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Abstract

This paper uses the endogenous regime switching model with dynamic feedback and interactions developed by Chang et al. (2023) to estimate global food price mean and volatility indicators, the latter measuring uncertainty and risk in the global food market. Both are then included in structural VAR models to examine their effects on domestic food price inflation for a range of countries with different food shares in total consumption and in the CPI basket. Next, counterfactual analysis is carried out to assess the effects on core inflation. The results suggest that both global food price mean and volatility shocks have sizeable effects on food price inflation in all countries and persistent second-round effects on core inflation in most countries. An extension of the analysis using disaggregate global food price data shows that the existence of second-round effects is independent of the size of the response of domestic food inflation to global food price shocks. These findings imply that policymakers should distinguish carefully between the two types of global food price shocks (namely mean or volatility) and their effects on core inflation to formulate appropriate policy responses.

Keywords: Food price volatility, core inflation, endogenous regime-switching, second-round effects

JEL Classification: C13, C58, E31, Q10

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1. Introduction

It is often argued that monetary authorities aiming to achieve price stability should target core rather than headline inflation, since the latter includes highly volatile food and energy prices that introduce noise and are not informative about medium- to long-term inflation trends (Giri, 2022). Indeed, most central banks around the world place greater emphasis on core rather than headline inflation when designing monetary policy. Two important issues arise in this context, i.e. exactly how volatile food and energy prices are and to what extent they affect core inflation. While plenty of evidence is available in the case of energy prices (see, for instance, Ferderer, 1996; Elder and Serletis, 2010; Kilian and Lewis, 2011; Wong, 2015), much less is known about food prices. As stressed by De Gregorio (2012), central banks should not overlook food price inflation since it has significant effects on core inflation, which appear to be particularly strong in countries with a large food share in the consumption basket. For this reason the present paper aims to provide new, extensive evidence on the inflationary impact of shocks to global food prices and their volatility and to assess their second-round effects on core inflation.

Specifically, we apply the endogenous regime-switching model with dynamic feedback and interactions developed by Chang et al. (2023) to monthly data on the United Nations Food and Agriculture Organization (FAO) nominal food price index from January 1990 to October 2023. The commodities included in this index represent around 40% of gross agricultural food commodity trade and can be informative about future global food inflation. The chosen model produces measures of both global food price mean and volatility, where the latter reflects uncertainty and risk in the global food market. Distinguishing between the two is of crucial importance for central banks to adopt appropriate policy responses depending on the type of shock. The estimated mean and volatility indicators are then included in a structural VAR model with sign restrictions to assess their effects on domestic food price inflation. Next, counterfactual analysis is used to examine possible second-round effects on core inflation. Finally, further evidence is obtained by using the real and the disaggregate nominal FAO food price indices. The analysis is carried out for eight countries with different food shares of total consumption and in the CPI basket, namely the US, the UK, the euro area, Canada, Japan, South Korea, Mexico and Denmark.

On the whole, this paper makes a fivefold contribution. First, it applies the recently developed endogenous regime switching model due to Chang et al. (2023) to derive measures of both global food price mean and volatility; compared to other methods the adopted one has the advantage of allowing for unsynchronised switches in the mean and in the volatility, which are determined by latent factors, and also of accounting for possible feedback from past innovations. Second, it uses the FAO food price index, which measures specifically food prices (both aggregate and disaggregate) as opposed to the overall commodity prices which are often analysed in other studies (see, e.g., Gelos and Ustyugova, 2017; Abbas and Lan, 2020). Third, it performs a VAR analysis with an appropriate identification scheme to examine the effects of global food price mean and volatility shocks. Fourth, it assesses the second-round effects of global food price shocks on core inflation by means of counterfactual analysis. Fifth, it also provides evidence in the case of real food prices as well as nominal disaggregate ones.

The remainder of the paper is structured as follows. Section 2 provides an overview of the relevant literature, Section 3 outlines the modelling framework, Section 4 discusses the empirical results, and Section 5 offers some concluding remarks.

2. Literature Review

Most existing studies are based on commodity price indices which also include aggregate food prices. For instance, Gelos and Ustyugova (2017) examine the structural characteristics associated with a stronger commodity price pass-through in a large sample of countries. Their findings suggest that economies with higher overall inflation or a larger food share in the CPI basket are more vulnerable to food price shocks, and also that the adoption of an inflation targeting regime helps to anchor inflation expectations, thereby reducing the second-round effects of food price shocks. They also report a stronger pass-through when there is a larger dispersion of inflation expectations, which is a measure of inflation uncertainty. Sekine and Tsuruga (2018) estimate the effects of commodity price shocks on headline inflation in a monthly panel of 144 countries and find that any initial effect on inflation disappears within one year, the risk of second-round effects being low. Abbas and Lan (2020) estimate both threshold and Markov-switching models and conclude that the inflation environment influences the pass-through dynamics of commodity prices (including food prices) to inflation, which tends to be higher in a volatile inflation regime.

It is also important to examine global food price shocks separately given their direct impact on food security and living standards. Studies of this type generally focus on the pass-through of food price shocks and on appropriate policy responses. For instance, Pourroy et al. (2016) suggest that the optimal monetary policy response to food price shocks depends on the income level, with consumer price inflation targeting being optimal in low income countries, while in high income countries non-food price inflation targeting is more appropriate. Using a new database for market prices within the EU, Ferrucci et al. (2018) investigate the nonlinear pass-through of food prices to consumer and producer price inflation, which they find to be partially explained by the Common Agricultural Policy. They also conclude that disaggregate food price data are more informative. The literature concerned with the impact of food prices on core inflation is relatively limited. Pedersen (2011) applies a VAR model with Cholesky decomposition to analyse the effects of food and energy prices on other consumer prices for 46 countries, and finds that food price shocks have stronger ones on core prices than energy price shocks. De Gregorio (2012) uses simple regression analysis to assess the effects of food prices on headline and core inflation and finds that second-round effects on the latter are stronger for countries with a large food consumption share in total consumption. Note that the latter two papers have two major shortcomings, namely they do not analyse either food price volatility or possible second-round effects of food price shocks on inflation.

Food price volatility seems to be primarily driven by demand and supply shocks (Qiu et al., 2012) or by the financialization of food commodity markets (Silvennoinen and Thorp, 2013). The former is measured as the realised variance of commodity futures (Triantafyllou et al., 2023), or using GARCH-type models (Gardebroek and Hernandez, 2013; Mensi et al., 2014; Cabrera and Schulz, 2016) or VAR models allowing for stochastic time-varying volatility (Jebabli et al., 2014), which are estimated for individual food commodity markets. However, such measures do not shed light on the degree of persistence of volatility and its impact on inflation or economic activity. Bellemare and Lee (2016) highlight the importance of distinguishing between increases in the level of food prices (namely a shift in the mean of the food price distribution) and in their volatility (i.e., a higher variance of the food price distribution) given their different policy implications. The following section outlines the model we use in this paper to differentiate between food price mean and volatility shocks.

3. Empirical Framework

3.1 The unsynchronised endogenous regime switching model

A recently developed model by Chang et al. (2023), known as the unsynchronised endogenous regime-switching model (UERS), allows to extract mean and volatility factors which govern the regime shifts between low and high mean and volatility states. This method is highly attractive since, as already mentioned, it allows for the mean and the volatility to shift at different times. The model takes the following general form:

$$y_t - \mu(s_{m,t}) = \sum_{k=1}^{p} \gamma_k(y_{t-k} - \mu(s_{m,t-k})) + \sigma(s_{v,t})u_t \quad (1)$$

where y_t is the variable of interest (in our case, the FAO food price index), μ is the mean, σ measures volatility, $s_{m,t}$ and $s_{v,t}$ are the mean and volatility state variables, and u_t are the innovations. In this framework the regime changes are determined by two autoregressive latent factors which are correlated with past innovations of the state-dependent process. As a result, the transition probabilities are time-varying and determined by the lagged values of the time series. The evolution of the state variable $s_{i,t}$ is driven by whether the unobserved latent factors w_{it} are above or below some unknown threshold τ_i:

$$s_{it} = \begin{cases} 0 & if \quad w_{it} \geq \tau_i \\ 1 & if \quad w_{it} < \tau_i \end{cases} \quad for\ i = m, v \quad (2)$$

where the factors $w_{i,t}$ are assumed to follow a zero-mean autoregressive process of order 1:

$$w_{i,t} = Aw_{i,t-1} + v_t \quad (3)$$

where $\mathrm{A} = \begin{pmatrix} \alpha_{mm} & \alpha_{mv} \\ \alpha_{vm} & \alpha_{vv} \end{pmatrix}$ and v_t are i.i.d. innovations. The endogenous regime changes arise from the correlation between v_{t+1} and the innovation term u_t of the state-dependent process according to the following correlation matrix:

$$\mathrm{P} = \begin{pmatrix} 1 & \rho_{vu}' \\ \rho_{vu} & \mathrm{P}_{vv} \end{pmatrix} = \begin{pmatrix} 1 & & \\ \rho_{v_m,u} & 1 & \\ \rho_{v_v,u} & \rho_{v_m,v_v} & 1 \end{pmatrix} \quad (4)$$

The evolution of the regime factors $w_{i,t}$ is determined by the dynamic interaction between the two factors, captured by the matrix A, and their contemporaneous correlation, measured by P. If $\alpha_{mv} \neq 0$, the volatility regime factor $w_{v,t}$ helps to predict the mean regime factor $w_{m,t}$. Likewise, if $\alpha_{vm} \neq 0$, $w_{m,t}$ helps to predict $w_{v,t}$. Larger values of α_{mm} and α_{vv} indicate a higher persistence of the mean and volatility regime factors. If $\rho_{v_m,u} \neq 0$ the latent factor $w_{m,t+1}$ is correlated with the observed time series y_t, which means that shocks to past changes in y_t affect endogenously the future transition between the mean states. Similarly, if $\rho_{v_v,u} \neq 0$, shocks to past changes in y_t affect endogenously the future transition between the volatility states. Since the state processes s_{it} are not a Markov chain, one needs to use the modified Markov switching filter by Chang et al. (2021) to account for the endogenous feedback channel and to estimate the model. The two unobserved latent factors (mean and volatility) can be used in the subsequent economic analysis; in the case of food prices they represent respectively an indicator of the average food price and of its volatility as well as of the likelihood of their remaining in the same state.

In order to assess the model performance, we compare its forecasting properties to those of a range of rival specifications. The first is the volatility endogenous regime switching model (VERS) developed by Chang et al. (2017), where only the volatility factor is allowed to switch. The second is a standard regime switching model with an exogenous Markov chain (MCRS). The third is the regime switching model with time-varying transition probabilities (TVRS) due to Diebold et al. (1994), where the transition probabilities are logistic functions of a predetermined transition variable z_t. We consider three possible variables for z_t, namely (1) the lagged FOA food price index, (2) lagged global inflation to account for overall increases in global prices, and (3) the lagged global output gap to capture overall global demand.[1] We use 5-, 10-, and 30-year rolling-windows to construct the forecasts for the various specifications, namely UERS, VERS, MCRS, TVRS with the lagged FOA index (TVRS-FOOD), TVRS with lagged global inflation (TVRS-INF), and TVRS with the lagged global output gap (TVRS-IP). The out-of-sample performance of the models is compared using the root mean square error (RMSE) and the relative RMSE.

[1] The output gap is measured by applying the Hodrick-Prescott filter with monthly-frequency adjusted smoothing parameters (Ravn and Uhlig, 2002) to world industrial production data.

3.2 A VAR model with global food price shocks

In order to assess how global food price mean and volatility shocks are transmitted to domestic prices, we estimate a structural VAR model of the following form:

$$X_t = \mu + B(L)X_t + u_t \tag{5}$$

where X_t is a 8×1 vector of endogenous variables which includes domestic food price inflation ($food_t$), domestic core consumer price inflation ($core_t$), domestic output growth (y_t), crude oil prices (oil_t), the real exchange rate (s_t), the policy interest rate (i_t) as well as the global food price mean ($w_{m,t}$) and volatility ($w_{v,t}$) indicators. We allow for up to 12 lags and use sign restrictions for identification purposes.

Table 1. Sign restrictions in the VAR model

	Supply	Demand	Oil price	Monetary policy	Exchange rate	Food price mean	Food price volatility
$food_t$	$+$	$+$		$-$	$-$	$+$	$+$
$core_t$	$+$	$+$		$-$	$-$		
y_t	$-$	$+$	$-$		$-$		
oil_t			$+$				
s_t	$+$				$+$		
i_t				$+$			
$w_{m,t}$						$+$	
$w_{v,t}$							$+$

Notes: Sign restrictions with $(+)$ indicating a positive response to the shock and $(-)$ indicating a negative response.

We identify seven shocks, which are detailed in Table 1. A domestic supply shock is a cost-push shock which reduces output growth but increases both food and core inflation and appreciates the real exchange rate. A domestic demand shock increases food and core inflation as well as output growth. We assume that demand and supply shocks affect headline inflation, therefore they have an impact on both core inflation and food prices. A global oil price shock lowers output and increases the oil price. We do not impose any restrictions on the response of food and core inflation to oil price shocks since these are known always to be recessionary, but the impact on inflation depends on whether the underlying shock stems from changes in oil demand or supply (Kilian, 2008). A contractionary monetary policy shock reduces food and core inflation, but increases the policy rate. An exchange rate appreciation lowers both inflation and output, but increases the real exchange rate. A global food price mean shock is expected to increase both domestic food price inflation and the global food price mean, while a food price volatility shock is assumed to increase domestic food price inflation and global food price volatility. The Phillips curve literature often treats changes in relative food prices as supply shocks which move the short run Phillips curve (Aoki, 2001). In fact, fluctuations in the world food prices, food being an essential consumption good, are often regarded as cost-push shocks (Monacelli, 2013). Despite this notion of food price shocks as supply shocks found in the literature, we keep the response of output to the global food price mean and volatility shocks unrestricted according to an agnostic identification approach (Uhlig, 2005). We assume that all variables respond to shocks on impact. The estimation is based on the Bayesian approach as in Uhlig (1994) and uses the algorithm by Rubio-Ramirez et al. (2010).

As a first step, impulse response analysis is carried out to investigate to what extent global food price mean and volatility shocks are passed through to food price inflation in the various countries under examination. Counterfactual analysis is then performed to assess possible second-round effects on core inflation. There are three reasons to expect their presence. First, many food items are intermediate inputs in the production process of other goods whose prices are included in core inflation, such as starch used in biodegradable plastics or natural fibres used for textiles and building construction; these increase overall production costs for firms, which are then passed on to consumers. Second, since food is a key component of the consumption basket, its price has significant effects on wage pressures (De Gregorio, 2012). Third, given their importance for consumers, food prices can strongly influence inflation expectations and the wage setting process. Since they are not included in core inflation measures, the presence of any effects on the latter suggests the existence of a strong cost or expectations pass-through channel. The extent to which food prices influence non-food prices matters greatly for central banks which target core inflation. To investigate this issue in the counterfactual analysis we shut off the domestic food price inflation response to the global food price mean and volatility shocks. This type of exercise has not been conducted by previous studies examining second-round effects (Pederson, 2011; De Gregorio, 2012), despite its usefulness to compare them with direct effects.

3.3 Extended analysis

The main analysis is extended in two ways. First, the estimation is redone using the real FOA food price index. While consumers' spending decisions are mainly driven by nominal prices, real ones are more informative about long-term trends in global food prices. Second, evidence is also obtained for disaggregate nominal food prices for individual categories (cereal, meat, vegetable oil, sugar and dairy). These results shed light on the relative importance for domestic inflation of the various components of global food prices and of their volatility (Ferrucci et al., 2018).

