axis measures deviations from pre-shock level in percent, except for inflation and the shadow rate (ppts). Country-specific volatility is included in the VAR, but not shown here.

Figure B.13: VAR robustness: Exclude USA — country-specific uncertainty shock



Notes: Impulse responses to country-specific uncertainty shocks in the EA (red solid line) and among global floaters (green solid line with plus-shaped markers). Shock size rescaled so that the median impact on total volatility equals that of one-standard deviation country-specific uncertainty shock in the EA. Shaded areas indicate point-wise 68% (dark) and 90% (light) HPDIs, respectively. Horizontal axis measures time in quarters, vertical axis measures deviations from pre-shock level in percent, except for inflation and policy rate (ppts). Country-specific volatility is included in the VAR, but not shown here.

Figure B.14: VAR robustness: Exclude USA — common uncertainty shock



Notes: Impulse responses to common uncertainty shocks in the EA (blue dashed line) and among global floaters (yellow dotted line with octagonal markers). Shock sizes rescaled so that the median impact on total volatility equals that of one-standard deviation country-specific uncertainty shock in the EA. Shaded areas indicate point-wise 68% (dark) and 90% (light) HPDIs, respectively. Horizontal axis measures time in quarters, vertical axis measures deviations from pre-shock level in percent, except for inflation and policy rate (ppts). Country-specific volatility is included in the VAR, but not shown here.

C Model appendix

C.1 Definitions and derivations

Production

Competitive final good firms produce the final good $\mathcal{F}_t$ with price P_t,[21] using a CES aggregator:

$$\mathcal{F}_t = \left[(1-(1-n)v)^{\frac{1}{\eta}} \left(Y_{H,t}\right)^{\frac{\eta-1}{\eta}} + ((1-n)v)^{\frac{1}{\eta}} \left(Y_{F,t}\right)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} , \tag{3.5}$$

by bundling domestic goods $Y_{H,t}$ and foreign imported goods $Y_{F,t}$ to minimize their expenditure $P_t^H Y_t^H + P_t^F Y_t^F$ given demand and prices. In the following, we describe the setup and first-order conditions for Home goods, with equivalent considerations for Foreign goods. The first order condition for Home goods is

$$Y_{H,t} = (1-(1-n)v) \left(\frac{P_{H,t}}{P_t} \right)^{-\eta} \mathcal{F}_t \, . \tag{C.1}$$

The domestic good $Y_{H,t}$ is assembled from a continuum of differentiated intermediate inputs $Y_t(i)$, $i \in [0, n]$, using the constant returns to scale Dixit-Stiglitz-technology

$$Y_{H,t} = \left[\left(\frac{1}{n} \right)^{\frac{1}{\epsilon}} \int_0^n Y_t(i)^{\frac{\epsilon-1}{\epsilon}} \, di \right]^{\frac{\epsilon}{\epsilon-1}} , \tag{C.2}$$

where $\epsilon > 1$ is the elasticity of substitution between intermediate goods. The optimal amount of inputs $Y_t(i)$, given their price $P_t(i)$, is determined by solving the following expenditure minimization problem:

$$\min_{Y_t(i)} \int_0^n P_t(i) Y_t(i) di + P_{H,t} \left[Y_{H,t} - \left[\left(\frac{1}{n} \right)^{\frac{1}{\epsilon}} \int_0^n Y_t(i)^{\frac{\epsilon-1}{\epsilon}} di \right]^{\frac{\epsilon}{\epsilon-1}} \right] . \tag{C.3}$$

Here, $P_{H,t}$ is the Lagrange multiplier, which has a natural interpretation as the price index for $Y_{H,t}$. The first order condition for each variety i is given by $Y_t(i) = \frac{1}{n} \left(\frac{P_t(i)}{P_{H,t}} \right)^{-\epsilon} Y_{H,t}$. Substituting for $Y_t(i)$ in (C.2), shows that $P_{H,t} =$

[21] We consider the final good as the numéraire and set its initial pre-shock value to 1.

$\left[\frac{1}{n}\int_0^n P_t(i)^{1-\epsilon}dj\right]^{\frac{1}{1-\epsilon}}$. Equivalent considerations apply to imported inputs $Y_t(j)$, produced by foreign intermediate goods firms $j \in (n, 1]$. The Home demand for varieties produced in Home and Foreign is then given by

$$Y_t(i) = \frac{1}{n}\left(\frac{P_t(i)}{P_{H,t}}\right)^{-\epsilon} Y_{H,t} \ , \quad Y_t(j) = \frac{1}{1-n}\left(\frac{P_t(j)}{P_{F,t}}\right)^{-\epsilon} Y_{F,t} \ , \tag{C.4}$$

for $i \in [0, n]$ and $j \in (n, 1]$, respectively, and where $P_{F,t} = \left[\frac{1}{1-n}\int_n^1 P_t(j)^{1-\epsilon}dj\right]^{\frac{1}{1-\epsilon}}$.

