SVERIGES RIKSBANK

Staff memo

Global Currents, Local Waves: The Foreign Influences Shaping Sweden's Economy

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Summary

As the world grapples with rising prices, central banks are taking action. In less than two years, the US Federal Reserve, steering the world's largest economy, has hiked its interest rate by 500 basis points. This rapid shift is not just a headline for Wall Street; it has implications for economies worldwide, including ours here in Sweden.

In this staff memo, we analyse how changes in US monetary policy impact Sweden's economy. Additionally, we assess the broader influence of global economic dynamics on the Swedish economy.

For our analysis, we use the Global Vector Error Correction (GVEC) model – a standard and common tool that we have specifically tailored to the Swedish economy.

Our findings suggest that even a small increase in US interest rates can significantly slow down Sweden's economy. This is not just because of the direct effects of the US rate change on Sweden. Rather, such a shift in US policy sets off a chain reaction in the global economy, affecting many countries and markets, including those with which Sweden has close ties. This ripple effect can significantly reduce Sweden's economic growth, even when the direct effects from the US are relatively small.

In a broader context, our research reveals that almost 73% of fluctuations in the Swedish economy can be traced back to international factors. Among these, the US, the Euro area, the UK, China and Norway emerge as dominant contributors. This finding highlights the importance of global economic dynamics in shaping Sweden's economy.

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1 Introduction

In the face of global inflation concerns, central banks worldwide are taking action. Notably, the US Federal Reserve, the central bank of the world's largest economy, has been raising its policy rate. These shifts in US monetary policy have far-reaching implications, influencing economies globally. As such, understanding the impact of these changes on the Swedish economy becomes increasingly critical.

Historically, studies such as Lindbeck (1975) and Lindé (2003) show that Sweden's economy often mirrors the patterns of larger economies. Yet, more recent research by Lindé and Reslow (2017) suggests that we in Sweden might not be factoring in the full scope of this international influence in our forecasts.

In response to this need, the Riksbank developed a new model called MAJA (Corbo and Strid, 2020). This DSGE model is designed to better understand and predict how major changes in our primary trading partners, the US and the Euro area, might affect us here in Sweden. But despite this advancement, there remains a lack of empirical studies that quantify these impacts.

This memo aims to address this gap by answering two main questions. First, how do US monetary policy shocks affect Sweden's economy? For this, we are using the approach outlined in Thomas (2023) but tailored to Sweden's situation. Second, we want to understand how domestic and foreign events shape Swedish economic fluctuations.

To get our answers, we use an off-the-shelf model - the Global Vector Error Correction (GVEC) model which is like a detailed map that shows how the economies of 25 countries, plus the Euro area, interact with each other (Pesaran et al., 2004). This model allows us to see how US monetary policy shocks directly and indirectly affect Sweden's economy and also helps us in pinpointing the key factors, both at home and abroad, that contribute most to fluctuations in the Swedish economy.

We find that a slight increase in the US interest rate has notable consequences for Sweden's economy. Specifically, a 25 basis points rise in US rates leads to a direct increase of 0.04 percentage points in Swedish output. Yet, when considering secondary effects through global interactions and commodity price changes, there's an overall decrease of 0.43 percentage points in Swedish output.

Looking broadly, we see that Sweden's response to a US rate increase mirrors that of many other countries, with the cross-country effects amplifying the negative impact. Countries that are deeply connected to the global financial system or with open trade policies are especially vulnerable to negative secondary effects of a US hike. Yet, even with its significant ties to global finance and trade, Sweden showcases stronger resilience against these US monetary policy shifts compared to other globally-connected nations, while on par with the global average.

Furthermore, our analysis shows that almost 73% of Swedish output fluctuations are driven by foreign influences. Specifically, the US contributes 15%, the Euro area 8%, the UK 4%, China 3%, and Norway 3%. Additionally, commodity prices play a notable role, with metal prices accounting for about 3% and oil prices for almost 2%.

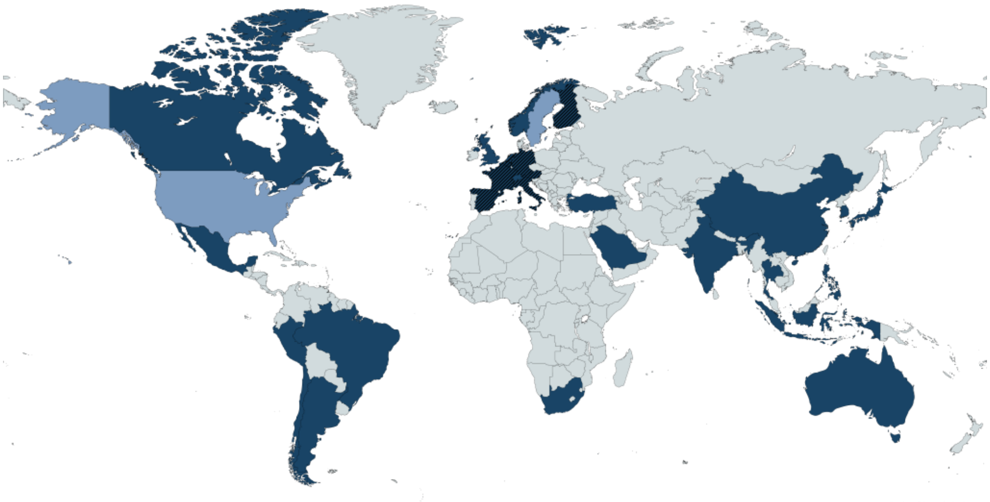
Overall, the findings underscore the interconnectedness of the global economy and align with the MAJA model's emphasis on the impact of global economic developments, particularly from the Euro area and the US, on the Swedish economy.