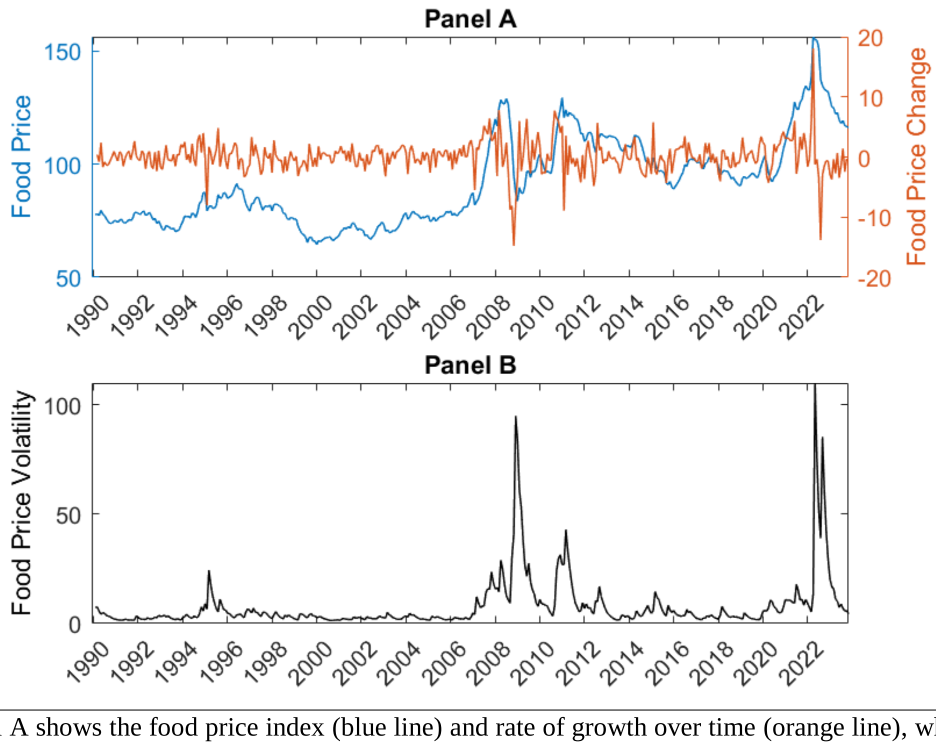
4. Data and Empirical Results

4.1 Data description

We use monthly data from January 1990 to October 2023. The FAO Food Price Index is obtained from the Food and Agriculture Organization of the United Nations website and is a global export share-weighted index comprising the weighted average of five food commodity price indices, namely cereal, meat, vegetable oils, sugar and dairy. As already mentioned, we use the nominal series for the main analysis, but then repeat the exercise using the real total series and the disaggregate nominal series as a robustness check. The analysis is conducted for the US, the UK, the euro area, Canada, Japan, South Korea, Mexico and Denmark. We obtain the core consumer price inflation and the food price inflation series from the Organisation for Economic Co-operation and Development (OECD) Consumer price indices database for all countries. Output growth is calculated using the OECD industrial production total industry series. The oil price is the crude West Texas Intermediate (WTI) one. Real effective exchange rate data and the central bank policy rates are obtained from the Bank for International Settlements (BIS). The world industrial production and world inflation data are the OECD total industrial production index and the OECD total inflation (CPI) series, respectively. All variables are included as annual growth rates, except the policy rates which are in levels. Annual data for food consumption in total consumption and food share in the CPI basket are constructed from the OECD Annual National Accounts and CPI databases. Owing to the unavailability of earlier data, we estimate the VAR model starting in November 1998 for Mexico, in January 1999 for the euro area and in May 1999 for South Korea.

Figure 1 plots the nominal FAO food price index alongside its rate of change (Panel A), calculated as the first difference in the log of the index, as well as its volatility (Panel B), computed using a simple GARCH(1,1) model. While food prices remained low in the first part of the sample, they have been higher on average since 2007. The series is characterised by several rather abrupt changes, which can be related to several food crises. This is also reflected in its growth rate and its volatility. The 2008 food crisis resulted in an increase in food prices by over 50% between the beginning of 2007 and the beginning of 2008, which was associated with food riots in many developing and emerging countries (Bellemare, 2015). The 2010-2012 food crisis resulted in a 40% rise in food prices caused by a combination of droughts in large parts of the world and by rising oil prices which increased the demand for biofuel. The rising food prices in 2021 and 2022 were the result of a combination of factors, namely the Covid-19 pandemic, which generated supply chain disruptions and increased the cost and complexity of global food distribution, and the Russian invasion of Ukraine in 2022, which increased food prices further, since both these countries are important exporters of cereal goods and vegetable oil inputs. The conflict also resulted in higher energy prices which feed into food production prices and increased the demand for biofuel. This already turbulent period also saw a series of floods and heatwaves across Europe and the Americas. While food prices have remained high since 2007, volatility stayed low for most of the same period, apart from the key events outlined above. This suggests that periods of high mean and high volatility do not always coincide, thus motivating the need for a model specification which allows for unsynchronised switches.

Figure 1. Global food price and volatility



Notes: Panel A shows the food price index (blue line) and rate of growth over time (orange line), while Panel B displays the conditional volatility of the food price index.

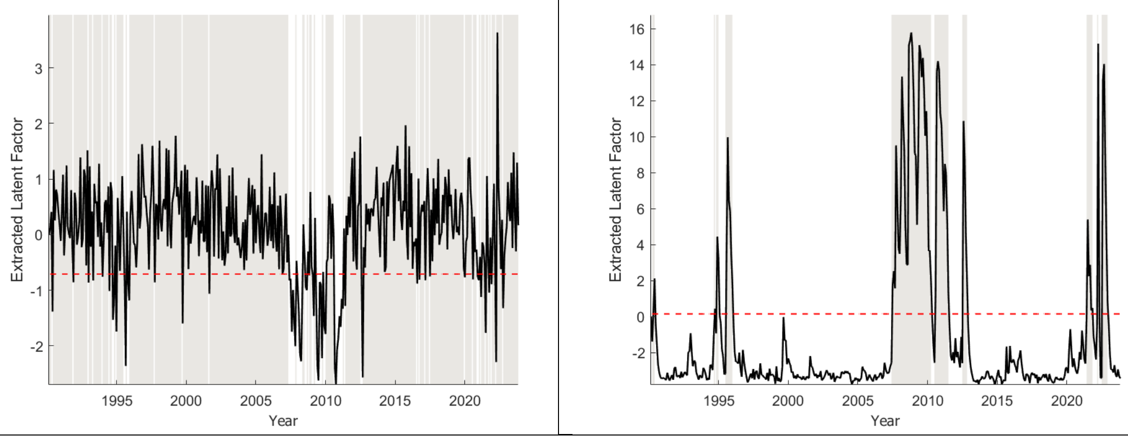
4.2 Measures of global food price mean and volatility

Figure 2 displays the extracted mean (Panel A) and volatility (Panel B) factors from the UERS. It can be seen that there were large increases in the volatility factor during the 2008 food crisis, whilst the mean factor did not exceed the threshold for most of the same period. The 2010-

2012 food crisis was also characterised by high volatility and a low mean, whereas in 2021 and 2022, a period with rapidly increasing food prices, both mean and volatility were high. It is clear, therefore, that high mean and volatility periods do not always coincide. Distinguishing between these two types of shocks is essential to choose appropriate policy responses. While mean shocks require policies affecting trends in food prices, for instance through a reduction of import tariffs and value added tax or the issuance of subsidies, volatility shocks can be mitigated through policies aimed at reducing uncertainty by disseminating information at both the local and global level, and also at making it easier for firms and consumers to cope with the remaining volatility, such as domestic buffer stocks and trade controls. Rising food prices require central banks concerned with headline as well as core inflation to implement contractionary policies. By contrast, higher volatility is often assumed to be a transitory phenomenon and therefore not to require a policy response. Thus, the correct identification of food price shocks as mean or volatility shocks is crucial for monetary authorities.

Figure 2. Extracted factors from the UERS

Panel A – Mean factor | **Panel B –Volatility factor**



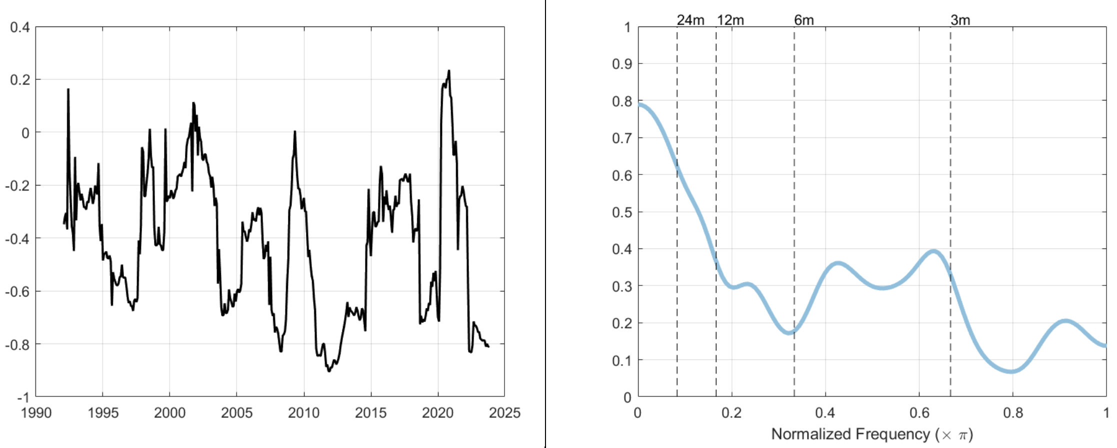
Notes: The extracted factors are represented by the black line while the estimated threshold is depicted by the red dashed line. The grey shaded areas indicate periods of high mean (Panel A) and high volatility (Panel B).

Figure 3 reports the 24-month rolling window correlation (Panel A) and coherence (Panel B) between the mean and volatility factors extracted from the UERS. As can be seen, the former is time-varying and negative for most of the sample period. The mean and volatility factors are especially highly correlated during the 2007-2008 and the 2010-2012 food crises, which is consistent with the evidence presented in Figure 2 regarding their moving in opposite directions. While the correlation was low during the Covid-19 pandemic, it has increased since

2022, which suggests a stronger linkage between the two factors in recent years. The coherence graph indicates a stronger co-movement of the two factors at lower frequencies between 3 and 6 months. Figure 4 displays the time-varying probability of remaining in the same low mean and high volatility regime. Four periods of high turbulence in international food markets are selected. Panel A focuses on the food crisis beginning in 2007; in this case the transition probability fluctuates substantially and moves in the opposite direction to the change in food prices. Panel B concerns a period of heightened food prices leading up to the 2010 food crisis. Again, there are large fluctuations in the transition probability which tends to move in the opposite direction to the food price growth rate. Panel C and D, which correspond to the 2012 and 2022 world food crises respectively, show a similar pattern, with the transition probabilities mirroring food price changes. In all cases, the transition probability of remaining in the low mean and high volatility regime is positive and exceeds the near-zero constant transition probability obtained from the exogenous MCRS model (the dashed red line). Note that the estimated time-varying transition probabilities imply that the likelihood of remaining in the high volatility regime changes across time periods. Lastly, we report the results of the forecast evaluation exercise in Table 2. As can be seen, the UERS has the lowest RMSE and root RMSE and thus outperforms all rival models in terms of its forecasting performance. On the whole, the evidence presented in this section suggests that the mean and volatility factors extracted from the UERS are suitable to capture the behaviour of global food prices.

Figure 3. Correlation and coherence of mean and volatility factors

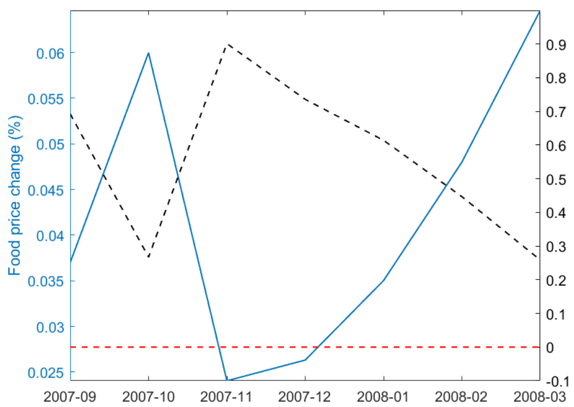
Panel A – Correlation	**Panel B – Coherence**



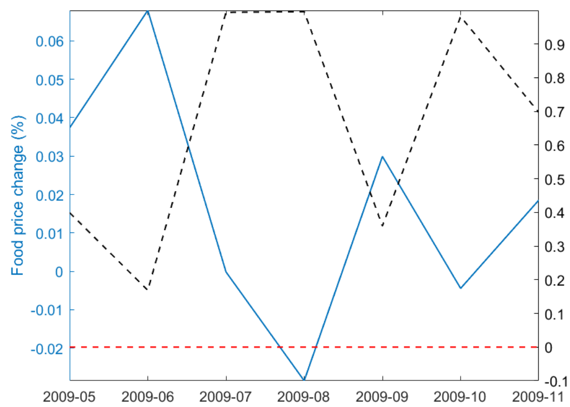
Notes: The correlation between the mean and volatility regime factors is based on a 24-month rolling window. The coherence is computed using the full sample.

Figure 4. Time-varying transition probabilities in the UERS

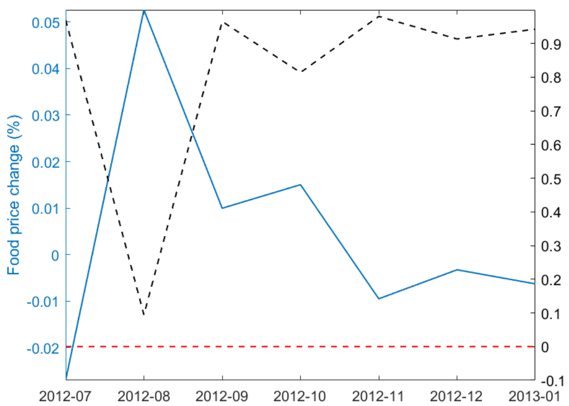
Panel A



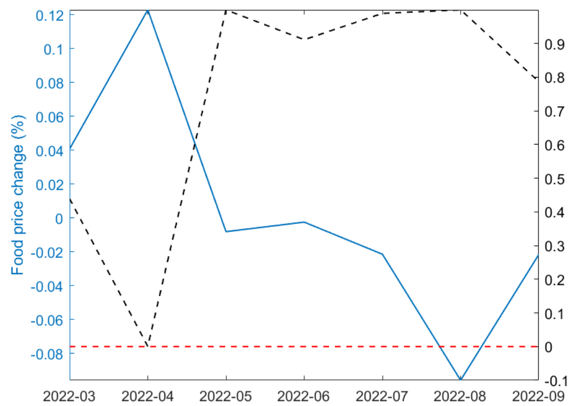
Panel B



Panel C



Panel D



Notes: The dashed black line represents the time-varying transition probabilities obtained from the UERS, the solid blue line shows the food price changes and the dashed red line indicates the constant transition probability estimated from the exogenous MCRS.

Table 2. Forecast comparison

	UERS	VERS	MCRS	TVRS-FOOD	TVRS-INF	TVRS-IP
5-year window						
RMSE	0.0014	0.0041	0.0019	0.0023	0.0025	0.0025
Relative RMSE	34.15	100.00	46.34	56.10	60.98	60.98
10-year window						
RMSE	0.0015	0.0041	0.0020	0.0024	0.0025	0.0025
Relative RMSE	36.59	100.00	48.78	58.54	60.98	60.98
30-year window						
RMSE	0.0015	0.0042	0.0020	0.0024	0.0026	0.0026
Relative RMSE	35.71	100.00	47.62	57.14	61.90	61.90

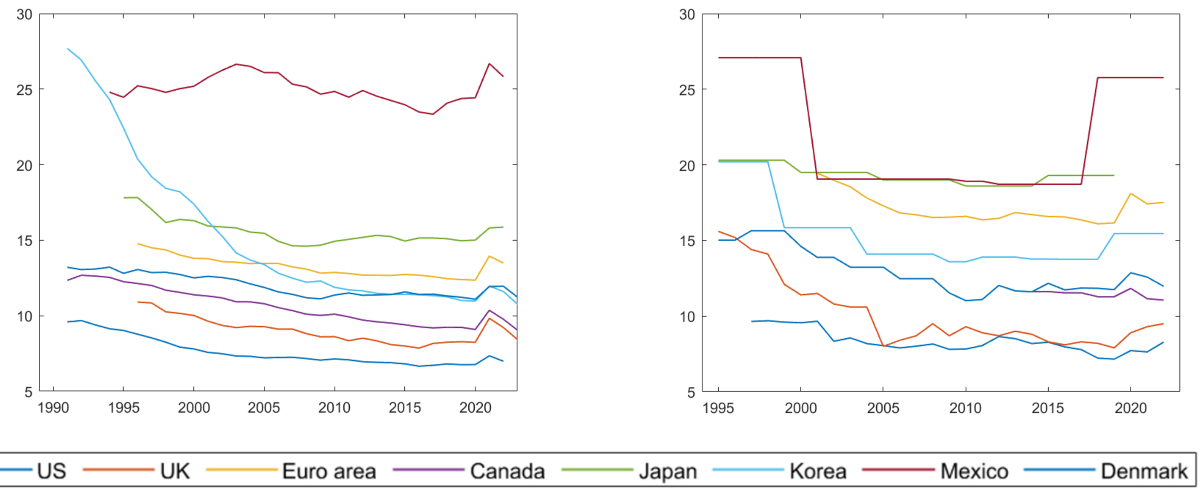
Notes: Forecast comparison based on one-step-ahead forecasts.

4.3 The direct and second-round effects of global food price shocks

Next we examine possible differences in the transmission of global food price shocks between the various countries in our sample. In Figure 5, Panel A displays the share of food consumption in total consumption and Panel B the share of food in the CPI basket for each country. It can be seen that both differ significantly across countries. Mexico appears to have both the highest food consumption share in total consumption and the highest food share in the CPI basket, both being around 15 percentage points higher than in the case of the US, which has the lowest share in both cases. There is little variation in the food consumption share in total consumption in recent years for all countries except South Korea, which experienced a large decrease from around 27% to 12% between 1990 and 2007. The food share in the CPI basket decreased for most economies in the late 1990s and early 2000s but remained stable subsequently.