Substituting these expressions into (3.5) allows deriving the domestic CPI, equation (3.6). Substituting for $Y_{H,t}$ from (C.1) and its counterpart for $Y_{F,t}$ in the domestic demand function for varieties (C.4), we obtain the Home demand for Home and Foreign intermediates, respectively:

$$Y_t(i) = \frac{1-(1-n)\upsilon}{n}\left(\frac{P_t(i)}{P_{H,t}}\right)^{-\epsilon}\left(\frac{P_{H,t}}{P_t}\right)^{-\eta}\mathcal{F}_t \ , \tag{C.5}$$

$$\begin{aligned} Y_t(j) &= \frac{(1-n)\upsilon}{1-n}\left(\frac{P_t(j)}{P_{F,t}}\right)^{-\epsilon}\left(\frac{P_{F,t}}{P_t}\right)^{-\eta}\mathcal{F}_t \\ &= \left(\frac{P_t^*(j)}{P_{F,t}^*}\right)^{-\epsilon}\left(\frac{P_{F,t}^*}{P_t^*}\right)^{-\eta}\upsilon\mathcal{Q}_t^{-\eta}\mathcal{F}_t \ . \end{aligned} \tag{C.6}$$

The last equality makes use of the law of one price and the real exchange rate definition $\mathcal{Q}_t \equiv \mathcal{E}_t P_t^*/P_t$. Due to symmetry, foreign demand for Home and Foreign intermediates, respectively, is given by:

$$\begin{aligned} Y_t^*(i) &= \frac{n\upsilon}{n}\left(\frac{P_t^*(i)}{P_{H,t}^*}\right)^{-\epsilon}\left(\frac{P_{H,t}^*}{P_t^*}\right)^{-\eta}\mathcal{F}_t^* \\ &= \left(\frac{P_t(i)}{P_{H,t}}\right)^{-\epsilon}\left(\frac{P_{H,t}}{P_t}\right)^{-\eta}\upsilon\mathcal{Q}_t^{\eta}\mathcal{F}_t^*, \end{aligned} \tag{C.7}$$

$$Y_t^*(j) = \frac{1-n\upsilon}{1-n}\left(\frac{P_t^*(j)}{P_{F,t}^*}\right)^{-\epsilon}\left(\frac{P_{F,t}^*}{P_t^*}\right)^{-\eta}\mathcal{F}_t^*. \tag{C.8}$$

Global demand $Y_t^d(h)$ for a generic intermediate good $h \in [0, 1]$ is the weighted average of domestic and foreign demand for this variety:

$$Y_t^d(h) = nY_t(h) + (1-n)Y_t^*(h) \, . \tag{C.9}$$

Summing up the respective Home and Foreign demand components, global demand for domestic and foreign varieties, respectively, is then given by:

$$Y_t^d(i) = \left(\frac{P_t(i)}{P_{H,t}}\right)^{-\epsilon} \left\{ \left(\frac{P_{H,t}}{P_t}\right)^{-\eta} \left[(1-(1-n)v)\mathcal{F}_t + (1-n)v\mathcal{Q}_t^{\eta}\mathcal{F}_t^*\right] \right\}, \quad \text{(C.10)}$$

$$Y_t^d(j) = \left(\frac{P_t^*(j)}{P_{F,t}^*}\right)^{-\epsilon} \left\{ \left(\frac{P_{F,t}^*}{P_t^*}\right)^{-\eta} \left[nv\mathcal{Q}_t^{-\eta}\mathcal{F}_t + (1-nv)\mathcal{F}_t^*\right] \right\}, \quad \text{(C.11)}$$

where $P_t^* = \left[nv\left(P_{H,t}^*\right)^{1-\eta} + (1-nv)\left(P_{F,t}^*\right)^{1-\eta}\right]^{\frac{1}{1-\eta}}$. Using (C.10) and (C.11), aggregate Home and Foreign output per capita is then given by

$$Y_t = \left[\frac{1}{n}\int_0^n Y_t^d(i)^{\frac{\epsilon-1}{\epsilon}} di\right]^{\frac{\epsilon}{\epsilon-1}} \quad \text{(C.12)}$$

$$= \left(\frac{P_{H,t}}{P_t}\right)^{-\eta} \left[(1-(1-n)v)\mathcal{F}_t + (1-n)v\mathcal{Q}_t^{\eta}\mathcal{F}_t^*\right] ,$$

$$Y_t^* = \left[\frac{1}{1-n}\int_n^1 Y_t^d(j)^{\frac{\epsilon-1}{\epsilon}} dj\right]^{\frac{\epsilon}{\epsilon-1}} = \left(\frac{P_{F,t}^*}{P_t^*}\right)^{-\eta} \left[nv\mathcal{Q}_t^{-\eta}\mathcal{F}_t + (1-nv)\mathcal{F}_t^*\right] . \quad \text{(C.13)}$$