In the following sections, we will detail the methodology, present the results, and conclude.

2 The GVEC Model

In building an empirical model, our primary objective is to accurately capture the full view of the world's economic landscape in which Sweden operates. To achieve this, we use the Global Vector Error Correction (GVEC) model. This off-the-shelf model is comprehensive; it merges the economic data of 25 carefully chosen countries along with the Euro area. The coloured regions in Figure 1 represent the economies included in this model. Their selection ensures that we encompass a rich blend of global dynamics – from emerging markets to advanced economies, and combined, they represent 90% of world's GDP.

Figure 1: Countries and Regions Included in GVEC Model



Note: Countries include Argentina, Australia, Brazil, Canada, China, Chile, Euro area, India, Indonesia, Japan, Korea, Malaysia, Mexico, Norway, New Zealand, Peru, Philippines, South Africa, Saudi Arabia, Singapore, Sweden, Switzerland, Thailand, Turkey, United Kingdom, and the USA.

For each country or region within the GVEC model, a Vector Error Correction (VEC) model is estimated. We opt for a VEC specification, because we want to account for long-run relations between domestic and foreign variables. Essentially, this model specification helps us understand how domestic and foreign economic variables relate to each other over an extended period, not just momentarily. These models are estimated over quarterly data, spanning four decades from 1979 to 2019.[2]

The VEC model (in VAR representation)[3] for a country/region i is given by

[2] We recognize concerns regarding the potential structural break due to Sweden's transition to a floating exchange rate in 1992. However, it is crucial to understand the complexity of our GVEC model, which requires 26 countries/region-specific models to be estimated. A narrower time frame starting from 1992 would significantly limit our data points, undermining the comprehensiveness and depth of our analysis. Furthermore, we have conducted tests for structural breaks in Appendix 5.2, and the results confirm the stability of our model across the entire period.

[3] To explain the model and its variables clearly, we use a VAR representation. More details about the model and how it can be transformed into a VEC model can be found in Appendix 5.1.

$$x_{it} = a_{i0} + a_{i1}\, t + \sum_{j=1}^{p_i} \Phi_{ij} x_{i,t-j} + \sum_{j=1}^{q_i} \Lambda_{ij} x^*_{i,t-j} + \sum_{j=1}^{q_i} \Psi_{ij} \omega_{t-j} + u_{it} \qquad (1)$$

Inside each of these VEC models, we have key economic indicators x_{it}: real GDP, inflation, real exchange rate, equity prices, and both short-term and long-term interest rates (where data is available). Since no country exists in isolation, each of our VEC models also considers what is happening in other countries j. That is captured in foreign variables $x^*_{it} = \sum_{j=0}^{N} w_{ij} x_{jt}$, which is essentially a weighted average of other countries' domestic variables, with the weights defined by bilateral trade flows. The individual economies are also affected by global commodity markets, which we can denote as ω_t: oil, raw materials, and metals. Whether a country imports or exports these commodities, its economy can be significantly shaped by their price fluctuations. It's important to note that these commodity prices don't exist in a vacuum; they are in turn also influenced by the global economy, with dominant economies wielding more significant impact. Please refer Appendix 5.1 for an in-depth examination of how commodity prices are modelled.

A standout feature of the GVEC model is its capacity to differentiate between the direct and indirect effects due to cross-country effects and commodity price fluctuations. By disabling specific feedback mechanisms within the individual VEC models, we can achieve this distinction.