Figure 5. Food consumption share and food share in the CPI basket

Panel A – Food consumption share in total consumption | **Panel B – Food share in the CPI basket**



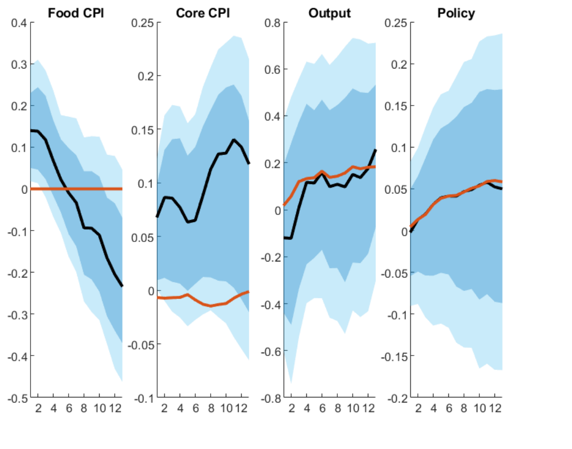
Notes: All data are reported in percentages.

Figures 6 to 13 display the impulse response functions (IRFs) obtained from the structural VAR model with sign restrictions for all countries in our sample. In all cases, the solid black line represents the median response, the dark blue shaded area corresponds to the 68% confidence band, the light blue shaded areas are the 95% confidence bands, and the solid orange line represents the counterfactual with the domestic food inflation channel shut off. The results for the US in Figure 6 (Panel A) suggest that the effects of food price mean shocks on domestic food price inflation are initially strong and positive, and then decline steadily and become negative after six months. The effect on core CPI is initially small but then increases, raising core CPI by around 0.15 percentage points within twelve months. This effect would have been zero without domestic food CPI reacting to the global food price mean shock (the orange solid line). There is an initial negative impact on output growth which turns positive after four months and leads to a total increase in output growth of 0.2 percentage points. The central bank response to a global food price mean shock is initially zero; this is followed by a gradual increase in the policy rate by up to 0.05 percentage points; in this case there is no difference between the standard IRF and the counterfactual, which suggests that monetary authorities do not respond to the increase in domestic food or core inflation. Food price volatility shocks (Panel B) seem to have almost identical effects on food CPI and output growth as the mean shocks. By contrast, the effects on core CPI are smaller, being around 0.05 percentage points. However, in the case of the policy rate there is a positive reaction in the presence of second-round effects, while the counterfactual suggests that in the absence of such effects there would have been no policy reaction initially and then a small monetary expansion.

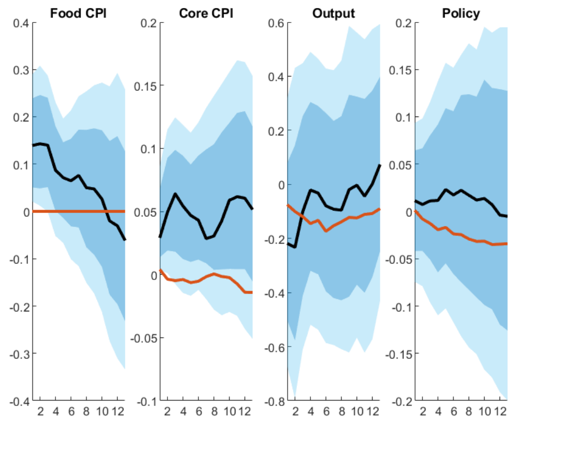
For all other countries in our sample except the euro area, global food price mean shocks have an initial positive effect on domestic food price inflation of around 0.1 to 0.2 percentage points which quickly turns negative. In the euro area instead (Figure 8), the effect turns positive again after ten months. The response of core CPI to a global food price mean shock would have been close to zero in all cases if there were no response of food CPI to the global food price mean shock. With the food CPI channel open, core CPI reacts positively with a magnitude of 0.05 to 0.15 percentage points in all cases, although the initial effect declines in the case of Canada (Figure 9) and Japan (Figure 10). For all other countries the effects are persistent and even strongly increasing in the case of the euro area and South Korea (Figure 11). Output growth responds negatively at first but then increases in all countries except the euro area, where it declines over the response horizon, and Canada and Denmark, where the response is more volatile. In the euro area, Mexico (Figure 12), South Korea and Denmark (Figure 13), monetary authorities appear to reduce the policy rate within twelve months after the global food price mean shock, while in all other countries the response is contractionary, possibly to counteract higher core inflation resulting from second-round effects rather than the direct effects of the global food price mean shock.

Figure 6. Responses to global shocks for the US

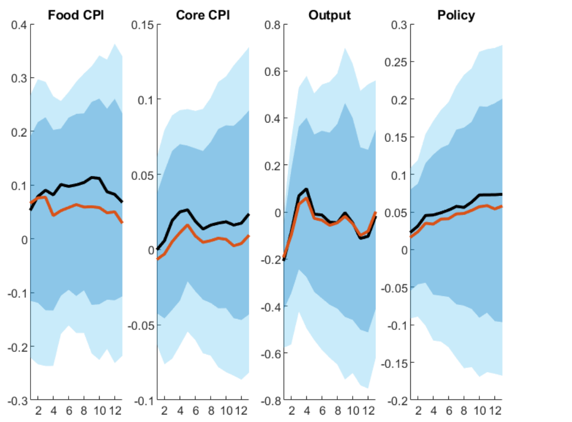
Panel A – Response to food price mean shock



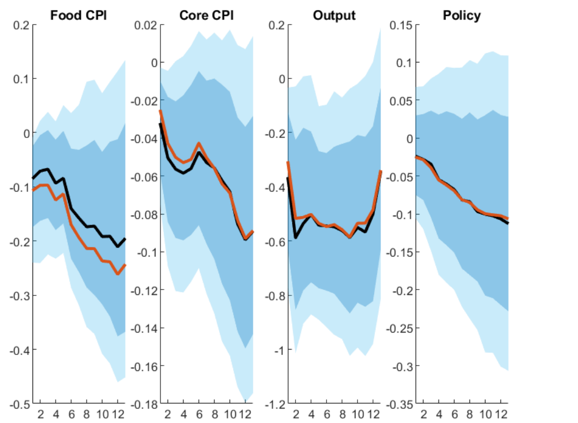
Panel B – Response to food price volatility shock



Panel C – Response to oil price shock



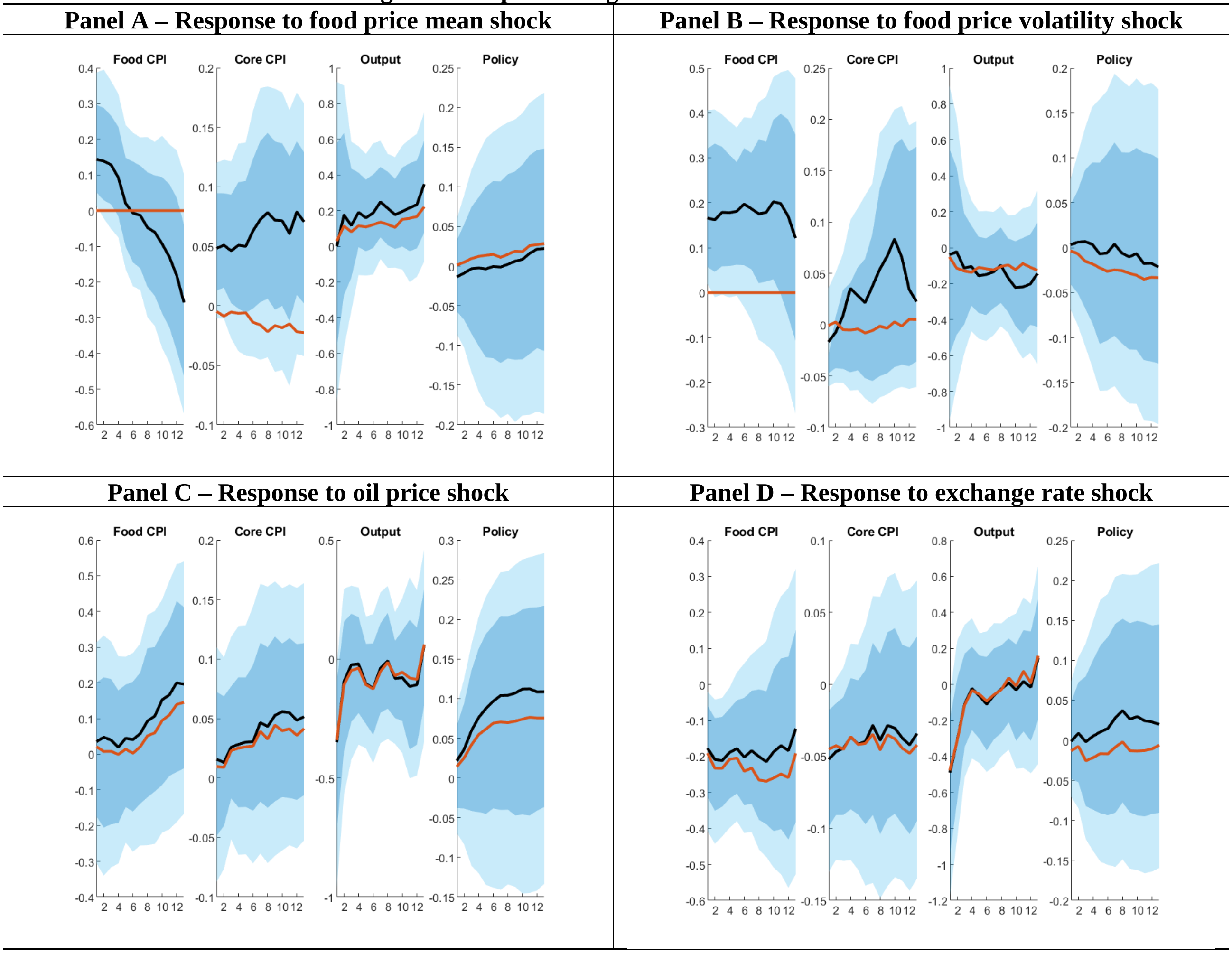
Panel D – Response to exchange rate shock



Notes: The solid black line represents the median response, the dark blue shaded area represents the 68% confidence band, while the light blue shaded areas represent the 95% confidence bands. The solid orange line represents the counterfactual with the domestic food inflation channel shut off. The responses of food CPI, core CPI and the policy rate are in percentage points, while the response of output growth is in percent.

There are more significant differences in the responses of domestic food CPI to global food price volatility shocks between countries. For instance, while for the UK (Figure 7) and Denmark the response seems to be more stable, it shows some strong variation in the case of the euro area, Japan and South Korea, all three of which have on average a higher food consumption share in total consumption and a higher food share in the CPI basket. The response of core CPI is positive and around 0.05 to 0.1 percentage points in all cases, provided that the food CPI channel is open. For the euro area the effect is persistent, as in the case of the US. In the UK and Canada the effect dies out eventually, while in the remaining countries there is greater variation in the response over time. Output growth is negatively affected in all countries except South Korea and Denmark, where the response fluctuates around zero. The policy response is first positive but then turns negative in the UK, the euro area and Canada, while in the other countries it fluctuates around zero. These findings indicate that monetary authorities are generally less concerned with food price volatility, which is consistent with their targeting core inflation.

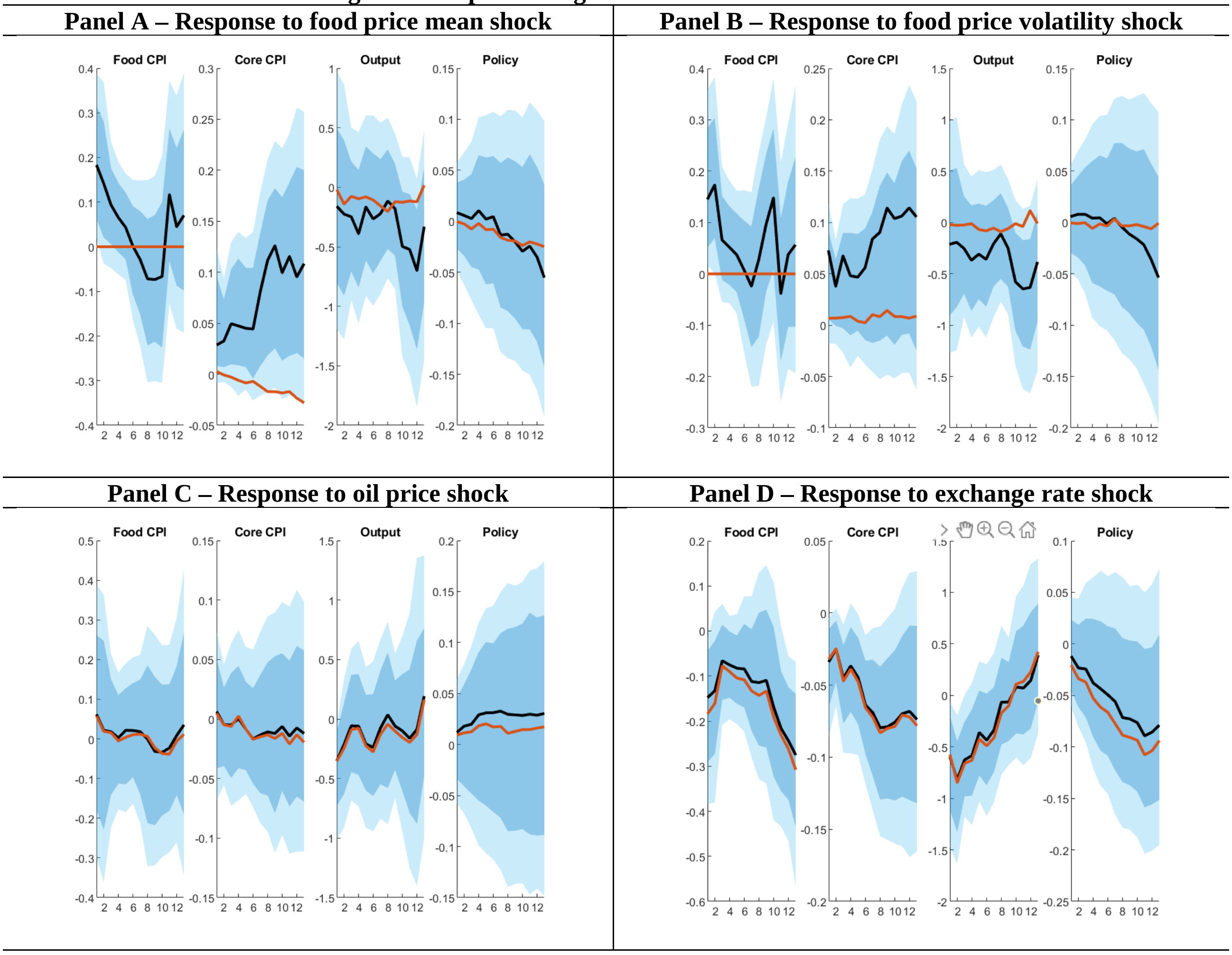
Figure 7. Responses to global shocks for the UK



Notes: The solid black line represents the median response, the dark blue shaded area represents the 68% confidence band, while the light blue shaded areas represent the 95% confidence bands. The solid orange line represents the counterfactual with the domestic food inflation channel shut off. The responses of food CPI, core CPI and the policy rate are in percentage points, while the response of output growth is in percent.