In the limiting case of $n \to 0$ (which implies $P_{F,t}^* = P_t^*$), we get

$$Y_t = \left(\frac{P_{H,t}}{P_t}\right)^{-\eta} \left[(1-v)\mathcal{F}_t + v\mathcal{Q}_t^{\eta}\mathcal{F}_t^*\right] \quad \text{and} \quad Y_t^* = \mathcal{F}_t^* . \quad \text{(C.14)}$$

Combining this expression with price adjustment costs and the Home terms of trade definition $\mathcal{S}_t = P_{F,t}/P_{H,t}$ yields the resource constraints (3.17) & (3.18) reported in the main text. The real exchange rate in the limiting case is linked to $\mathcal{S}_t$ via

$$\mathcal{Q}_t = \left[(1-v)\mathcal{S}_t^{\eta-1} + v\right]^{-\frac{1}{1-\eta}} . \quad \text{(C.15)}$$

Defining Consumer Price Index (CPI) inflation Π_t as P_t/P_{t-1} and Producer Price Index (PPI) inflation as $\Pi_{H,t} = P_{H,t}/P_{H,t-1}$, equation (3.6) implies that PPI and CPI are linked via

$$\Pi_t^{1-\eta} = (1-v)\Big(\Pi_{H,t}S_{t-1}^{-1}Q_{t-1}\Big)^{1-\eta} + v(Q_t\Pi_t)^{1-\eta} . \quad \text{(C.16)}$$

In a symmetric equilibrium, the nonlinear Phillips Curve, i.e., the price setting FOC, is given by

$$\frac{Q_t}{S_t}\phi_P\left(\frac{\Pi_{H,t}}{\Pi_{H,t-1}^{\gamma}\Pi_H^{1-\gamma}}-1\right)\frac{\Pi_{H,t}}{\Pi_{H,t-1}^{\gamma}\Pi_H^{1-\gamma}}$$
$$=(1-\epsilon)\frac{Q_t}{S_t}+\epsilon MC_t+\phi_P\mathbb{E}_t M_{t,t+1}\frac{Q_{t+1}}{S_{t+1}}\frac{Y_{H,t+1}}{Y_{H,t}}\left(\frac{\Pi_{H,t+1}}{\Pi_{H,t}^{\gamma}\Pi_H^{1-\gamma}}-1\right)\frac{\Pi_{H,t+1}}{\Pi_{H,t}^{\gamma}\Pi_H^{1-\gamma}}, \tag{C.17}$$

where MC_t denotes real marginal costs and $M_{t,t+1}$ is the stochastic discount factor defined in the next section.

The firm's first-order conditions for the optimal input choice of labor and capital services are:

$$\frac{r_t^k}{P_t}=MC_t\frac{\partial Y_t}{\partial K_t^{serv}} \tag{C.18}$$
$$\frac{W_t}{P_t}=MC_t\frac{\partial Y_t}{\partial N_t} \tag{C.19}$$

Households

We assume an endogenous discount factor that decreases in the consumption output ratio (see, e.g., Kollmann, 2016):

$$\beta_t=\bar{\beta}\left[1-\phi_B\left(\frac{C_t}{Y_t}-\frac{C}{Y}\right)\right], \tag{C.20}$$

where $0\leq\bar{\beta}\leq 1$ is the pure discount factor and ϕ_B measures the slope of the discount factor.

Similarly to equation (3.1) for Home, the household in Foreign has the value function

$$V_t^*=\max\left[(1-\beta_t^*)\left(\xi_{C,t}\left(C_t^*\right)^{\varphi}\left(1-N_t^*\right)^{1-\varphi}\right)^{\frac{1-\sigma}{\theta_V}}+\beta_t^*\left(\mathbb{E}_t\left[\left(V_{t+1}^*\right)^{1-\sigma}\right]\right)^{\frac{1}{\theta_V}}\right]^{\frac{\theta_V}{1-\sigma}}, \tag{C.21}$$

which is also subject to common but not country-specific fluctuations in the demand shifter; β_t^* is defined analogously to β_t in (C.20).

The Euler equations of the Home household for Home and Foreign bonds, respectively, are

$$1 = \mathbb{E}_t \left[M_{t,t+1} \frac{R_t}{\Pi_{t+1}} \right] \quad \text{and} \quad 1 = \mathbb{E}_t \left[M_{t,t+1} \frac{R_t^* \mathcal{E}_{t+1}}{\mathcal{E}_t \Pi_{t+1}} \right] , \tag{C.22}$$

where $M_{t,t+1}$ is the stochastic discount factor derived below. The Foreign household's Euler equation for Foreign bonds is

$$1 = \mathbb{E}_t \left[M^*_{t,t+1} \frac{R_t^*}{\Pi^*_{t+1}} \right] . \tag{C.23}$$

The optimal choice for K_t is governed by

$$q_t = \mathbb{E}_t M_{t,t+1} \left(\frac{r^k_{t+1}}{P_{t+1}} u_{t+1} + q_{t+1} \left(1 - \delta(u_{t+1})\right) \right) , \tag{C.24}$$

where q is Tobin's marginal Q. The investment choice FOC is:

$$\frac{1}{q_t} = 1 - \phi_K \left(\frac{I_t}{K_{t-1}} - \delta_0 \right) \tag{C.25}$$

while the utilization decision is governed by

$$q_t \left(\delta_1 + (u_t - 1)\, \delta_2 \right) = \frac{r^K_t}{P_t} . \tag{C.26}$$