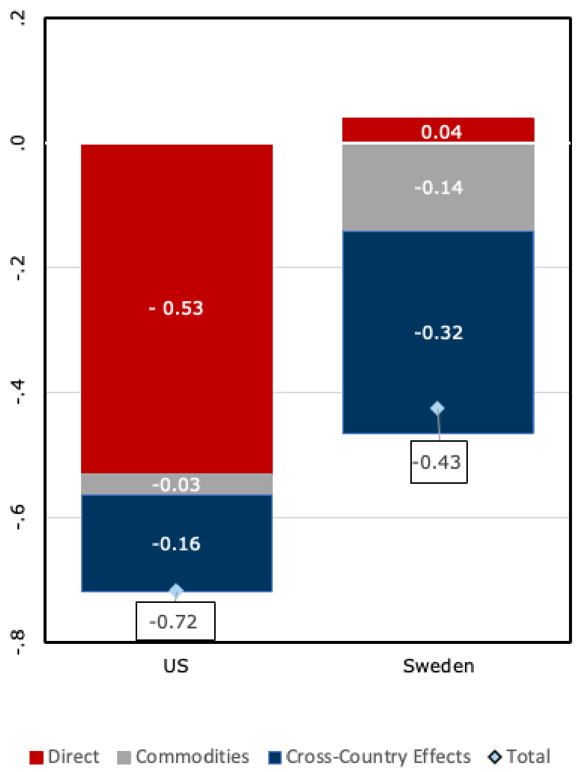
After we have estimated the individual VEC models, we stack them and solve them together to arrive at the GVEC model.

In Appendix 5.1, we provide a detailed overview of the GVEC model's technicalities. Additionally, we check that the estimated GVEC model is valid and we verify that the model filters out global comovements such that we are able to isolate pure spillover effects. We have also detailed the identification of the US monetary policy shock and presented the derived structural impulse response functions.

3 Results

Figure 2 illustrates the *cumulative* impact of a 25 basis points hike by the US Fed on both the US and Swedish economy after 8 quarters. The direct effect is depicted in red, while the indirect influences via cross-country interactions and commodity price changes are shown in blue and gray respectively.[4]

Figure 2: Impact of US Monetary Policy Tightening on US and Swedish Real Output Growth



Note: impact on output growth after 8 quarters cumulatively after 25 basis points US monetary policy hike.

In the US, we see a cumulative decline of about 0.53% in its economic output over two years due to the rate hike, as reflected in Figure 1. But this economic downturn is not contained within its borders. As the ripples spread to other countries and markets, it initiates a feedback loop, intensifying the downturn due to the additional drag from cross-country effects and commodity price fluctuations. In essence, the initial recession in the US affects other economies, and the subsequent downturns in those countries then circle back to further dampen the US economy.

The impact on Sweden is more complex. At first glance, Sweden seems to benefit, with a modest direct effect of 0.04% cumulative growth after two years, as illustrated in red in Figure 1. This positive impact emerges as US bonds, now yielding higher returns, draw

[4] We report the cumulative effect after 8 quarters. Note that our magnitudes of the estimates of US monetary policy spillovers are in line with the findings in the existing literature (see Table 2 in Georgiadis (2016) for an overview).

the attention of global investors. The allure of these US investments can lead to a capital shift away from countries like Sweden, leading the Swedish krona to lose some of its strength compared to the dollar. A weaker krona has a silver lining: it makes Swedish exports more affordable, leading to an uptick in Swedish sales, hence the initial positive bump for Sweden's economy.[5]

But that is not the full story. Beyond the direct effects, global dynamics set in. Figure 1 shows that the modest uptick on Sweden's economy turns into a significant negative impact when taking into account global interactions and commodity price shifts.

Miranda-Agrippino and Rey (2020) found that monetary contractions in the US cause a ripple effect: global banks pull back, domestic credit drop worldwide, international lending slows down, and financial conditions abroad tighten. As a result, businesses and people across the globe become wary. The global caution leads to economic slowdowns outside the US. As Sweden engages with this interconnected global landscape, it experiences these secondary, cross-country effects.[6]

Furthermore, the ensuing global slowdown can cause global demand for commodities like metals, raw materials and oil to drop. This can lower their prices. Since Sweden sells metals and raw materials to other countries, lower prices mean it earns less from these sales, which can hurt its economy. Oil, however, is a different story. As Thomas (2023) points out, US monetary policy shocks don't really change oil prices. Instead, OPEC's decisions determine the oil price. But, since oil is priced in dollars and the krona's value drops compared to the dollar, oil can become more expensive for Sweden. This means that Sweden's energy costs rise, adding another challenge to its economy.