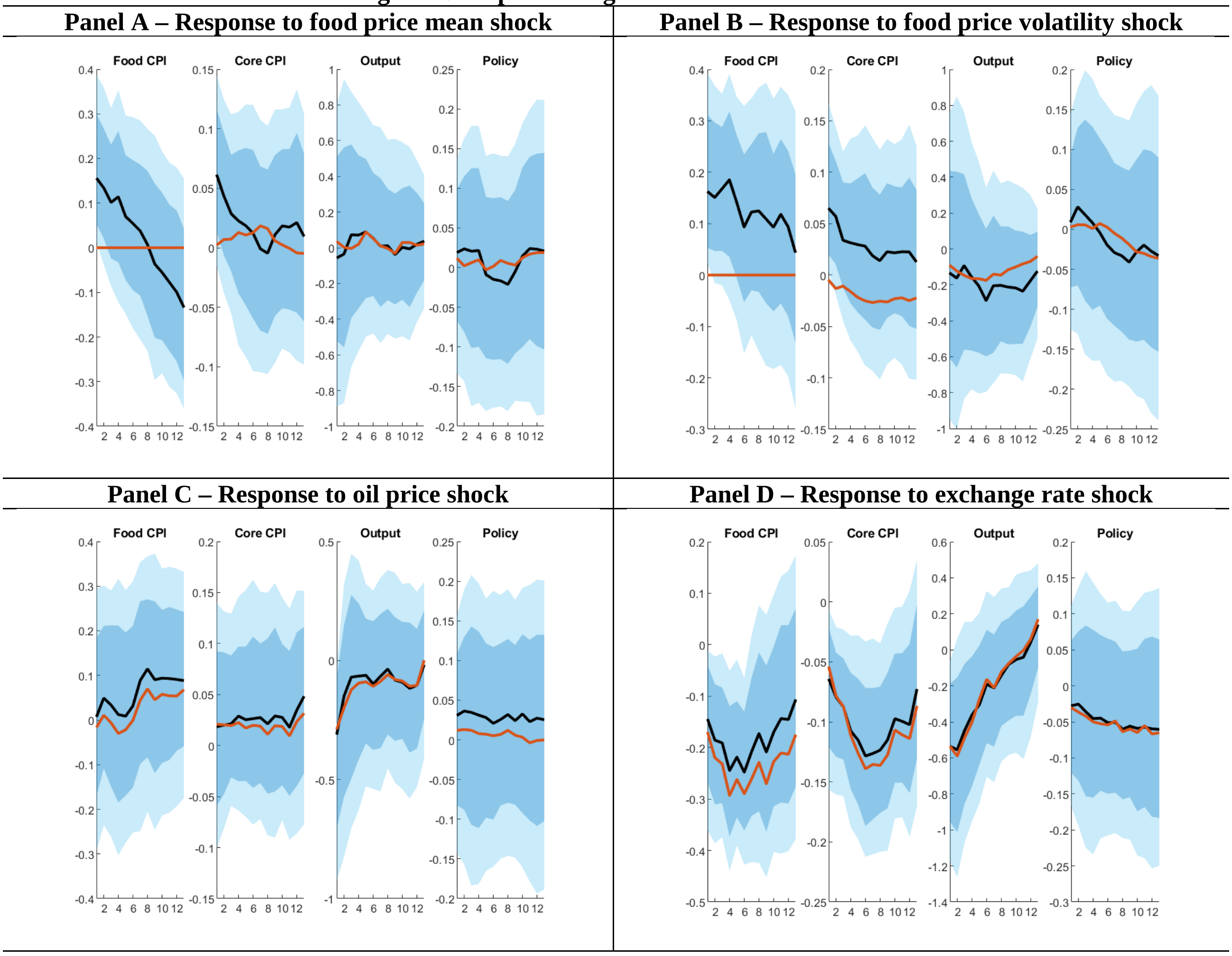
The response of food CPI to oil price shocks (Panel C in Figures 6 to 13) is positive and strong in all cases, except the euro area, Japan and South Korea, for which it is close to zero. Core CPI shows no significant response except for the UK and Mexico, which indicates a weak pass-through of oil price shocks to domestic core inflation. Output growth initially falls after an oil price shock but quickly turns positive after around two months, with the exception of the euro area and Japan, for which it is highly volatile. There are large differences in the policy response to oil price shocks. While there is a clear monetary contraction in the US, the UK and Mexico, there is almost no response in the euro area, Canada, Japan, South Korea and Denmark. An unexpected exchange rate appreciation (Panel D in Figure 6 to 13) reduces both domestic food and core CPI, the former by up to 0.3 and the latter by up to 0.1 percentage points. An exchange rate shock also depresses output growth initially, although it recovers after six to eight months in most countries. The policy response is uniformly negative, although much stronger in the case of the US, the euro area, Japan, Mexico and Denmark, for which the policy rate decreases by up to 0.1 percentage points.

Figure 8. Responses to global shocks for the euro area



Notes: The solid black line represents the median response, the dark blue shaded area represents the 68% confidence band, while the light blue shaded areas represent the 95% confidence bands. The solid orange line represents the counterfactual with the domestic food inflation channel shut off. The responses of food CPI, core CPI and the policy rate are in percentage points, while the response of output growth is in percent.

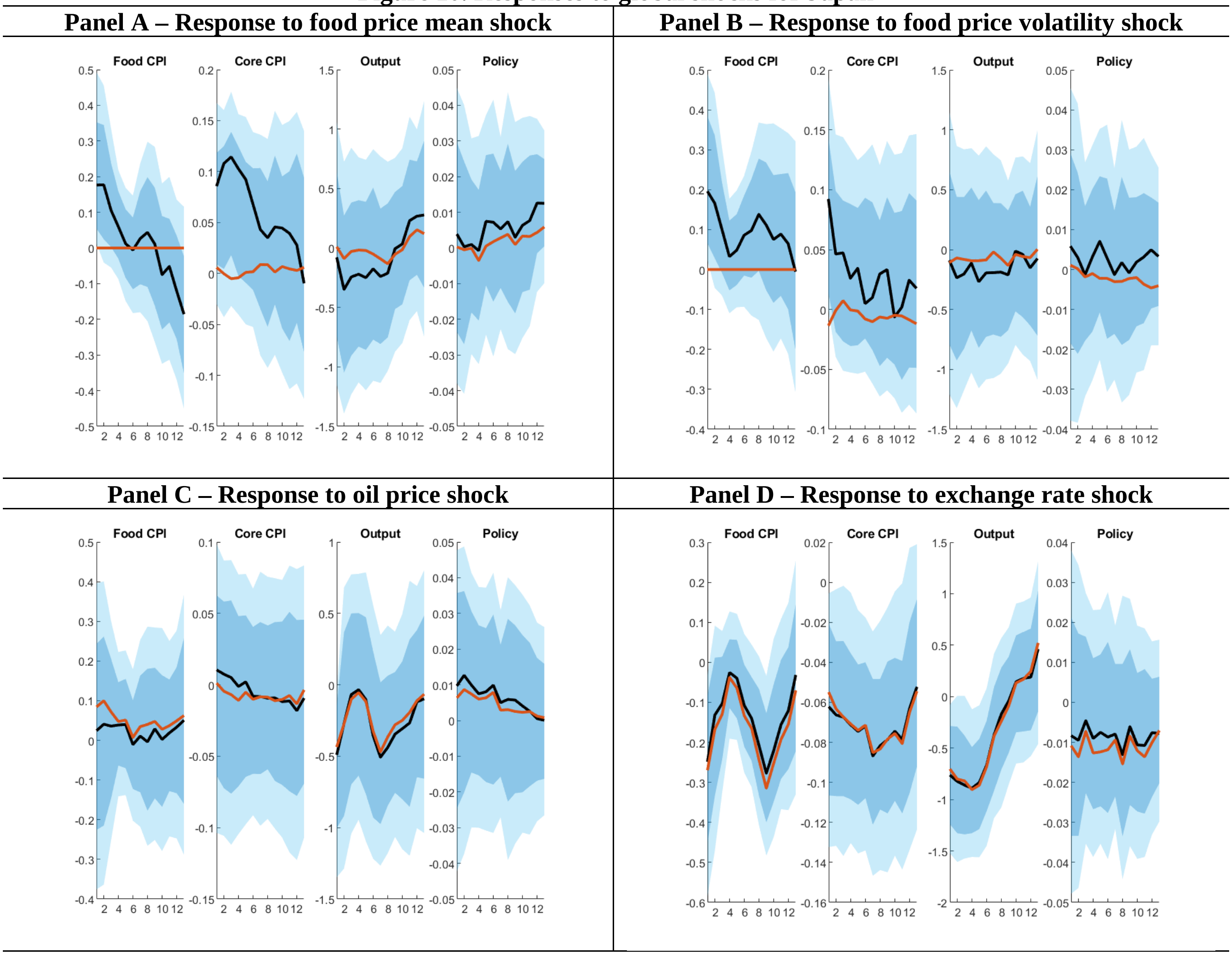
Figure 9. Responses to global shocks for Canada



Notes: The solid black line represents the median response, the dark blue shaded area represents the 68% confidence band, while the light blue shaded areas represent the 95% confidence bands. The solid orange line represents the counterfactual with the domestic food inflation channel shut off. The responses of food CPI, core CPI and the policy rate are in percentage points, while the response of output growth is in percent.

These results are to some extent similar to those of De Gregorio (2012), who reports second-round effects on core inflation, and of Pedersen (2011), who finds that a food price shock starts to have significant effects on core inflation after two quarters (we report an increase in the impact after four to six months in many cases). In contrast to these studies, however, we find that neither the food consumption share in total consumption nor the food share in the CPI basket of the individual countries matter greatly in terms of possible second-round effects on core inflation. While in the US, the UK and the euro area, global food price mean and volatility shocks have increasing second-round effects on core inflation, these die out quickly in the case of Canada and Japan, and in South Korea, Mexico and Denmark the mean shock has increasing second-round effects but those of the volatility shock die out quickly. The presence of persistent second-round effects of both global food price mean and volatility shocks on core inflation indicates that food prices can have lasting effects on non-food prices; this suggests that there exists either a strong expectations channel or a strong cost pass-through channel in many countries.

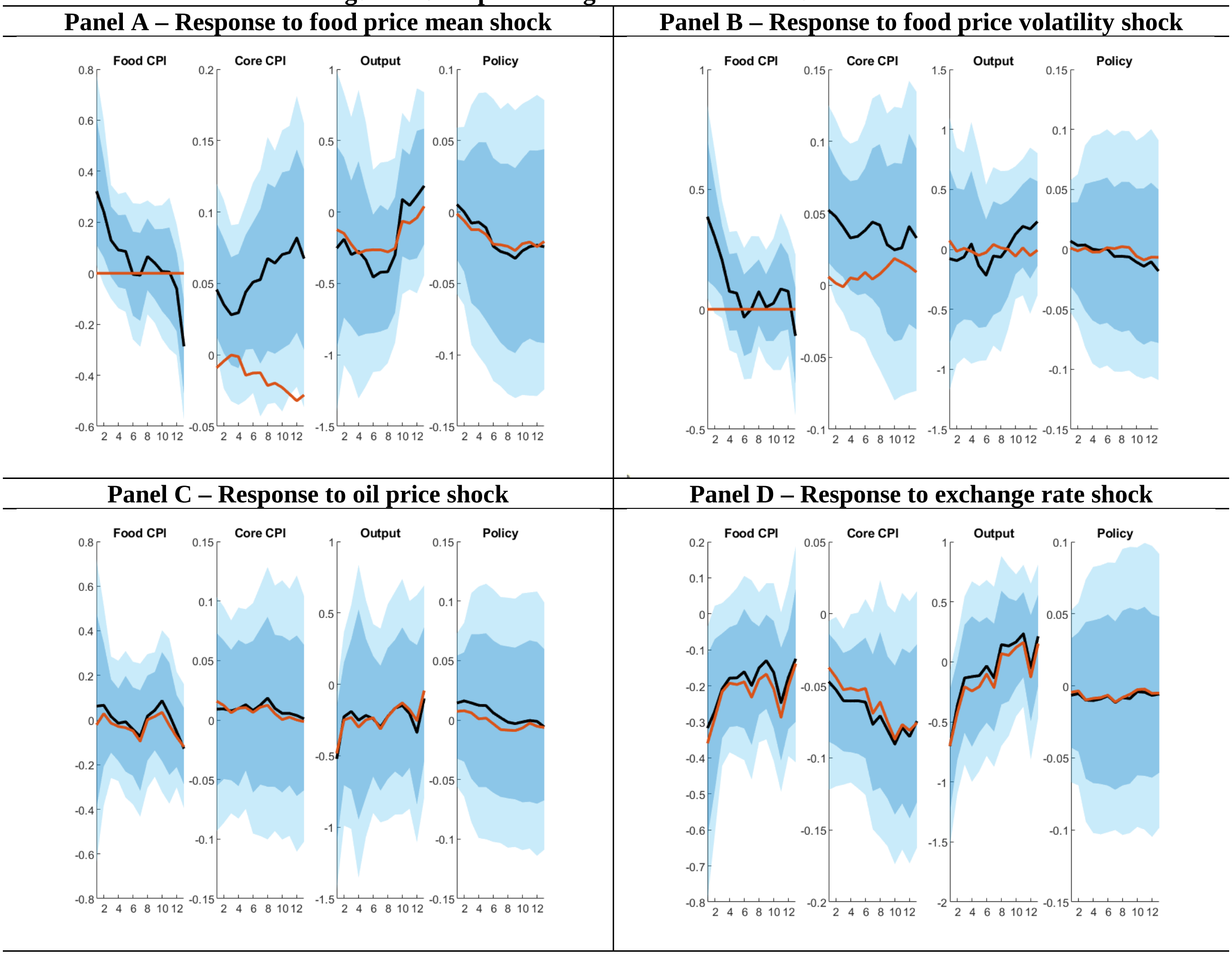
Figure 10. Responses to global shocks for Japan



Notes: The solid black line represents the median response, the dark blue shaded area represents the 68% confidence band, while the light blue shaded areas represent the 95% confidence bands. The solid orange line represents the counterfactual with the domestic food inflation channel shut off. The responses of food CPI, core CPI and the policy rate are in percentage points, while the response of output growth is in percent.

It is also noteworthy that central banks seem to respond more strongly to global food mean rather than volatility shocks (although the response to the latter type of shocks increases in the presence of second-round effects on core inflation). This is consistent with their discarding the volatile behaviour of food prices when formulating policies and focusing instead on their long-run trends.

Figure 11. Responses to global shocks for South Korea

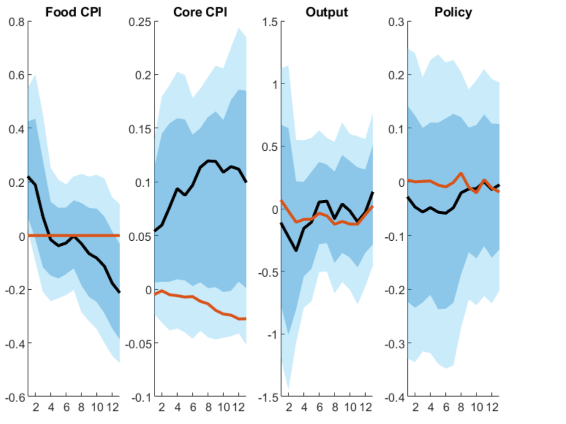


Notes: The solid black line represents the median response, the dark blue shaded area represents the 68% confidence band, while the light blue shaded areas represent the 95% confidence bands. The solid orange line represents the counterfactual with the domestic food inflation channel shut off.

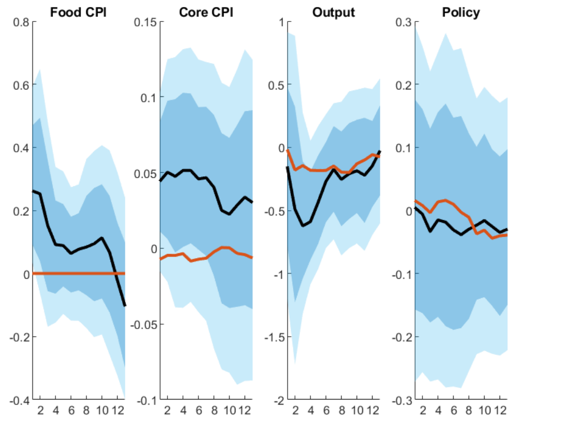
Figures 14 to 17 display the responses to domestic shocks. A positive domestic supply shock has a strong negative effect on both food and core CPI in all cases. In Canada, Japan, South Korea and Mexico the initially negative response of food CPI turns positive after six to eight months. The effect on output growth is positive at first, but it dies out over the twelve-month horizon in all countries except the euro area and Japan, which experience greater variation in the output growth response. Most central banks do not react to a domestic supply shock, except the Bank of England and the Bank of Canada, which respond by respectively decreasing and increasing the policy rate. Food CPI increases by around 0.1 to 0.3 percentage points in response to a positive demand shock, but this effect is persistent in the US and the UK only. In all other countries, food CPI declines quickly thereafter. Similarly, core CPI responds positively at first to a positive demand shock but thereafter the effects differ greatly between countries. Specifically, in the US, the euro area and South Korea, core CPI keeps rising over the entire response horizon, but it falls instead in Japan and Mexico. In the UK, Canada and Denmark it appears to fluctuate more. After an initial positive response, output growth slows down and reaches zero within twelve months in almost all countries. Monetary authorities seem to respond with a strong tightening in most cases.