C.2 Deriving the Stochastic Discount Factor

The stochastic discount factor is given by

$$M_{t,t+1} \equiv \frac{\partial V_t / \partial C_{t+1}}{\partial V_t / \partial C_t} , \tag{C.27}$$

where

$$\frac{\partial V}{\partial C_t} = V_t^{1 - \frac{1-\sigma}{\theta_V}} \varphi (1 - \beta_t) \frac{\left(\xi_{H,t} \xi_{C,t} C_t^{\varphi} (1 - N_t)^{1-\varphi} \right)^{\frac{1-\sigma}{\theta_V}}}{C_t} \tag{C.28}$$

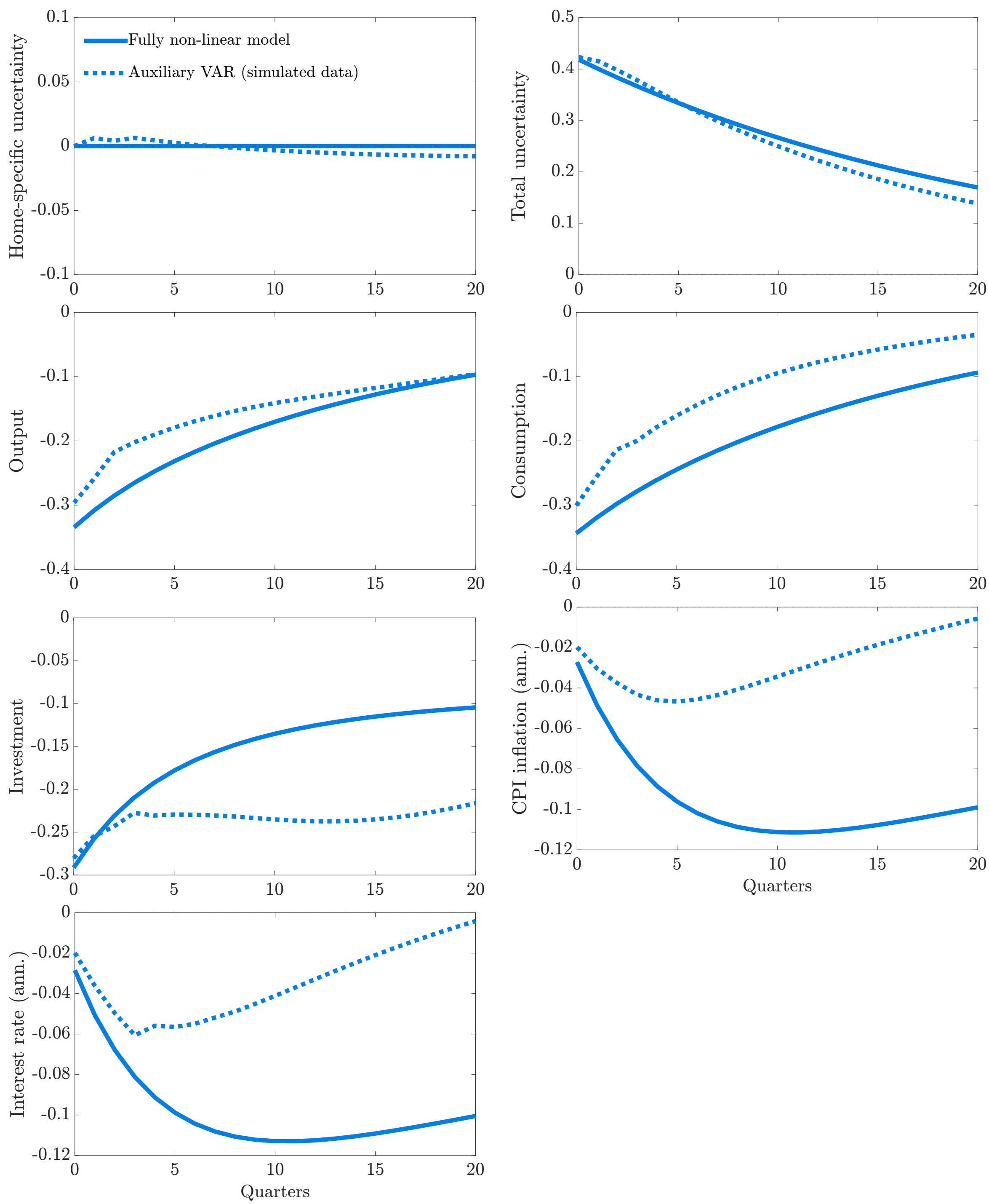
and, using the Benveniste-Scheinkman envelope theorem,