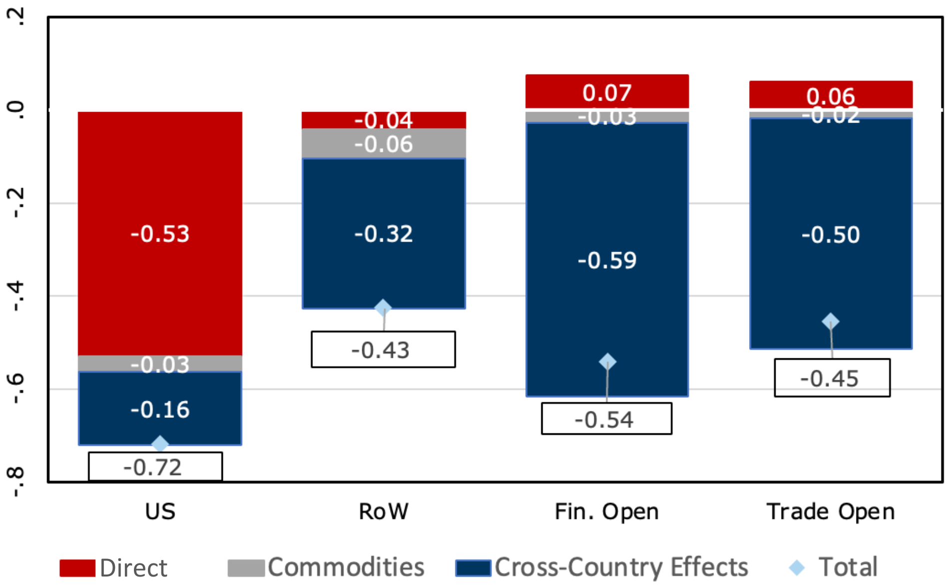
In Figure 3, we see that Sweden's response to a US rate increase is mirrors that of many other countries, with the cross-country effects amplifying the negative impact. Most countries, especially those deeply connected to the global financial system or with open trade policies, are significantly adversely impacted by a Fed hike.

So, where does Sweden fit in all this? Even though Sweden is closely tied to global finance and trade, it handles these shifts reasonably well. Compared to other globally integrated economies, Sweden demonstrates a relatively stronger resilience against these US monetary policy shocks.

[5] The depreciation of the Swedish krona, while potentially beneficial for exports in the short term, is not without its drawbacks. A weakened krona means imports become more expensive, putting pressure on domestic costs, including essential imports. It can also amplify inflationary pressures and erode purchasing power for consumers.

[6] For example, if Germany, a major trading partner of Sweden, slows down because of these global effects, they might buy fewer Swedish goods. This can hurt Sweden's exports and economy. Similarly, if global uncertainties make Norwegian investors nervous, they might invest less in Sweden.

Figure 3: Amplified impact on financially and trade open economies, underlining global interconnectedness

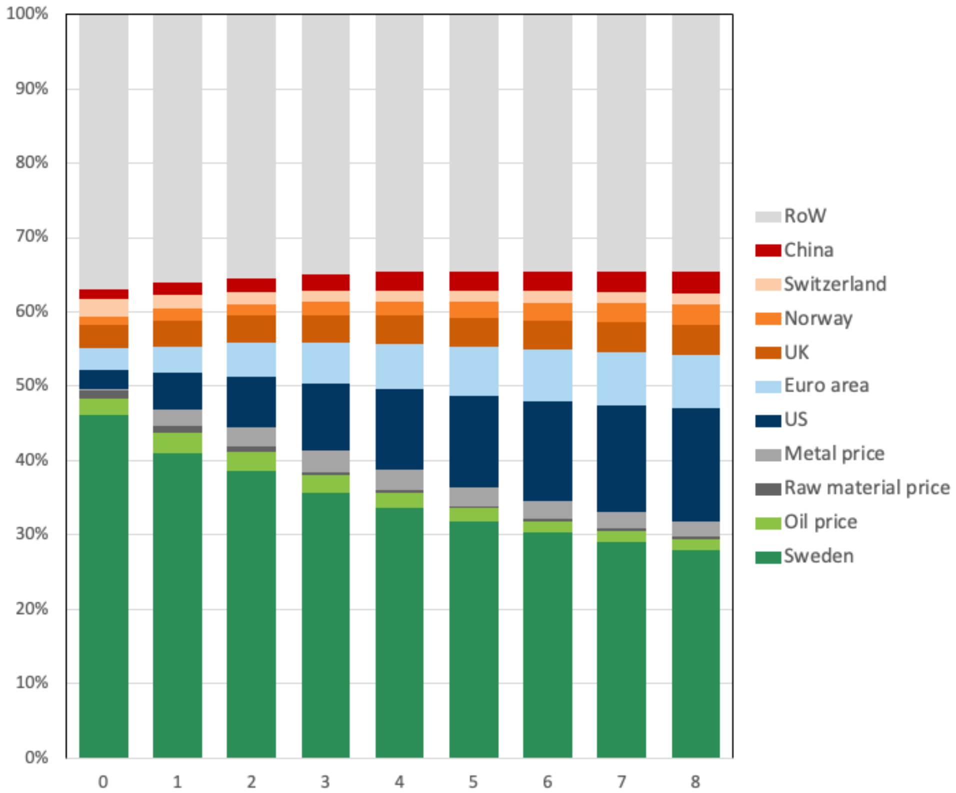


Note: impact on output growth after 8 quarters cumulatively after 25 basis points US monetary policy hike. Rest of the world (RoW) is the average of all countries included in the GVEC model except for the US. Financially open countries, as determined by the KOF Financial Globalization Index, encompass Australia, Canada, the Euro Area, Norway, New Zealand, Sweden, Switzerland, the UK, Peru, and Singapore. Trade open countries, as defined by the KOF Trade Globalization Index, include Australia, the Euro Area, Malaysia, Norway, New Zealand, Saudi Arabia, Singapore, Sweden, Switzerland, Thailand, and the United Kingdom