Figure 12. Responses to global shocks for Mexico

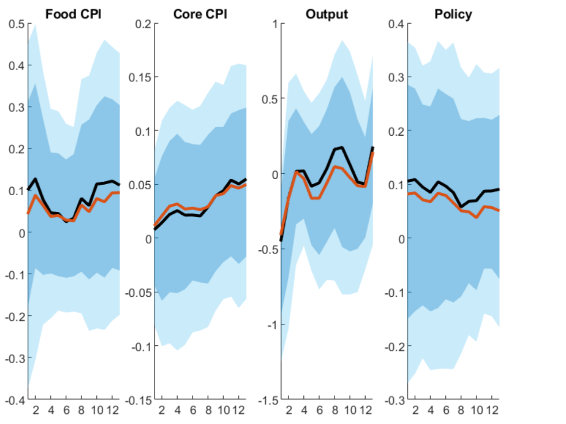
Panel A – Response to food price mean shock



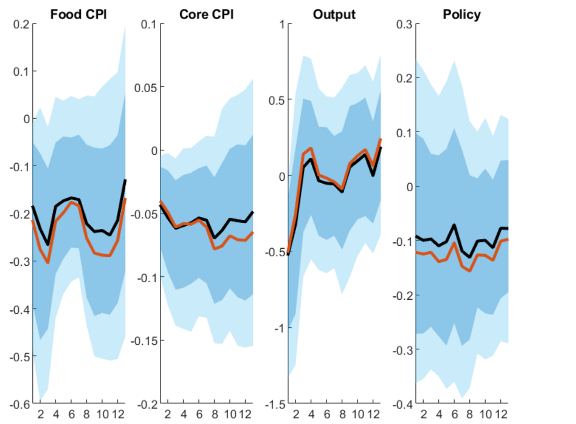
Panel B – Response to food price volatility shock



Panel C – Response to oil price shock



Panel D – Response to exchange rate shock

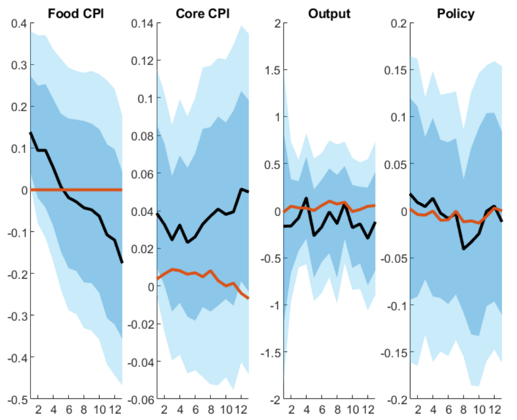


Notes: The solid black line represents the median response, the dark blue shaded area represents the 68% confidence band, while the light blue shaded areas represent the 95% confidence bands. The solid orange line represents the counterfactual with the domestic food inflation channel shut off. The responses of food CPI, core CPI and the policy rate are in percentage points, while the response of output growth is in percent.

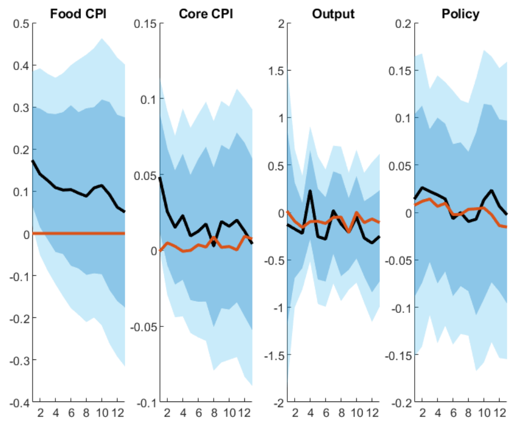
The effects of a domestic demand shock are more persistent than those of global food price mean and volatility shocks in the case of domestic food inflation, but the opposite holds in the case of core inflation. There is no difference between the standard and the counterfactual response for either domestic supply or domestic demand shocks. A contractionary monetary policy shock reduces both food and core CPI, as expected, whilst output growth initially increases and then declines. The evolution of the policy rate after the policy shock is stronger in the presence of second-round effects of the global food price mean and volatility shocks on core inflation, which indicates that monetary authorities implement more aggressive policies when core inflation is high because of the impact of global food price shocks.

Figure 13. Responses to global shocks for Denmark

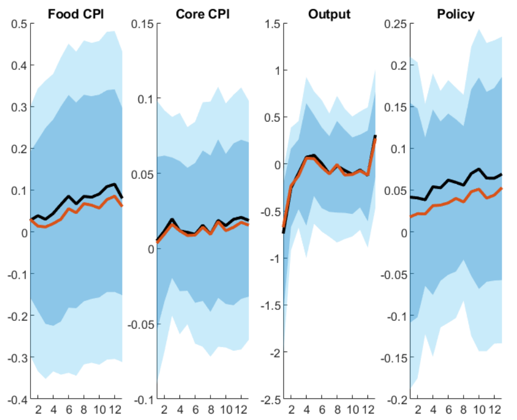
Panel A – Response to food price mean shock



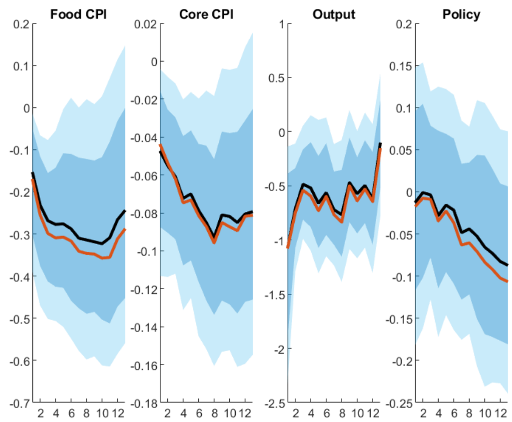
Panel B – Response to food price volatility shock



Panel C – Response to oil price shock



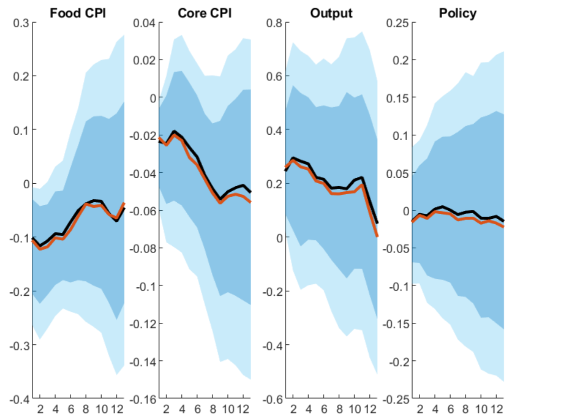
Panel D – Response to exchange rate shock



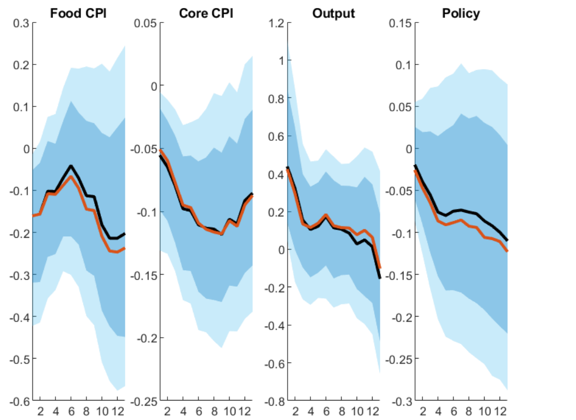
Notes: The solid black line represents the median response, the dark blue shaded area represents the 68% confidence band, while the light blue shaded areas represent the 95% confidence bands. The solid orange line represents the counterfactual with the domestic food inflation channel shut off. The responses of food CPI, core CPI and the policy rate are in percentage points, while the response of output growth is in percent.

Figure 14. Responses to domestic shocks for the US and UK

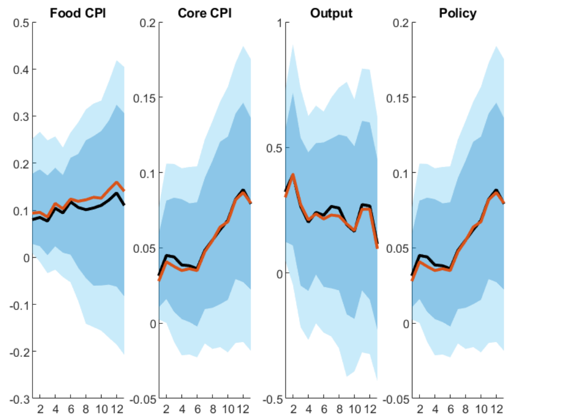
Panel A – US response to supply shock



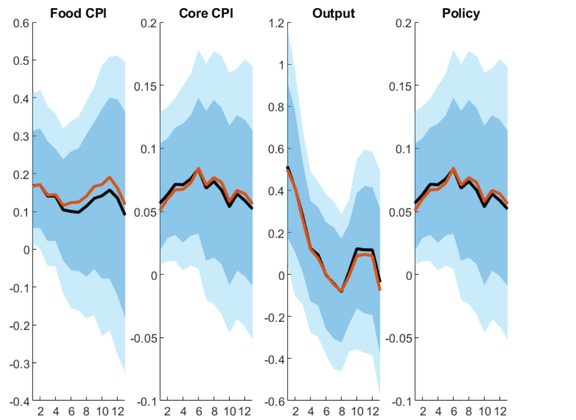
Panel B – UK response to supply shock



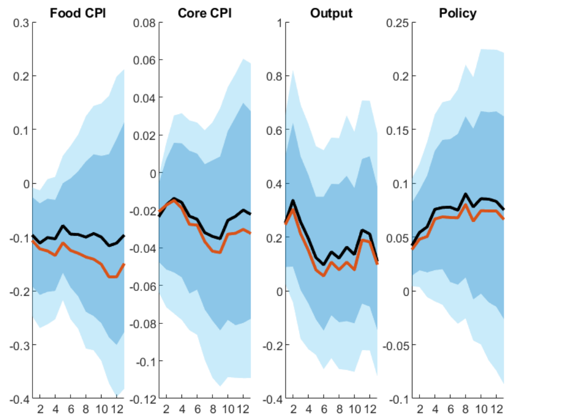
Panel C – US response to demand shock



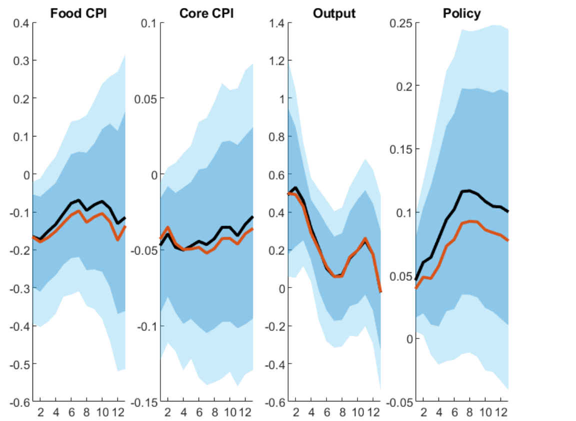
Panel D – UK response to demand shock



Panel E – US response to policy shock



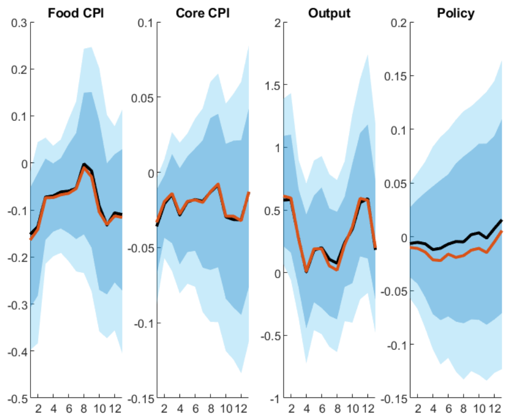
Panel F – UK response to policy shock



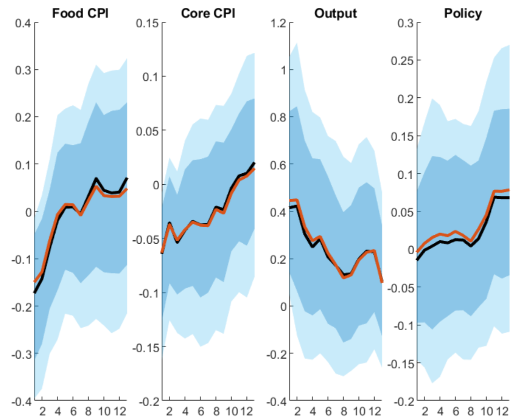
Notes: The solid black line represents the median response, the dark blue shaded area represents the 68% confidence band, while the light blue shaded areas represent the 95% confidence bands. The solid orange line represents the counterfactual with the domestic food inflation channel shut off. The responses of food CPI, core CPI and the policy rate are in percentage points, while the response of output growth is in percent.

Figure 15. Responses to domestic shocks for the euro area and Canada

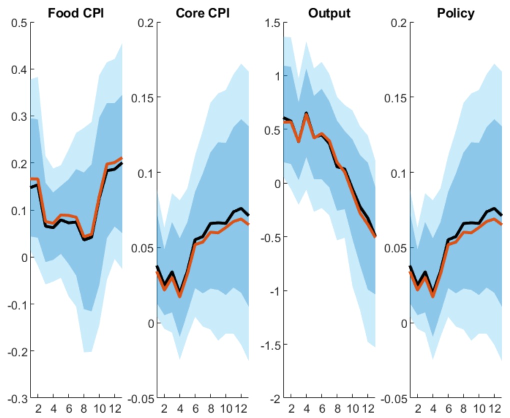
Panel A – Euro area response to supply shock



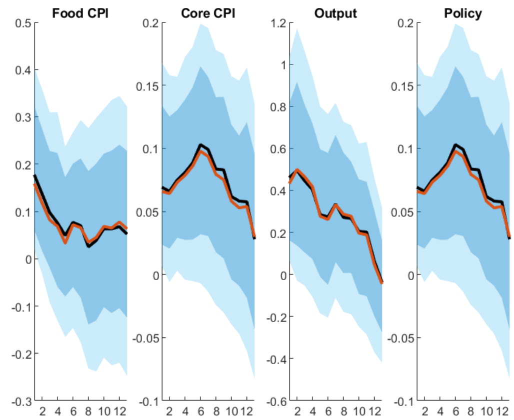
Panel B – Canada response to supply shock



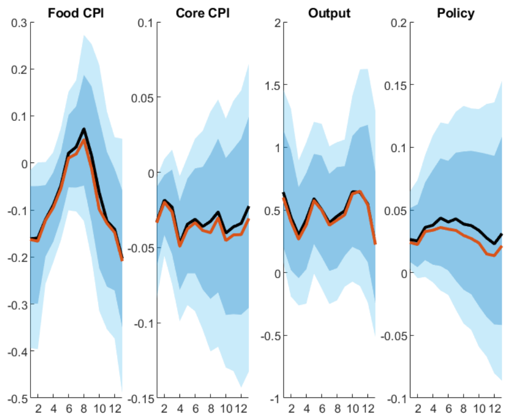
Panel C – Euro area response to demand shock



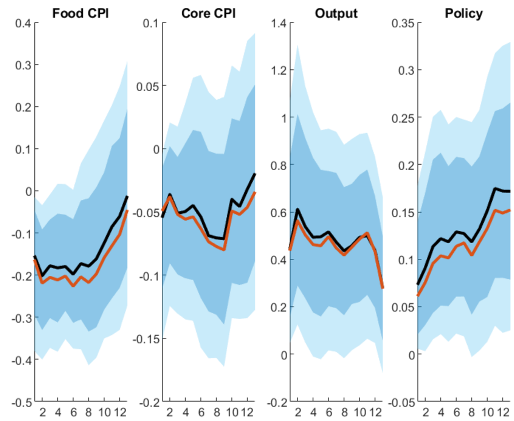
Panel D – Canada response to demand shock



Panel E – Euro area response to policy shock



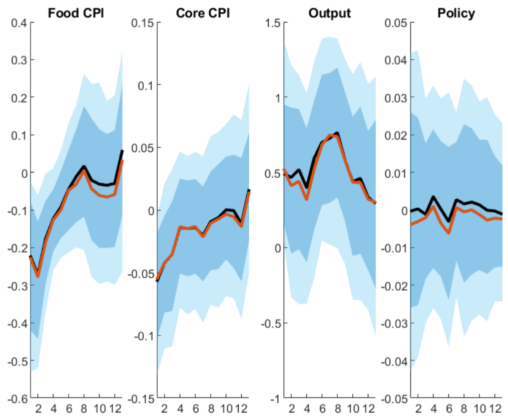
Panel F – Canada response to policy shock



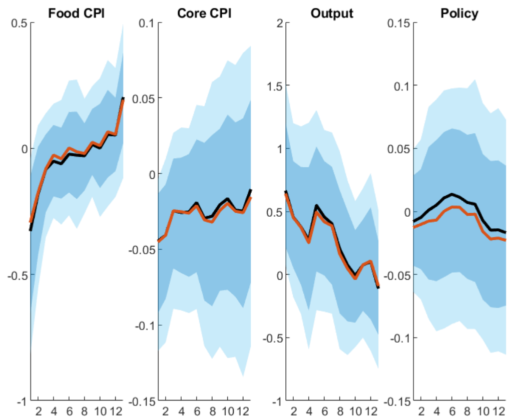
Notes: The solid black line represents the median response, the dark blue shaded area represents the 68% confidence band, while the light blue shaded areas represent the 95% confidence bands. The solid orange line represents the counterfactual with the domestic food inflation channel shut off. The responses of food CPI, core CPI and the policy rate are in percentage points, while the response of output growth is in percent.