$$\begin{aligned}\frac{\partial V_t}{\partial C_{t+1}} =& \frac{\theta_V}{1-\sigma}\left((1-\beta_t)\left(\xi_{H,t}\xi_{C,t}C_t^{\varphi}\left(1-N_t\right)^{1-\varphi}\right)^{\frac{1-\sigma}{\theta_V}} + \beta_t\left(\mathbb{E}_t V_{t+1}^{1-\sigma}\right)^{\frac{1}{\theta_V}}\right)^{\frac{\theta_V}{1-\sigma}-1} \\ & \times \beta_t \frac{1}{\theta_V}\left(\mathbb{E}_t V_{t+1}^{1-\sigma}\right)^{\frac{1}{\theta_V}-1}\mathbb{E}_t\left(\left(1-\sigma\right)V_{t+1}^{-\sigma}\frac{\partial V_{t+1}}{\partial C_{t+1}}\right) \\ \overset{(C.28)}{=} & V_t^{1-\frac{1-\sigma}{\theta_V}}\beta_t\left(\mathbb{E}_t V_{t+1}^{1-\sigma}\right)^{\frac{1}{\theta_V}-1} \\ & \times \mathbb{E}_t\left(V_{t+1}^{-\sigma}V_{t+1}^{1-\frac{1-\sigma}{\theta_V}}\varphi(1-\beta_{t+1})\frac{\left(\xi_{H,t+1}\xi_{C,t+1}C_{t+1}^{\varphi}\left(1-N_{t+1}\right)^{1-\varphi}\right)^{\frac{1-\sigma}{\theta_V}}}{C_{t+1}}\right).\end{aligned} \tag{C.29}$$

Thus,

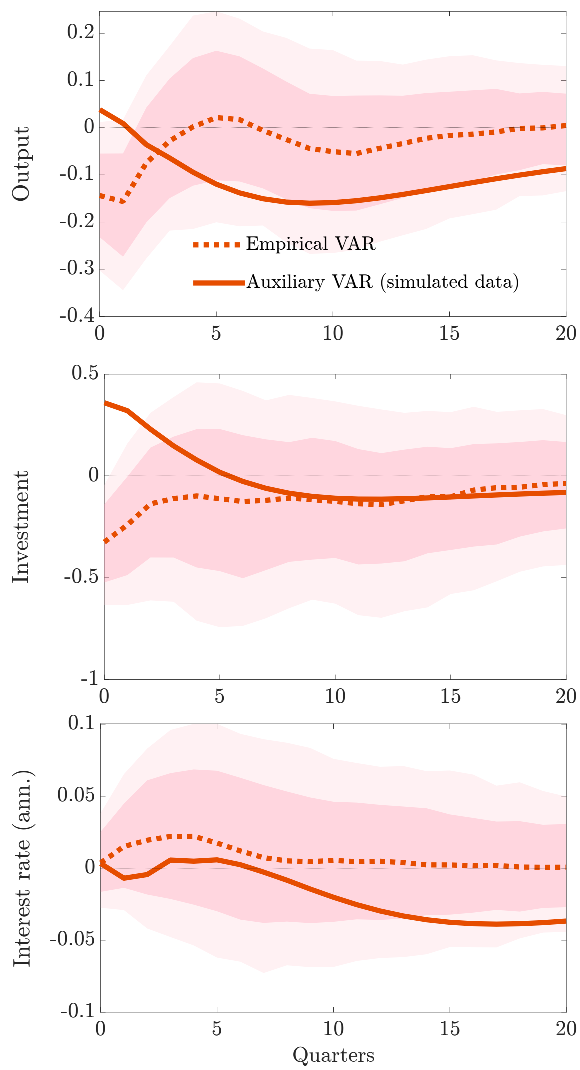
$$\begin{aligned}M_{t,t+1} \equiv \frac{\frac{\partial V_t}{\partial C_{t+1}}}{\frac{\partial V}{\partial C_t}} =& \beta_t \mathbb{E}_t \frac{1-\beta_{t+1}}{1-\beta_t} \\ & \times \left(\frac{\xi_{H,t+1}\xi_{C,t+1}C_{t+1}^{\varphi}(1-N_{t+1})^{1-\varphi}}{\xi_{H,t}\xi_{C,t}C_t^{\varphi}\left(1-N_t\right)^{1-\varphi}}\right)^{\frac{1-\sigma}{\theta_V}}\frac{C_t}{C_{t+1}}\left(\frac{V_{t+1}^{1-\sigma}}{\mathbb{E}_t V_{t+1}^{1-\sigma}}\right)^{1-\frac{1}{\theta_V}}.\end{aligned} \tag{C.30}$$