Taking a broader perspective, Figure 4 illustrates the myriad of factors influencing the Swedish economy. The forecast error variance decomposition indicates that almost 73% of the fluctuations in Sweden's economy can be traced back to foreign influences. Notably, the US emerges as a key contributor. About 15% of Sweden's economic fluctuations are linked to shocks in the US. Of this, the US stock market alone accounts for 10%. The Eurozone and the UK are other major influencers, accounting for 8% and 4% respectively to Sweden's fluctuations. China influences another 3%, largely due to its vast production and trade activities. Additionally, neighbouring Norway contributes 3% to these fluctuations.

Among these international factors, commodities also play a part. Oil prices determine around 2% of the shifts in Sweden's economy, while metal prices, given Sweden's status as a significant metal exporter, influence a notable 3%.

Figure 4: Forecast Error Variance Decomposition of Swedish Real GDP



Note: foreign influences account for almost 73% of Swedish output fluctuations after 8 quarters. The US, Euro area, UK, China, and neighbour Norway are key contributors, explaining 15%, 8%, 4%, 3%, and 3% of changes respectively. The US stock market alone accounts for 10%. Notably, China's contribution is primarily driven by its own output. Metal prices, significant for Sweden as a metal exporter, explain about 3%, while oil prices, with Sweden as an importer, account for almost 2%. The other European country in the sample, Switzerland, explains 1%. Rest of the world includes Argentina, Australia, Brazil, Canada, Chile, India, Indonesia, Japan, Korea, Malaysia, Mexico, New Zealand, Peru, Philippines, Saudi Arabia, Singapore, South Africa, Thailand, and Turkey.

4 Concluding Remarks

Our analysis provides insights into the impact of international shocks on Sweden's economy. It's evident that in today's globally connected world, monetary shifts in major economies, such as the US, create significant ripples across continents, affecting countries such as Sweden.

At first glance, Sweden might appear to be minimally impacted by shifts in US monetary policy. Yet, the secondary effects of a Fed rate increase have tangible consequences for the Swedish economy. Our analysis indicates that a 25 basis points hike in US monetary policy results in a 0.43 percentage points contraction in Swedish output, due to cross-country interactions and commodity price fluctuations.

Our data also suggests that almost 73% of Sweden's economy is shaped by global events. Notably, the US is a major driver, accounting for 15% of economic variations in Sweden. Additionally, the Eurozone, UK, China and Norway contribute to 8%, 4%, 3% and 3% of these changes, respectively. Given these insights, it's crucial for policymakers to closely track economic developments in major world economies.

The Riksbank has already taken steps to incorporate these insights into its policy-making with the development of the MAJA model, which explicitly considers the impacts of global economic developments. This study provides empirical support for the approach adopted by the MAJA model and underscores its relevance in today's interconnected global economy. As we move forward in this era of rising interest rates, these findings offer valuable insights for future policy considerations in Sweden.

5 Appendix

5.1 GVEC Model Details

The analysis employs the GVEC methodology, originally proposed by Pesaran et al. (2004). The GVEC model is a multi-country framework that consists of country/region-specific vector error-correction (VEC) models. The use of VEC models, as opposed to a Vector Autoregressive (VAR) model, allows for the consideration of long-run relationships among the domestic variables. The model for country i (in VAR representation) is given by:

$$x_{it} = a_{i0} + a_{i1}\, t + \sum_{j=1}^{p_i} \Phi_{ij} x_{i,t-j} + \sum_{j=1}^{q_i} \Lambda_{ij} x^*_{i,t-j} + \sum_{j=1}^{q_i} \Psi_{ij} \omega_{t-j} + u_{it} \tag{1}$$

In this model, the vector of constants is denoted by a_{i0}, and the coefficients vector associated with a time trend t is represented by a_{i1}. The matrices of coefficients are Φ_{ij}, Λ_{ij}, and Ψ_{ij}. The idiosyncratic country-specific shocks are encapsulated in the vector u_{it}, which are assumed to be serially uncorrelated zero-mean processes. The vector x_{it} includes country i's domestic variables, such as real output, inflation, real exchange rate, real equity prices, and both long and short-term interest rates, when available.