Figure 16. Responses to domestic shocks for Japan and South Korean

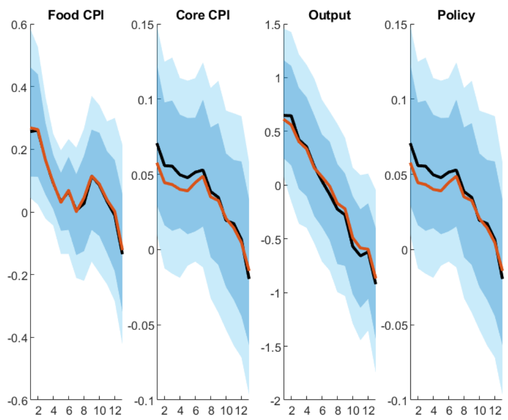
Panel A – Japan response to supply shock



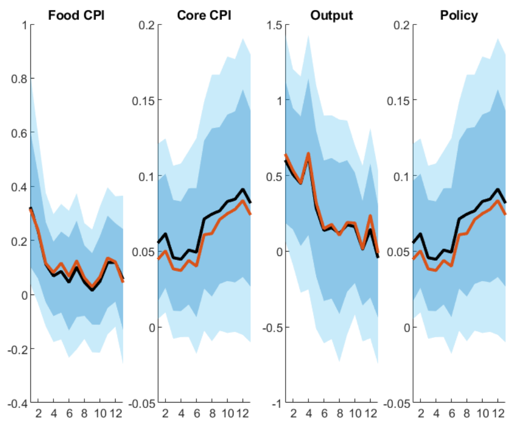
Panel B – South Korea response to supply shock



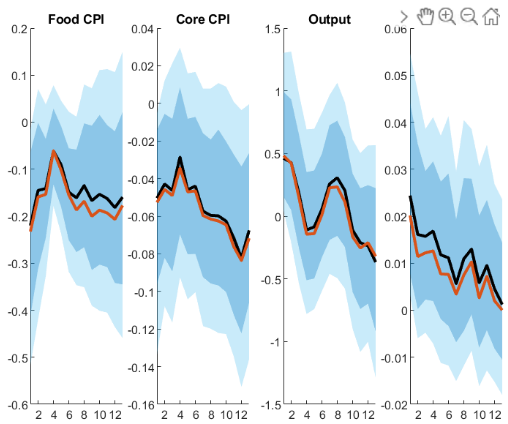
Panel C – Japan response to demand shock



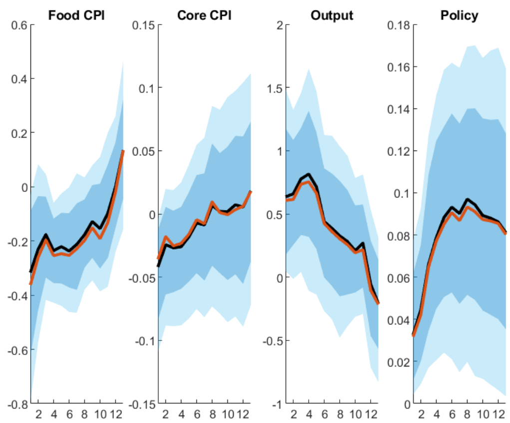
Panel D – South Korea response to demand shock



Panel E – Japan response to policy shock



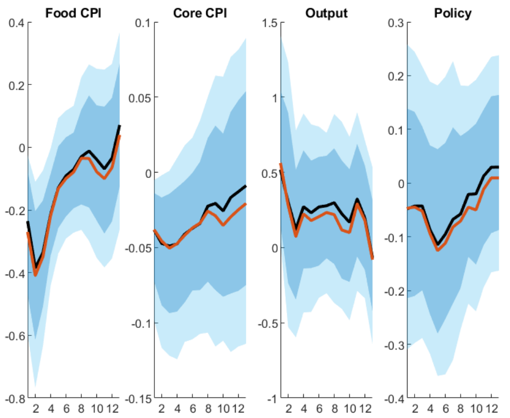
Panel F – South Korea response to policy shock



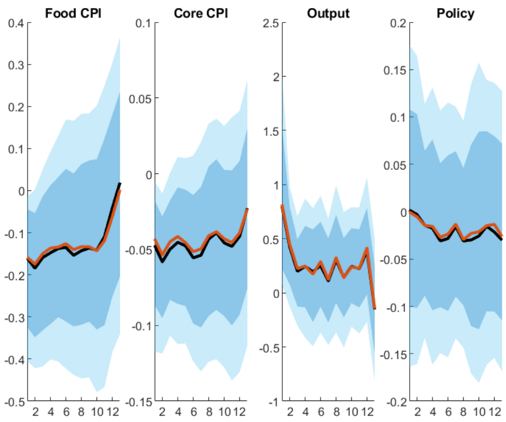
Notes: The solid black line represents the median response, the dark blue shaded area represents the 68% confidence band, while the light blue shaded areas represent the 95% confidence bands. The solid orange line represents the counterfactual with the domestic food inflation channel shut off. The responses of food CPI, core CPI and the policy rate are in percentage points, while the response of output growth is in percent.

Figure 17. Responses to domestic shocks for Mexico and Denmark

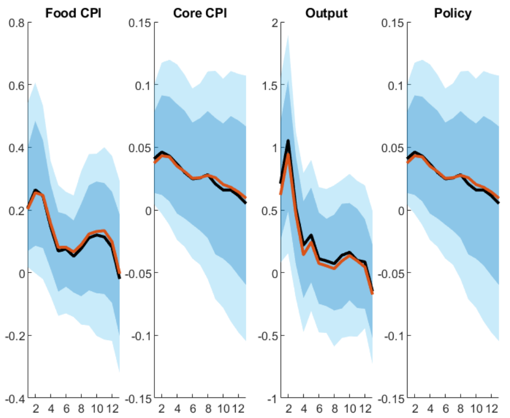
Panel A – Mexico response to supply shock



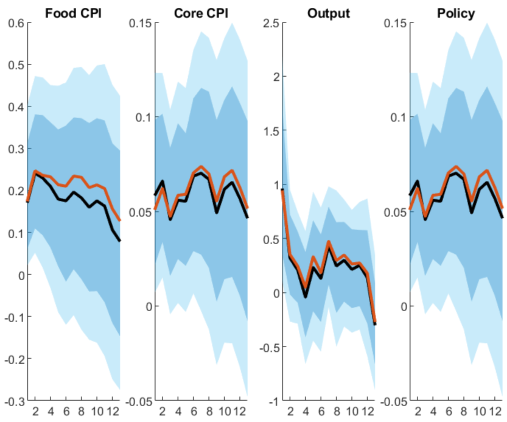
Panel B – Denmark response to supply shock



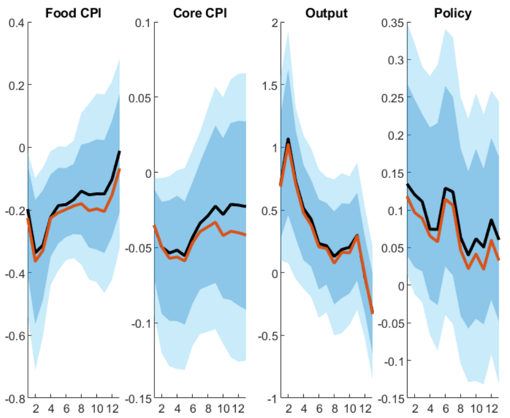
Panel C – Mexico response to demand shock



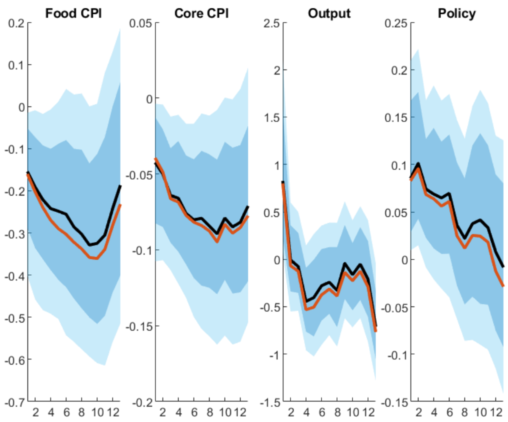
Panel D – Denmark response to demand shock



Panel E – Mexico response to policy shock



Panel F – Denmark response to policy shock



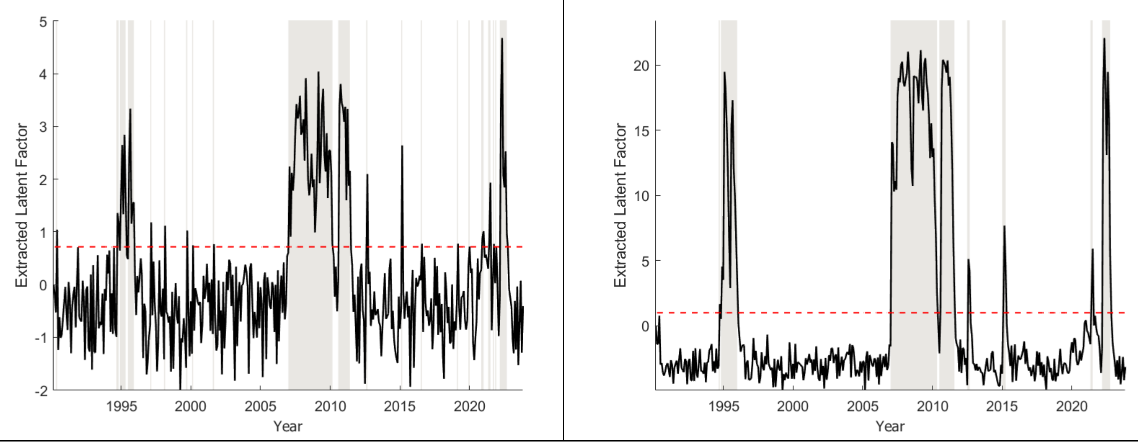
Notes: The solid black line represents the median response, the dark blue shaded area represents the 68% confidence band, while the light blue shaded areas represent the 95% confidence bands. The solid orange line represents the counterfactual with the domestic food inflation channel shut off. The responses of food CPI, core CPI and the policy rate are in percentage points, while the response of output growth is in percent.

4.4 Extensions to the analysis using real and disaggregate food prices

In this section we present the results of two extensions to the analysis using the real FAO food price index and the nominal disaggregate FAO food price indices. Figure 18 displays the mean and volatility factors extracted from the UERS model for real food prices. There are some interesting differences compared to our earlier findings for the nominal index. In particular, the mean factor now seems to exhibit less variation and is characterised by less time spent above the threshold than in the case of the nominal series. This is not surprising as the real series controls for the aggregate price level. By contrast, the volatility factor displays a similar behaviour to the one in the nominal case, which suggests that volatility is equally present in nominal and real food prices.

Figure 18. Extracted factors using real food prices

Panel A – Mean factor	**Panel B – Volatility factor**

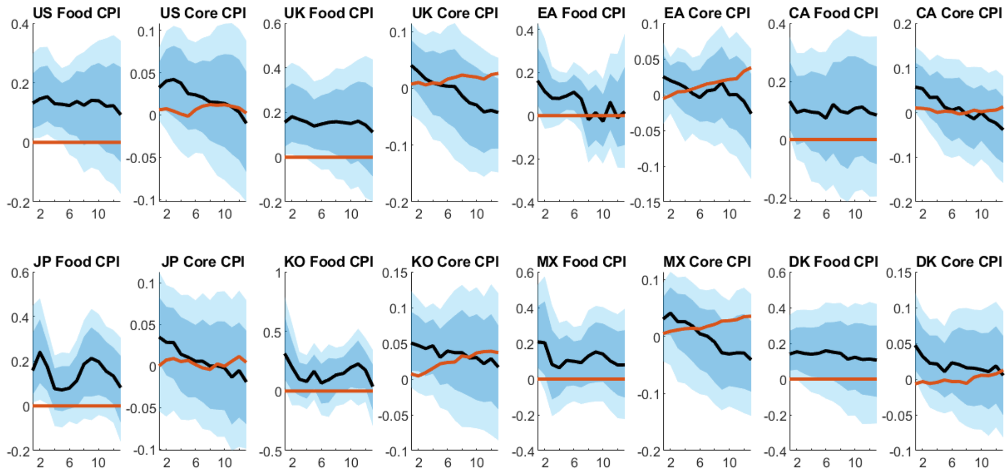


Notes: The extracted factors are represented by the black line while the estimated threshold is depicted by the red dashed line. The grey shaded areas indicate periods of high mean (Panel A) and high volatility (Panel B).

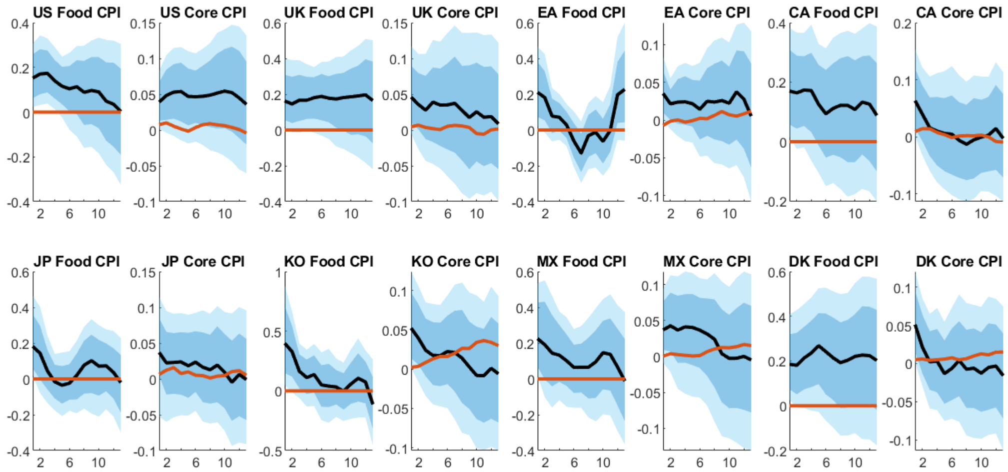
The responses of food CPI and core CPI to real food price mean and volatility shocks are shown in Figure 19. The effects of both types of shocks on domestic food CPI now appear to be more persistent than in the case of nominal shocks. This presumably reflects the absence of noisy price changes in the real series. Most interestingly, in contrast to the nominal food price mean shocks, real ones do not have persistent second-round effects on core CPI, the initial positive impact dying out over the response horizon. The same applies to real food price volatility shocks, for which persistent second-round effects are found only in the case of the US. The other IRFs from the VAR model with real food price shocks are displayed in Appendix A.

Figure 19. Inflation responses to real food price shocks

Panel A – Response to real food price mean shock



Panel B – Response to real food price volatility shock



Notes: The solid black line represents the median response, the dark blue shaded area represents the 68% confidence band, while the light blue shaded areas represent the 95% confidence bands. The solid orange line represents the counterfactual with the domestic food inflation channel shut off. US = United States; UK = United Kingdom; EA = euro area; CA = Canada; JP = Japan; KO = South Korea; MX = Mexico; DK = Denmark.

For the remainder of the analysis we use disaggregate food price data to assess the relative importance of individual food price categories for domestic inflation.[2] Figure 20 shows the mean and volatility factors obtained from using global cereal prices alongside the responses of food CPI and core CPI to cereal price mean and volatility shocks. The cereal price index contains price quotations for wheat, maize, barley and rice, which are highly important for international food security. Both the mean and the volatility factors behave similarly to those

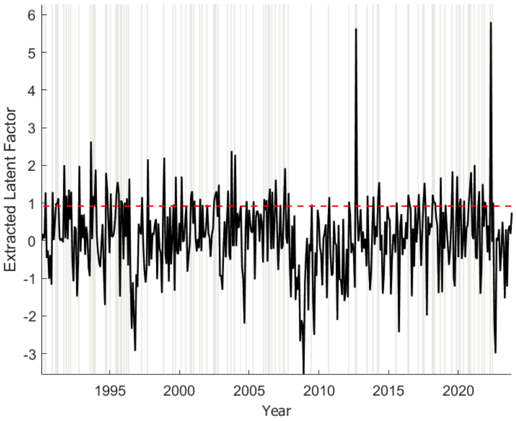
[2] The responses of output growth and the policy rate to the disaggregate nominal food price shocks are displayed in Appendix B.

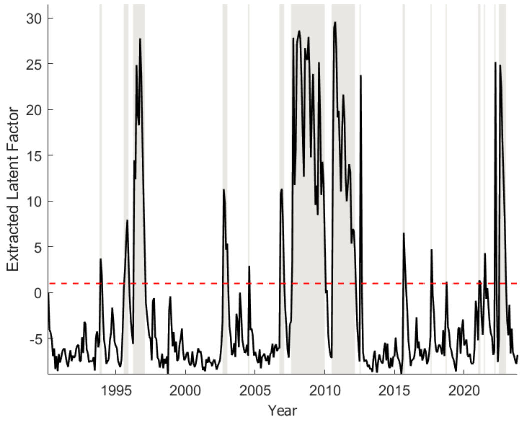
for the nominal aggregate series. The response of food CPI to a cereal price mean shock is smaller and less persistent than in the case of the aggregate shocks. On the other hand, the effects on core CPI are now more volatile but die out over time. The responses of food and core CPI to a cereal price volatility shock are smaller than in the case of the aggregate food price series. Figure 21 displays the extracted factors and the IRFs for global meat prices (which include prices for bovine, pig, poultry and ovine meat types). The mean factor shows some similarities to that for the nominal aggregate series, whilst the volatility one exhibits a very different behaviour over time, most high volatility periods not coinciding with those for the aggregate series. Food CPI in Japan, South Korea and Mexico exhibits a weaker response of 0.05 percentage points to meat price mean and volatility shocks in all countries except the US, the euro area and Canada; there are still persistent second-round effects on core inflation, but they are smaller than in the case of aggregate food prices.