Figure C.1: Auxiliary VAR vs. non-linear responses



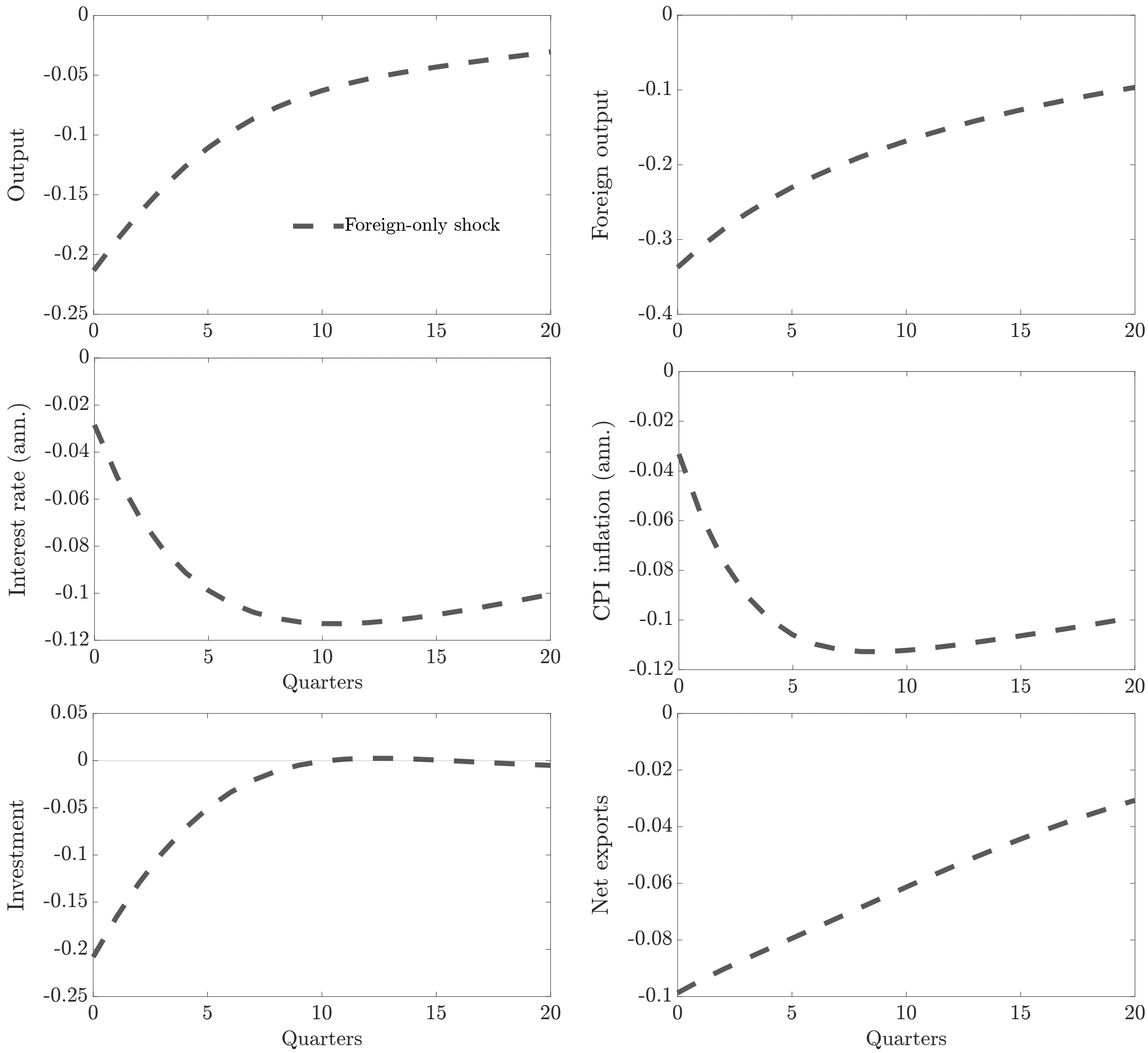
Notes: Model impulse responses to a one-standard-deviation common uncertainty shock in a monetary union according to the non-linear model (solid) and the auxiliary VAR model (dotted). Horizontal axis: quarters, vertical axis: deviations from pre-shock level in percent, except for inflation and interest rate (ppts).