The foreign variables, $x^*_{it} = \sum_{j=0}^{N} w_{ij} x_{jt}$, are constructed as the weighted averages of the corresponding domestic variables of the other j countries, with weights w_{ij} being the bilateral trade flows. The national economies are also influenced by the prices of oil, metal, and raw materials, which follow the process ω_t:

$$\omega_t = \mu_0 + \mu_1 t + \sum_{j=1}^{\tilde{p}} \Psi_j \omega_{t-j} + \sum_{j=1}^{\tilde{q}} \Lambda_j \widetilde{W} x_{t-j} + \eta_t \tag{2}$$

The vectors of constants and time trend coefficients are represented by μ_0 and μ_1 respectively, while Ψ_j and Λ_j are matrices of coefficients, and η_t is the error term. The term $\widetilde{W} x_{t-j}$ are GDP-weighted averages of all countries' domestic variables, capturing the feedback effects from all countries on the prices of oil, metal, and raw materials.

The country-specific models in (1) are then transformed into the corresponding vector error correction form, which allows to distinguish between short-run and long-run relations and interpret long-run relations as 'cointegrating'. More specifically, the error correction terms allow for cointegration within x_{it} and between x_{it} and x^*_{it}, and therefore across x_{it} and x_{jt}, for $i \neq j$. In this way, the transmission channels are embedded in the GVEC model through the estimated cointegration vectors. The country-specific VEC models are estimated separately conditional on x^*_{it} and ω_t, which are assumed to be weakly exogenous (see Appendix 5.2).

Finally, the estimated country/region-specific models are stacked and solved simultaneously to yield the GVEC equation.

$$\boldsymbol{y}_t = \boldsymbol{c}_0 + \boldsymbol{c}_1\, t + \sum_{j=1}^{p} \boldsymbol{C}_j y_{t-1} + \epsilon_t \qquad (3)$$

with $\boldsymbol{y}_t = (\boldsymbol{x}'_t, \omega'_t)'$; $\boldsymbol{c}_j = \begin{bmatrix} \boldsymbol{G}_0 & -\Psi_0 \\ \boldsymbol{0}_{m_\omega \times k} & \mathbb{I}_{m_\omega} \end{bmatrix}^{-1} \begin{bmatrix} \boldsymbol{a}_j \\ \mu_j \end{bmatrix}, j = 0{,}1;$

$C_j = \begin{bmatrix} \boldsymbol{G}_0 & -\Psi_0 \\ \boldsymbol{0}_{m_\omega \times k} & \mathbb{I}_{m_\omega} \end{bmatrix}^{-1} \begin{bmatrix} \boldsymbol{G}_j & \boldsymbol{\Psi}_j \\ \boldsymbol{\Lambda}_{jj} & \boldsymbol{\Phi}_j \end{bmatrix}, j = 1, \dots, p;$

$\epsilon_t = \begin{bmatrix} \boldsymbol{G}_0 & -\Psi_0 \\ \boldsymbol{0}_{m_\omega \times k} & \mathbb{I}_{m_\omega} \end{bmatrix}^{-1} \begin{bmatrix} \boldsymbol{u}_t \\ \mu_t \end{bmatrix},$

$$\boldsymbol{G}_0 = \begin{pmatrix} (\mathbb{I}_{k_0}, -\boldsymbol{\Lambda}_{oo})\boldsymbol{W}_0 \\ (\mathbb{I}_{k_1}, -\boldsymbol{\Lambda}_{1o})\boldsymbol{W}_1 \\ \vdots \\ (\mathbb{I}_{k_N}, -\boldsymbol{\Lambda}_{No})\boldsymbol{W}_N \end{pmatrix}; \ \boldsymbol{G}_j = \begin{pmatrix} (\boldsymbol{\Phi}_{0j}, -\boldsymbol{\Lambda}_{oj})\boldsymbol{W}_0 \\ (\boldsymbol{\Phi}_{1j}, -\boldsymbol{\Lambda}_{1j})\boldsymbol{W}_1 \\ \vdots \\ (\boldsymbol{\Phi}_{Nj}, -\boldsymbol{\Lambda}_{Nj})\boldsymbol{W}_N \end{pmatrix}, j = 1, \dots, p$$

with $\boldsymbol{W}_i$ the link matrix containing w_{ij}.

Note that by setting $x^*_{it} = x_{US,t}$ in (1), indirect effects of US monetary policy through cross-country interactions can be excluded. Similarly, by removing the feedback effects' term in (2), indirect effects through commodity prices can be precluded, implying that a US monetary policy shock does not propagate via a change in oil, metal, and raw material prices to the rest of the world.