Figure 22 displays the results for the vegetable oil price series, which includes the price for ten different types of oil. Again, there some similarities to the results obtained with the aggregate index. Specifically, food and core CPI respond in a similar manner to the previous case to vegetable oil price mean and volatility shocks, though the effect is larger in the case of the aggregate index. The results for the sugar series are reported in Figure 23 and are very different from the aggregate ones. Sugar prices appear to have been volatile across the entire sample period and were also characterised by large changes in the mean. The effects of sugar price mean shocks on domestic food CPI is much smaller (around 0.05 percentage points) in the UK, South Korea and Mexico, while a sugar price volatility shock has a smaller effect on food CPI in the euro area and South Korea. The effects of both shocks on core CPI, however, are persistent in most countries. Figure 24 reports the results for the dairy price index which includes price quotations for butter, cheese and milk powder items. Both mean and volatility factors behave similarly to those obtained for the aggregate series, but with some stronger variation at the beginning of the sample. There is a considerably smaller effect of dairy price mean shocks on food CPI in Japan and South Korea, which is not surprising, since dairy consumption is lower in these countries compared to the others in our sample. Elsewhere, the response is positive and declines as in the aggregate case, but does not turn negative and instead dies out within twelve months. Dairy price volatility shocks affect food CPI in a similar way to the aggregate shocks, but with a smaller effect on core CPI.

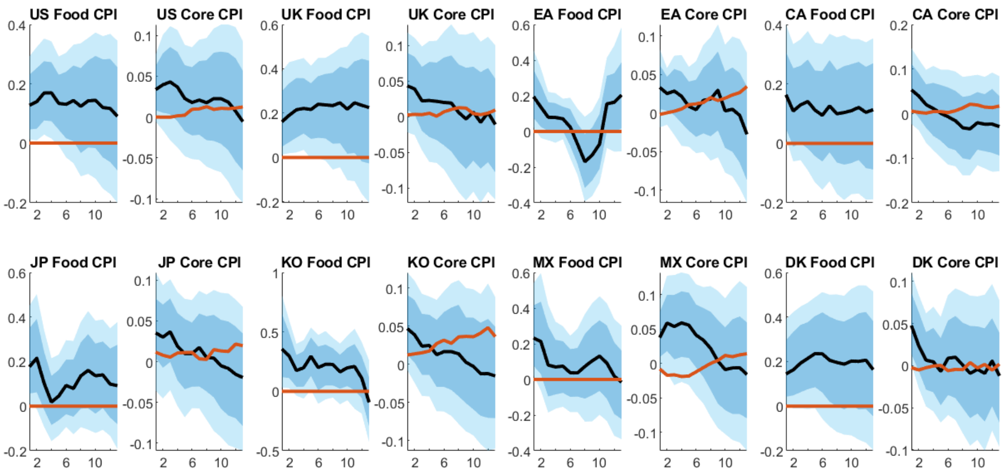
Figure 20. Results using the cereal price index

Panel A – Cereal price mean factor	Panel B – Cereal price volatility factor

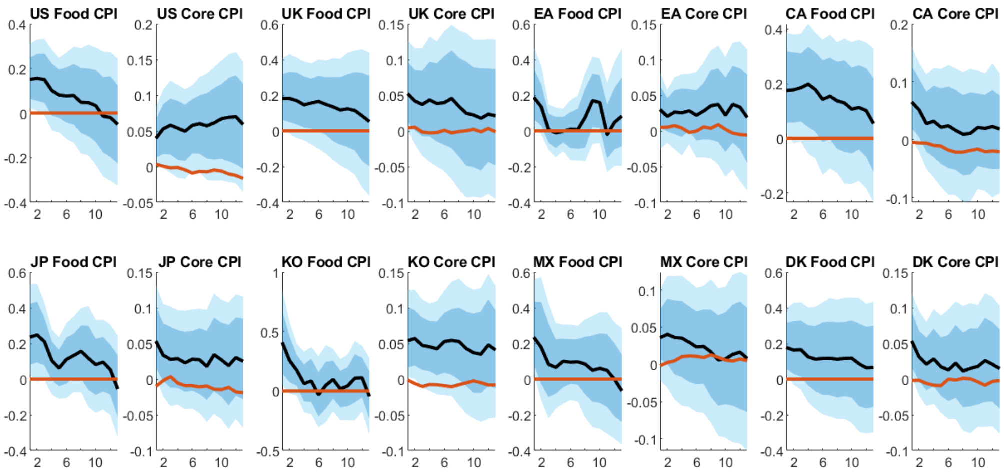




Panel C – Inflation responses to cereal price mean shock



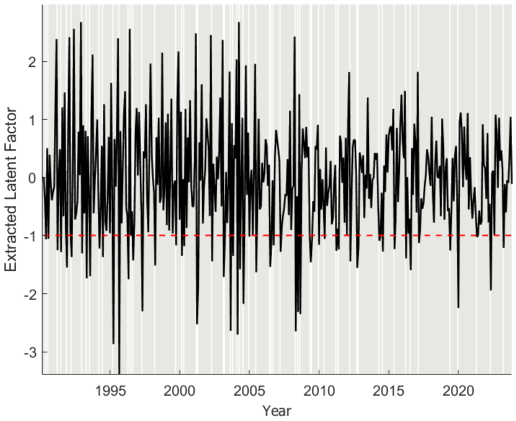
Panel D – Inflation responses to cereal price volatility shock

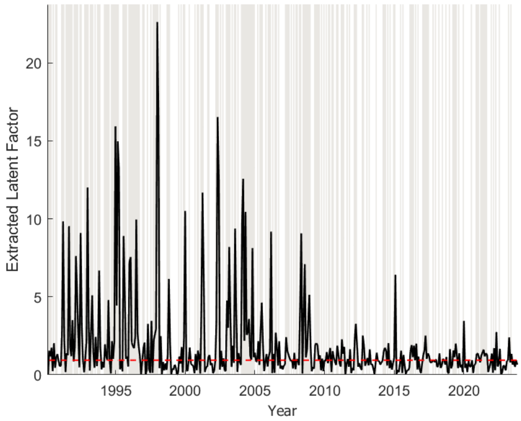


Notes: Panel A and B: The extracted factors are represented by the black line while the estimated threshold is depicted by the red dashed line. The grey shaded areas indicate periods of high mean (Panel A) and high volatility (Panel B). Panel C and D: The solid black line represents the median response, the dark blue shaded area represents the 68% confidence band, while the light blue shaded areas represent the 95% confidence bands. The solid orange line represents the counterfactual with the domestic food inflation channel shut off. US = United States; UK = United Kingdom; EA = euro area; CA = Canada; JP = Japan; KO = South Korea; MX = Mexico; DK = Denmark.

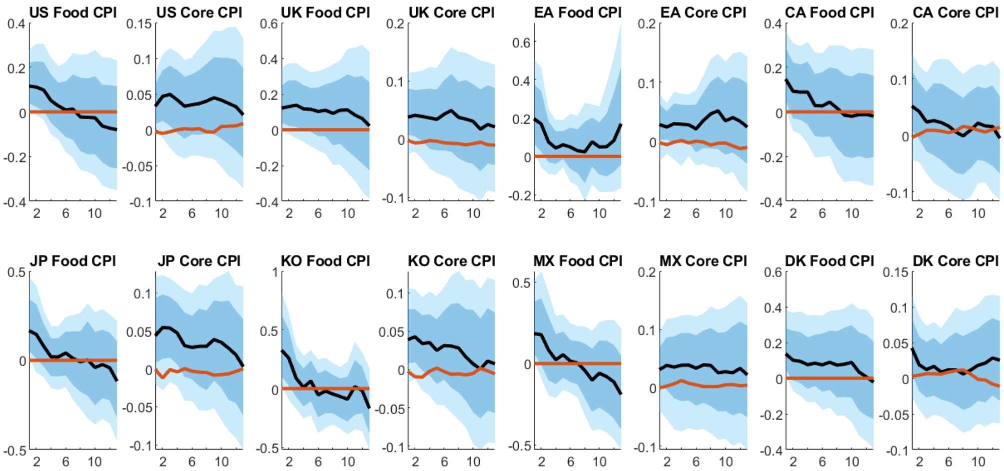
Figure 21. Results using the meat price index

Panel A – Meat price mean factor	Panel B – Meat price volatility factor

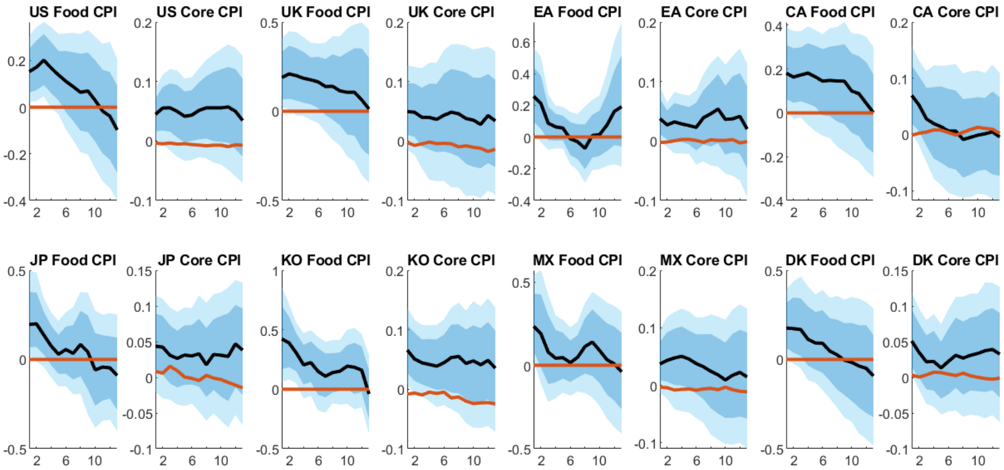




Panel C – Inflation responses to meat price mean shock



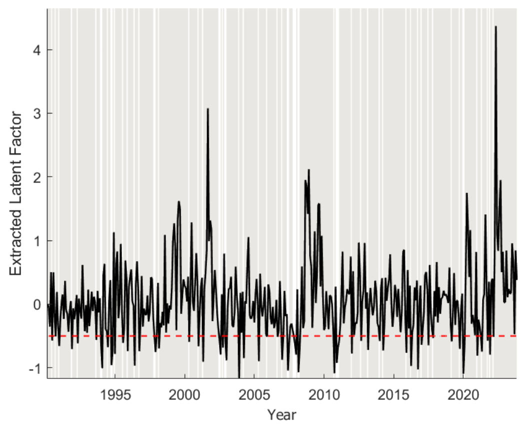
Panel D – Inflation responses to meat price volatility shock



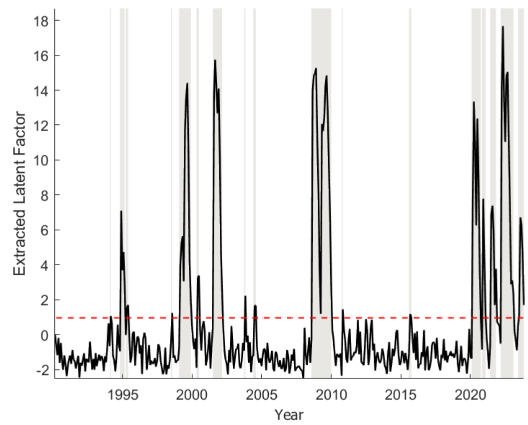
Notes: Panel A and B: The extracted factors are represented by the black line while the estimated threshold is depicted by the red dashed line. The grey shaded areas indicate periods of high mean (Panel A) and high volatility (Panel B). Panel C and D: The solid black line represents the median response, the dark blue shaded area represents the 68% confidence band, while the light blue shaded areas represent the 95% confidence bands. The solid orange line represents the counterfactual with the domestic food inflation channel shut off. US = United States; UK = United Kingdom; EA = euro area; CA = Canada; JP = Japan; KO = South Korea; MX = Mexico; DK = Denmark.

Figure 22. Results using the vegetable oil price index

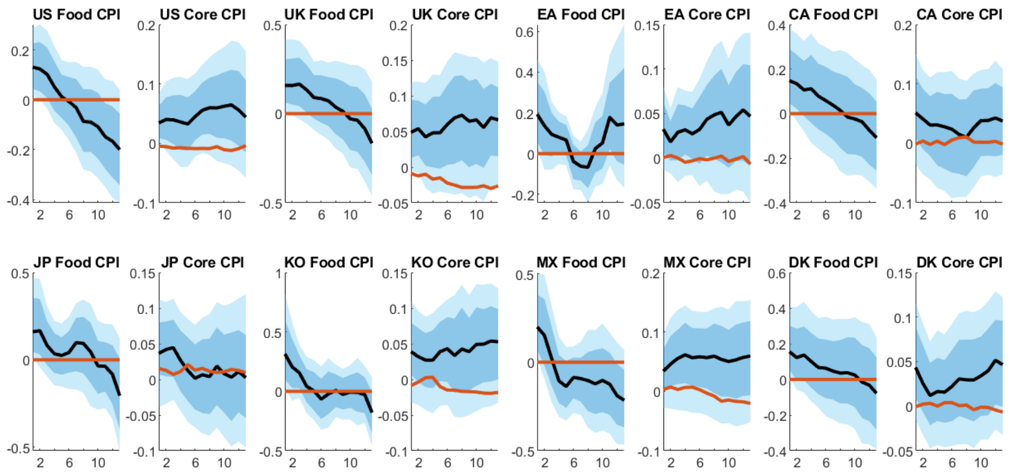
Panel A – Vegetable oil price mean factor



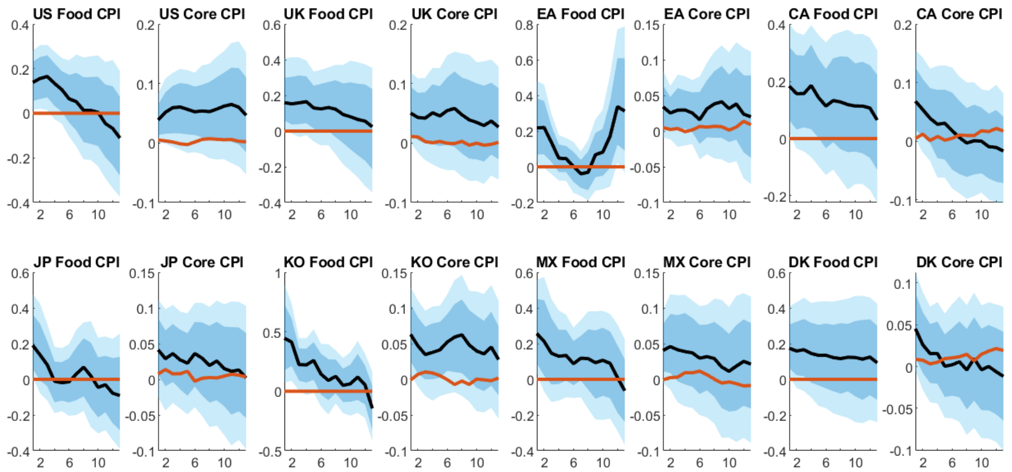
Panel B – Vegetable oil price volatility factor



Panel C – Inflation responses to vegetable oil price mean shock



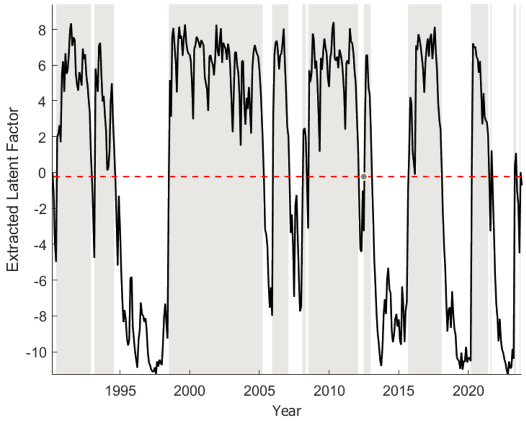
Panel D – Inflation responses to vegetable oil price volatility shock



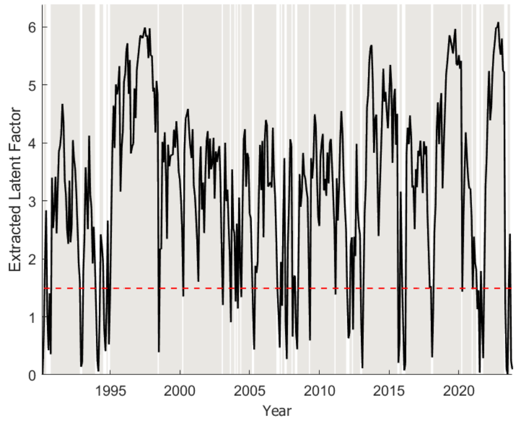
Notes: Panel A and B: The extracted factors are represented by the black line while the estimated threshold is depicted by the red dashed line. The grey shaded areas indicate periods of high mean (Panel A) and high volatility (Panel B). Panel C and D: The solid black line represents the median response, the dark blue shaded area represents the 68% confidence band, while the light blue shaded areas represent the 95% confidence bands. The solid orange line represents the counterfactual with the domestic food inflation channel shut off. US = United States; UK = United Kingdom; EA = euro area; CA = Canada; JP = Japan; KO = South Korea; MX = Mexico; DK = Denmark.