Figure C.2: Model fit—external validation



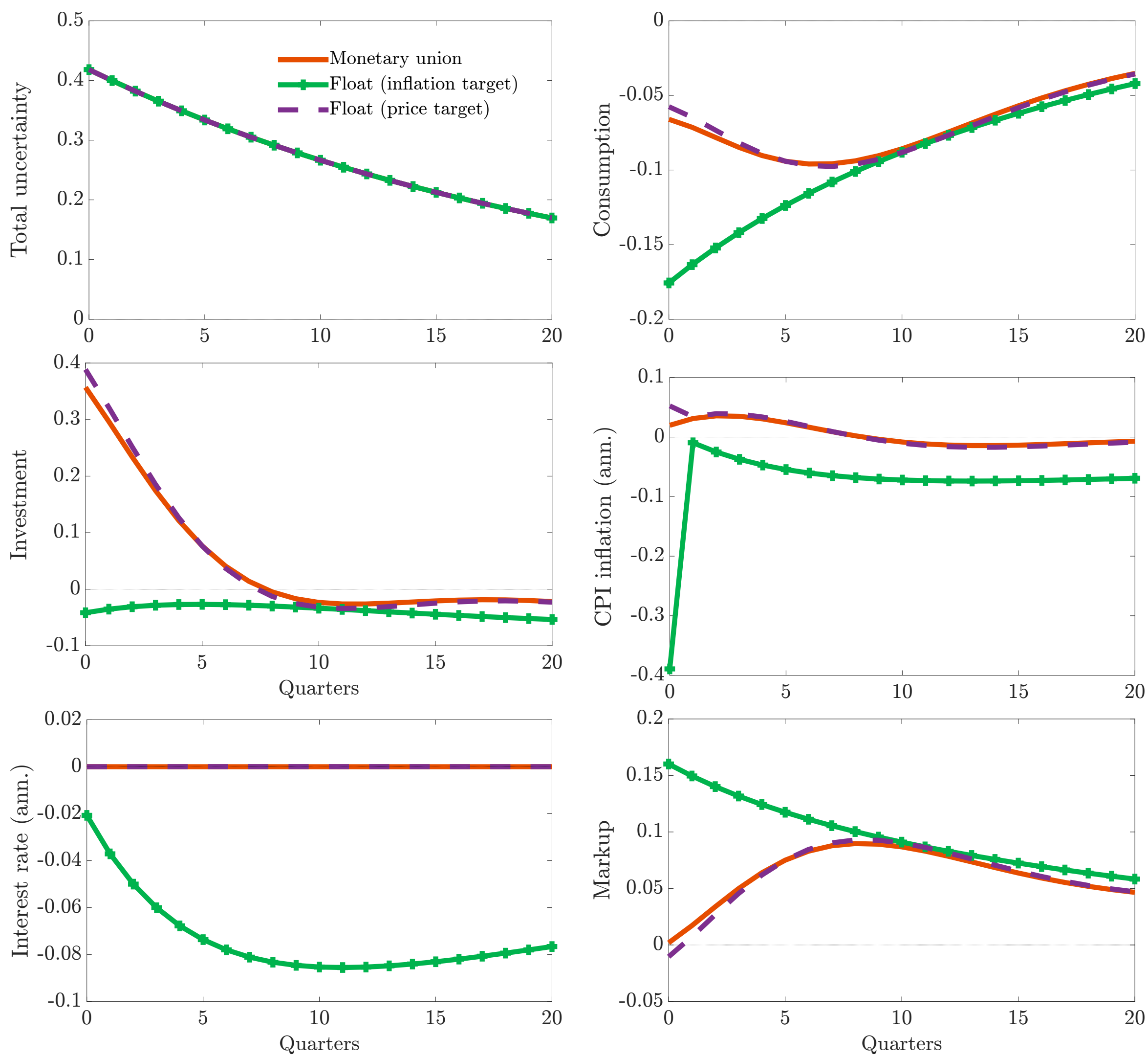
Notes: Impulse responses from auxiliary VAR (red solid line) and untargeted empirical VAR (red dotted line) to a one-standard-deviation country-specific uncertainty shock in a monetary union. Quarterly responses are in percentage deviations from the stochastic steady state, except for CPI inflation, which is in ppts. Bands are pointwise 68% (dark) and 90% (light) HPDIs.

Figure C.3: Effects of shock that only hits Foreign



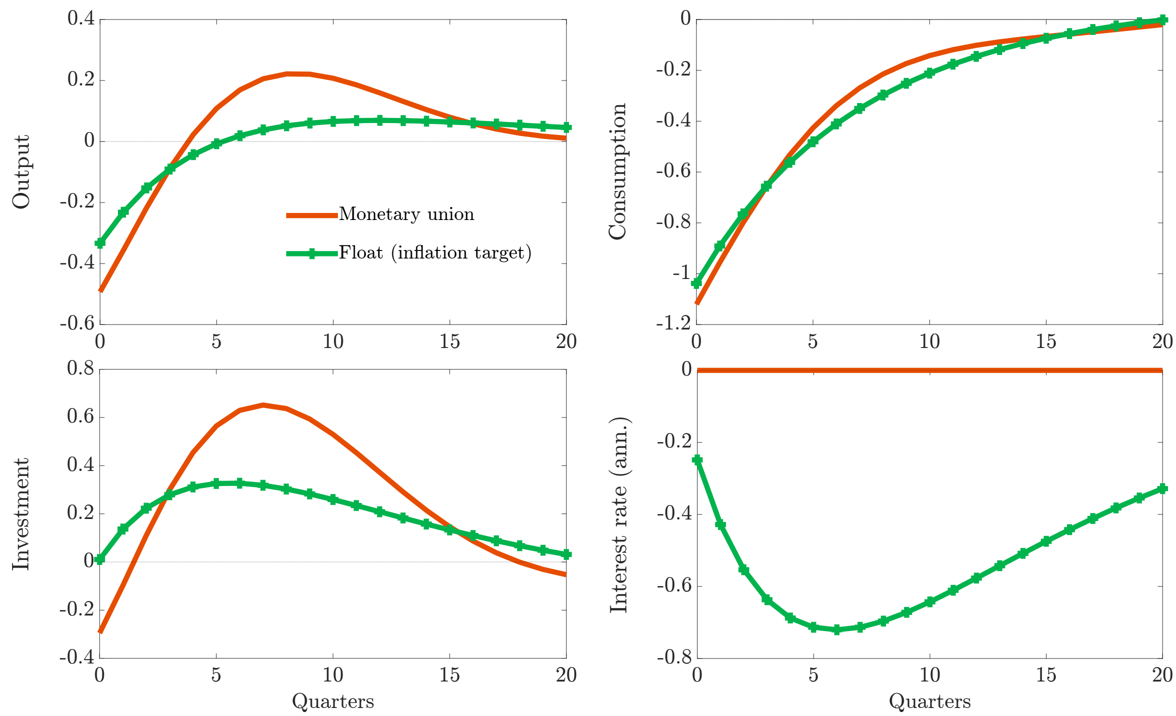
Notes: Model impulse responses to a one-standard-deviation Foreign-specific (grey dotted line) uncertainty shock in a monetary union. Quarterly responses are in percentage deviations from the stochastic steady state, except for CPI inflation and the interest rate, which are in ppts, and net exports, which are in percent of output at the stochastic steady state.