Given the GVEC equation in (3), we can estimate the impact of a US monetary policy shock, represented as $v_{\ell t}$, using a structural impulse response.

$$SGIRF(\boldsymbol{y}_t; \boldsymbol{v}_{\ell t}; n) = \frac{\boldsymbol{e}'_j \boldsymbol{B}_n \left(\boldsymbol{P}_{H_0} \begin{bmatrix} \boldsymbol{G}_o & -\boldsymbol{\Psi}_0 \\ \boldsymbol{0}_{m_\omega \times k} & \mathbb{I}_{m_\omega} \end{bmatrix} \right)^{-1} \Sigma_v \boldsymbol{e}_\ell}{\sqrt{\boldsymbol{e}'_\ell \Sigma_v \boldsymbol{e}_\ell}} \qquad (4)$$

Here, $\boldsymbol{e}$ is a selection vector. $\boldsymbol{B}_n = \sum_{j=1}^{p} \boldsymbol{C}_j \boldsymbol{B}_{n-j}$ is derived recursively from the MA presentation of (3): $\boldsymbol{y}_t = \epsilon_t + \boldsymbol{B}_1 \epsilon_{t-1} + \boldsymbol{B}_2\, \epsilon_{t-2} + \cdots$. To structurally identify a US monetary policy shock, the US short-term interest rate is placed after the commodity prices, long-term interest rate, equity prices, inflation, and real output in the US model, following the 'recursiveness assumption' suggested by Christiano et al. (1999). The other countries are unordered in the model.

The identification of the shock is embedded in $\boldsymbol{P}$ in the equation. The matrix $\boldsymbol{P}$ is defined as:

$$\boldsymbol{P}_{H_0} = \begin{pmatrix} \boldsymbol{P} & 0 & 0 & 0 \\ 0 & \mathbb{I}_{k_1} & 0 & 0 \\ 0 & 0 & \ddots & 0 \\ 0 & 0 & 0 & \mathbb{I}_{k_N} \end{pmatrix} \text{ and } \Sigma_v = Cov(\mathbf{v}_t)$$

with $\mathbf{v} = \left[\left(\boldsymbol{P} \begin{pmatrix} \eta_n \\ \boldsymbol{u}_{0t} \end{pmatrix} \right)', \boldsymbol{u}'_{1t}, \dots, \boldsymbol{u}'_{Nt} \right].$

5.2 Estimation and Validation

We estimate this GVEC model over the time period from the second quarter of 1979 to the fourth quarter of 2019, using quarterly data sourced from Mohaddes and Raissi (2020).

The validity of the estimated GVEC model rests on two fundamental assumptions. The first assumption is that foreign variables are weakly exogenous.[7] As shown in Table 1, this hypothesis is only rejected for a handful of smaller countries' variables. The concern would be more significant if weak exogeneity were rejected in larger economies such as the US or the euro area models. As anticipated, the US foreign real equity prices and foreign interest rates do not pass the test and are consequently excluded from the US model.

Table 1: F-Statistics for testing weak exogeneity of the foreign and global variables

		y^*	π^*	q^*	e^*	i^{S*}	i^{L*}	p^{oil}	p^{mat}	p^{met}
Argentina	F(2,138)	1.43	1.30	0.50	-	3.83*	0.82	3.44*	2.68	2.33
Australia	F(4,141)	1.26	2.11	0.90	-	0.64	1.89	0.42	1.75	0.17
Brazil	F(2,140)	3.33*	0.73	0.86	-	0.40	1.61	0.88	0.46	0.64
Canada	F(4,141)	2.52*	3.69*	0.64	-	0.94	0.34	2.01	1.74	0.85
China	F(1,141)	0.00	1.67	0.00	-	0.87	3.19*	0.52	0.27	2.56
Chile	F(2,138)	1.16	0.15	1.40	-	0.63	1.07	0.82	1.82	2.69
Euro Area	F(1,129)	0.91	0.48	3.33	-	2.99	2.86	0.64	0.15	0.93
India	F(2,138)	1.08	0.87	1.89	-	2.44	0.89	0.21	0.47	0.80
Indonesia	F(2,140)	1.91	1.07	1.22	-	1.07	1.39	0.33	0.09	0.33
Japan	F(2,136)	3.95*	0.31	0.72	-	2.80	0.02	0.45	1.07	2.78
Korea	F(3,135)	0.09	0.46	0.91	-	1.19	1.72	1.01	0.88	0.01
Malaysia	F(2,144)	2.71	4.12*	2.29	-	4.25*	0.29	3.15*	1.36	1.30
Mexico	F(4,143)	0.45	4.26*	0.82	-	1.07	0.79	1.66	1.36	1.70
Norway	F(3,135)	1.04	1.69	0.54	-	1.02	2.24	0.30	0.25	0.79
New Zealand	F(3,135)	1.55	1.02	0.54	-	2.10	1.75	2.80*	1.45	3.43*
Peru	F(2,140)	0.38	0.95	0.61	-	0.78	0.13	2.25	0.12	0.59
Philippines	F(1,139)	1.69	2.88	2.84	-	0.41	1.64	7.21*	5.47*	9.97*
South Africa	F(1,137)	0.10	2.35	0.37	-	1.90	0.30	0.60	2.84	0.24
Saudi Arabia	F(1,143)	0.00	0.85	1.67	-	0.96	0.00	0.66	0.88	0.41
Singapore	F(1,139)	7.75	0.05	6.93*	-	2.60	1.07	1.51	0.61	11.00 *
Sweden	F(2,136)	0.49	0.27	0.16	-	0.53	0.51	0.75	0.15	2.24
Switzerland	F(3,135)	1.53	0.37	0.81	-	0.36	0.81	1.54	1.04	0.82
Thailand	F(3,137)	1.21	0.67	0.80	-	0.98	3.75*	0.05	0.33	0.41
Turkey	F(1,141)	2.11	1.91	0.01	-	0.20	0.08	0.05	0.29	0.25
United Kingdom	F(1,137)	2.22	0.93	0.02	-	0.30	1.03	3.39	0.64	0.16
USA	F(2,134)	2.17	1.28	-	0.88	-	-	0.95	2.81	2.72