Figure C.4: Effects of country-specific uncertainty shocks with alternative policies



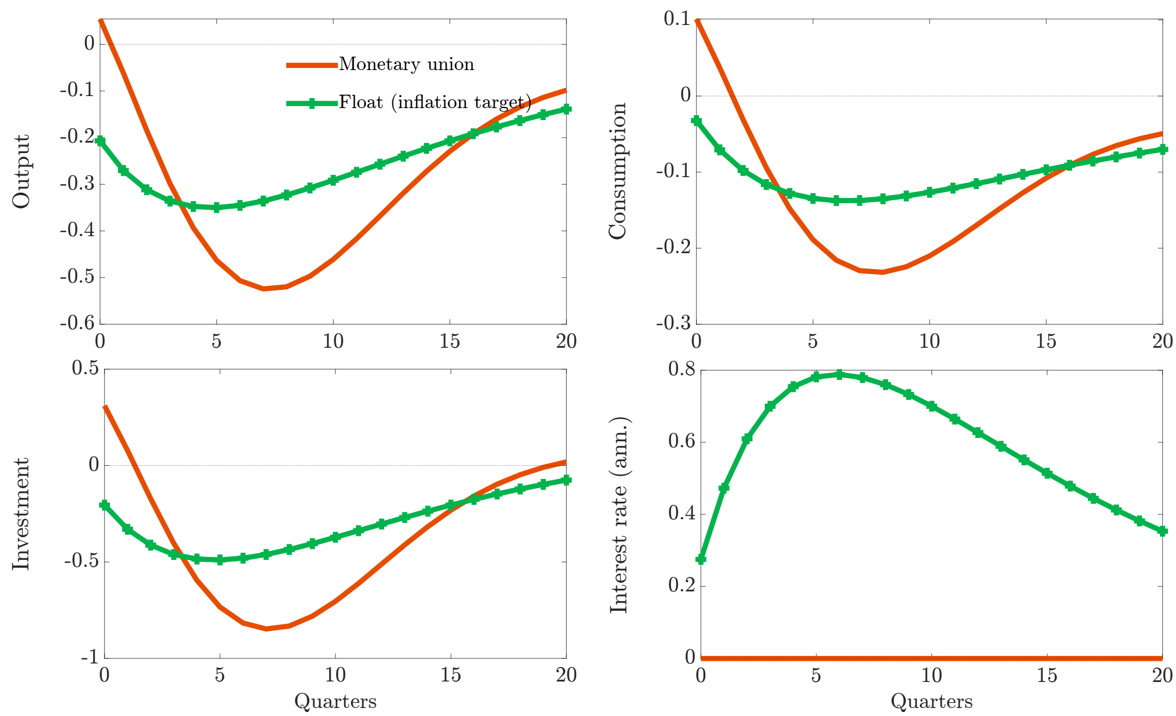
Model impulse responses to a one-standard-deviation country-specific uncertainty shock in a monetary union (red solid line), a float with inflation targeting (green solid line with plus-shaped markers), and a float with price targeting (purple dotted line). Quarterly responses are in percentage deviations from the stochastic steady state, except for CPI inflation and the interest rate, which are in ppts.

Figure C.5: Effects of country-specific level preference shock



Notes: Model impulse responses to a one-standard-deviation country-specific (red solid line) and common (green line with markers) preference shock in a monetary union. Quarterly responses are in percentage deviations from the stochastic steady state, except for the interest rate, which is in ppts.

Figure C.6: Effects of country-specific level technology shock



Notes: Model impulse responses to a one-standard-deviation country-specific (red solid line) and common (green line with markers) technology shock in a monetary union. Quarterly responses are in percentage deviations from the stochastic steady state, except for the interest rate, which is in ppts.