Source: own calculations. Note: * rejected at the 5% significance level. y real output, π inflation, q equity prices, e real exchange rate, i^S short-term interest rate, i^L long-term interest rate, p^{oil} oil prices, p^{met} metal prices, and p^{mat} raw material prices.

[7] The assumption of weak exogeneity in the context of cointegrating models implies no long-run feedback from the domestic variables, x_{it}, to the foreign variables $x_{it}{}^*$, and commodity prices ω_t, without necessarily ruling out any lagged short-run feedback between the two set of variables. Technically, this means that the error correction term of the country-specific VEC model – which measure the extent of disequilibria in the domestic economy – does not affect the foreign variables and commodity prices significantly. Thus, while fluctuations abroad have a direct influence on the domestic variables, they are not affected immediately by developments in the domestic economies.

The second assumption is that the parameters of the country-specific models remain stable over time. Table 2 presents the outcomes of the structural stability tests conducted in this study. The tests considered include the maximal OLS cumulative sum (CUSUM) (PKsup), its mean square variant (PKmsq), the Nyblom-test, the Wald form of the likelihood ratio statistic (QLR), the mean Wald statistic (MW), the Wald statistic based on the exponential average (APW), and their robust versions. The 90%-critical values are computed under the null hypothesis of parameter stability, calculated using sieve bootstrap samples from the GVEC solution.

Table 2: Tests for parameter constancy per variable across the country-specific models

	Domestic variables						Numbers	%
	y [26]	π [26]	q [19]	e [25]	i^S [25]	i^L [12]		
PK_{sup}	0	3	0	1	1	0	5	3.8
PK_{msq}	2	0	0	0	0	0	2	1.5
Nyblom	1	2	0	2	4	3	12	9.0
robust-Nyblom	0	0	0	1	1	1	3	2.3
QLR	6	12	6	6	17	9	56	42.1
robust-QLR	2	3	1	2	3	1	12	9.0
MW	2	4	4	5	4	5	24	18.0
robust-MW	0	2	0	4	1	2	9	6.8
APW	8	12	6	6	16	9	57	42.9
robust-APW	2	3	1	3	2	2	13	9.8

Source: own calculations. Note: y real output, π inflation, q equity prices, e real exchange rate, i^S short-term interest rate, i^L long-term interest rate. Number of rejections of the null of parameter constancy per variable across the country-specific models at the 1% level. Statistics with the prefix 'robust' denote the heteroscedasticity-robust version of the tests. All tests are implemented at the 1% significance level.

The test results show minimal variation across variables, but significant variation across the tests. The rate of rejection is highly dependent on whether heteroscedasticity-robust versions of these tests are employed. This suggests that when changes in error variances are accounted for, the parameter coefficients exhibit reasonable stability. The rejections in the non-robust versions of Nyblom, QLR, MW, and APW are driven by breaks in error variances rather than the parameter coefficient (Stock and Watson, 2002). To accommodate this, bootstrapping is used for the impulse response analysis.

Based on our findings, our estimated GVEC model meets these two conditions, confirming its validity.

Lastly, we verify that our GVEC model accurately measures spillover effects and not just comovement between countries. By conditioning the country-models on weakly exogenous foreign variables, the correlations of the remaining shocks across countries are filtered out. Table 3 presents the average cross-sectional correlations. The correlations among variables in levels are high, ranging from approximately 30% to 95%. These correlations decrease after first differencing, but remain substantial. However, the country-models conditioned on the foreign variables (VECMX*) filter out most of the comovement, as the correlation of the residuals are close to zero.

Table 3: Cross-sectional averages of the average pairwise correlations

	Levels	First Diff.	VECMX* Residuals
Real output	0.96	0.14	-0.00
Inflation	0.33	0.07	0.03
Real equity prices	0.68	0.44	-0.01
Short-term interest rate	0.58	0.08	0.02
Long-term interest rate	0.88	0.35	0.00

Source: own calculations.

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