Figure 23. Results using the sugar price index

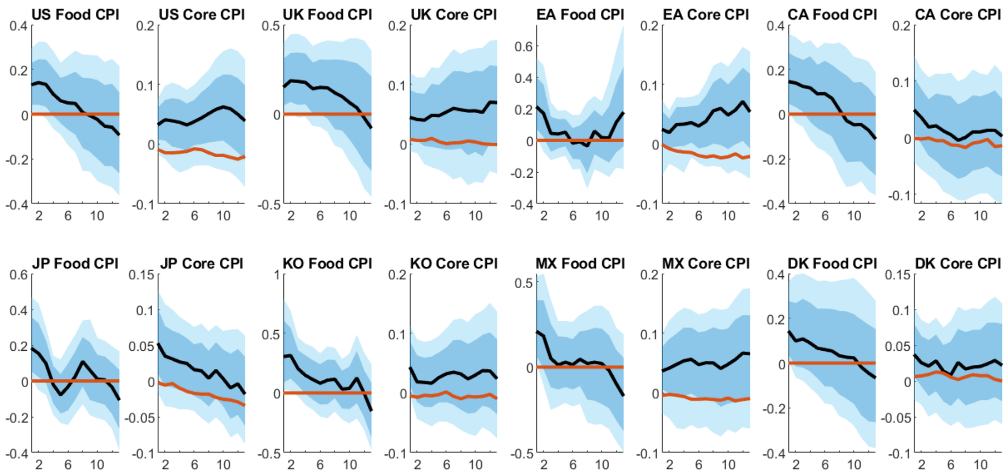
Panel A – Sugar price mean factor



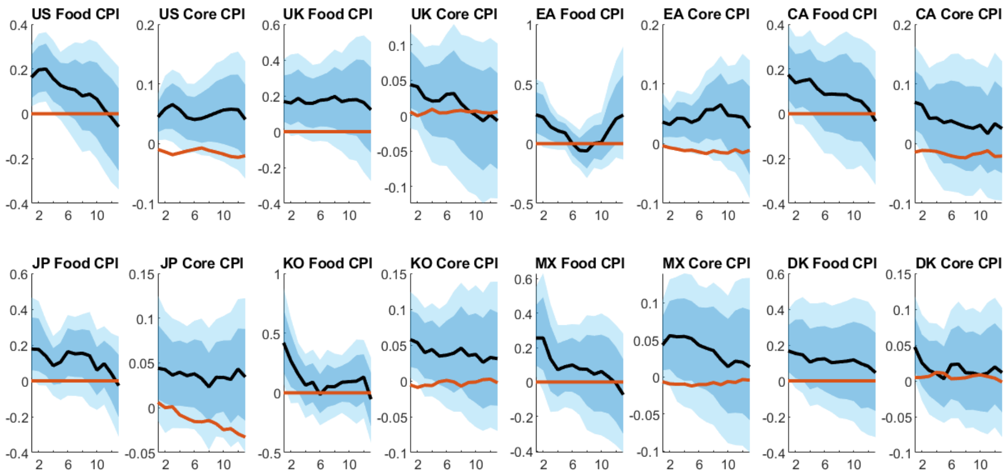
Panel B – Sugar price volatility factor



Panel C – Inflation responses to sugar price mean shock



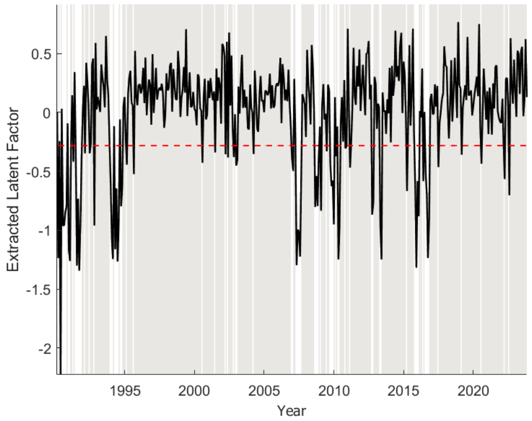
Panel D – Inflation responses to sugar price volatility shock

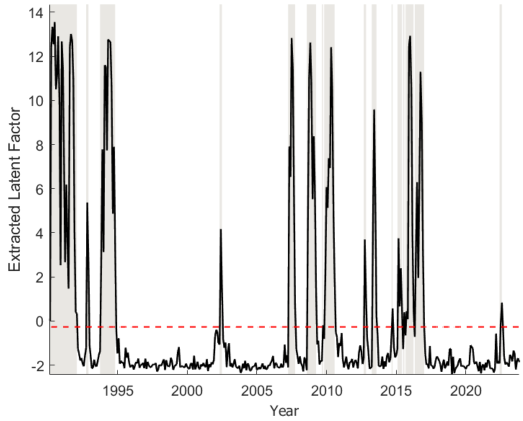


Notes: Panel A and B: The extracted factors are represented by the black line while the estimated threshold is depicted by the red dashed line. The grey shaded areas indicate periods of high mean (Panel A) and high volatility (Panel B). Panel C and D: The solid black line represents the median response, the dark blue shaded area represents the 68% confidence band, while the light blue shaded areas represent the 95% confidence bands. The solid orange line represents the counterfactual with the domestic food inflation channel shut off. US = United States; UK = United Kingdom; EA = euro area; CA = Canada; JP = Japan; KO = South Korea; MX = Mexico; DK = Denmark.

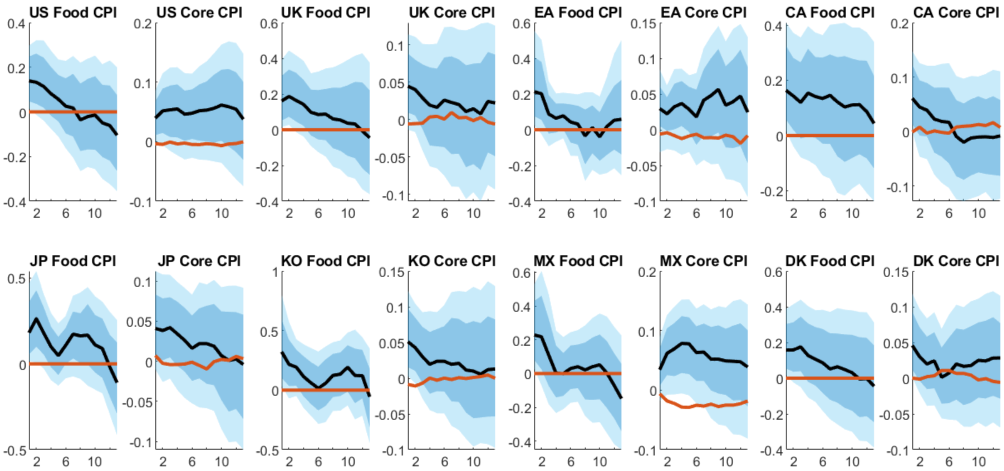
Figure 24. Results using the dairy price index

Panel A – Dairy price mean factor	Panel B – Dairy price volatility factor

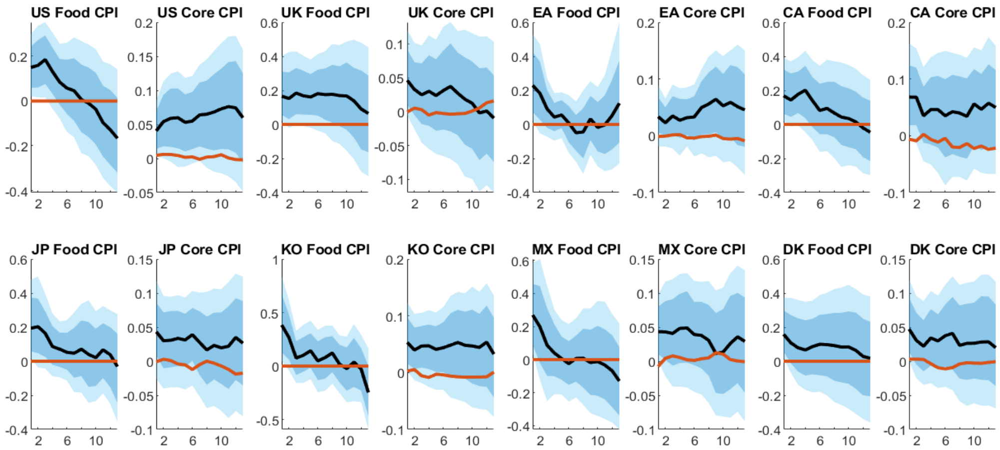




Panel C – Inflation responses to dairy price mean shock



Panel D – Inflation responses to dairy price volatility shock



Notes: Panel A and B: The extracted factors are represented by the black line while the estimated threshold is depicted by the red dashed line. The grey shaded areas indicate periods of high mean (Panel A) and high volatility (Panel B). Panel C and D: The solid black line represents the median response, the dark blue shaded area represents the 68% confidence band, while the light blue shaded areas represent the 95% confidence bands. The solid orange line represents the counterfactual with the domestic food inflation channel shut off. US = United States; UK = United Kingdom; EA = euro area; CA = Canada; JP = Japan; KO = South Korea; MX = Mexico; DK = Denmark.

The most persistent second-round effects on core inflation are caused by vegetable oil price mean shocks, while cereal price volatility shocks have highly volatile effects. On average, the second-round effects of the disaggregate shocks are smaller than those of the aggregate ones. Finally, the second-round effects appear to be persistent regardless of the level of aggregation of the data, while their size is dependent on that of the response of food CPI to the aggregate and disaggregate global food price mean and volatility shocks.

5. Conclusions

This paper uses the unsynchronised endogenous regime switching model with dynamic feedback and interactions developed by Chang et al. (2023) to extract global food price mean and volatility factors based on the United Nations Food and Agriculture Organization (FAO) nominal food price index. The chosen specification is shown to outperform a range of competing models in terms of its out-of-sample forecasting properties. A structural VAR model is then estimated to assess the importance of the pass-through of shocks to the obtained global food price mean and volatility indicators to domestic food price inflation in a range of countries with different food consumption shares out of total consumption and different food shares in the CPI basket. Further, counterfactual analysis is conducted to assess the effects of the two types of shocks on core inflation. Finally, the analysis is extended by re-estimating the models using real and disaggregate nominal FAO food price indices in turn.

The findings can be summarised as follows. First, the estimated endogenous regime-switching specification allowed us to construct global food price mean and volatility indicators, the latter capturing in particular the likelihood of volatility (a measure of uncertainty in the global food market) remaining in the same regime for long periods of time. Second, the results obtained from the structural VAR models show that domestic food consumer price inflation reacts strongly to global food price mean and volatility shocks, but these effects are only transitory. It also appears that the response of food CPI to global food price volatility shocks is more volatile in countries with a higher food consumption share in total consumption and a higher food share in the CPI basket. Third, there is evidence that global food price mean and volatility shocks affect core inflation through second-round effects of domestic food consumer price inflation; these are highly persistent and even increasing over time in most countries, especially in the case of mean shocks. This implies that food price inflation can affect non-food price inflation as a result of shocks originating from global food prices. In contrast to previous studies, we find that the food consumption share in total consumption or the food share in the CPI basket of individual countries do not play a role in terms of the existence or size of second-round effects. Fourth, it appears that central banks react more to global food price mean shocks than to volatility ones when designing policies to target inflation. Finally, the results based on real and disaggregate food prices suggest that the second-round effects on core inflation are persistent regardless of the level of aggregation of the data, which only affects the size of the effects.

These findings have important implications for policymakers. More specifically, our analysis highlights the importance of distinguishing between the effects of global food price mean and volatility shocks, which require different policy responses and can help central banks choose the best measure of consumer price inflation to target. Furthermore, the presence of persistent second-round effects on core inflation implies that there is a strong pass-through channel, either through inflation expectations or firms' mark-up, which is important for central banks to take into account. Future research should focus upon establishing the exact nature of this channel.

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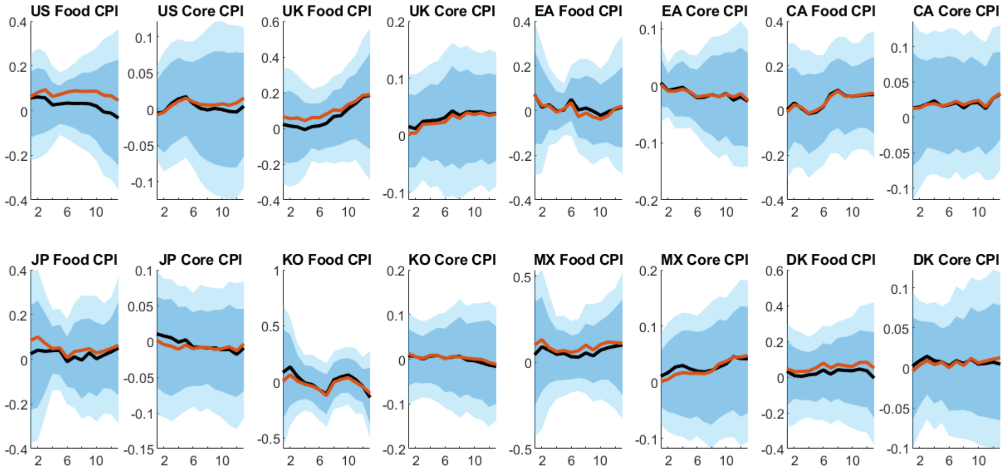
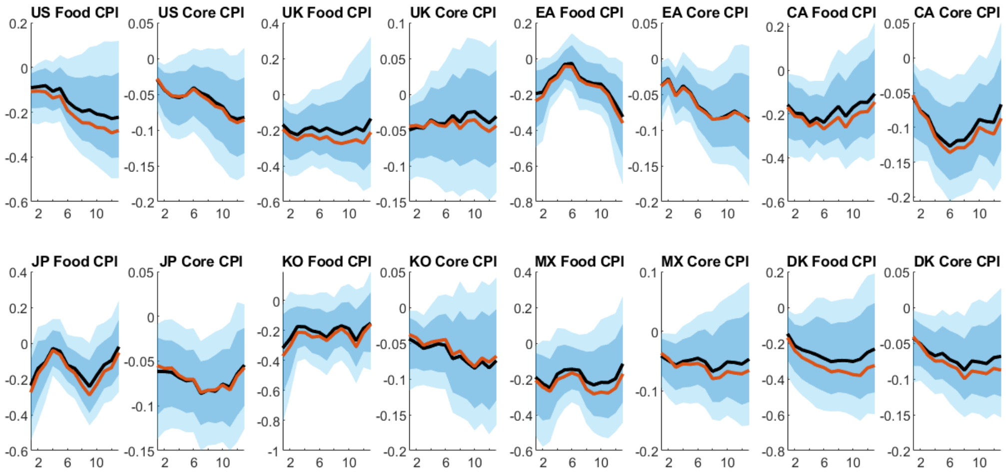
Appendix A. Additional results from the VAR model with real food prices

Figure A1. Inflation responses to other foreign shocks

Panel A – Response to oil price shock



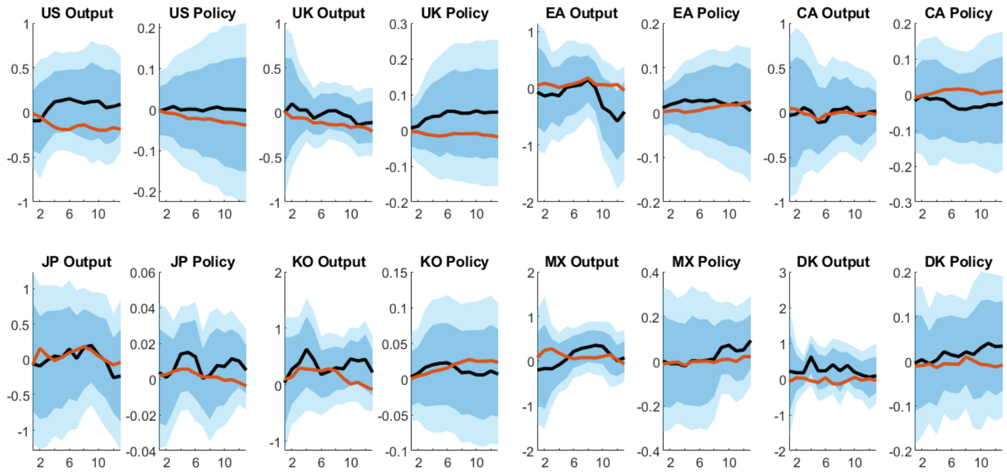
Panel B – Response to exchange rate shock



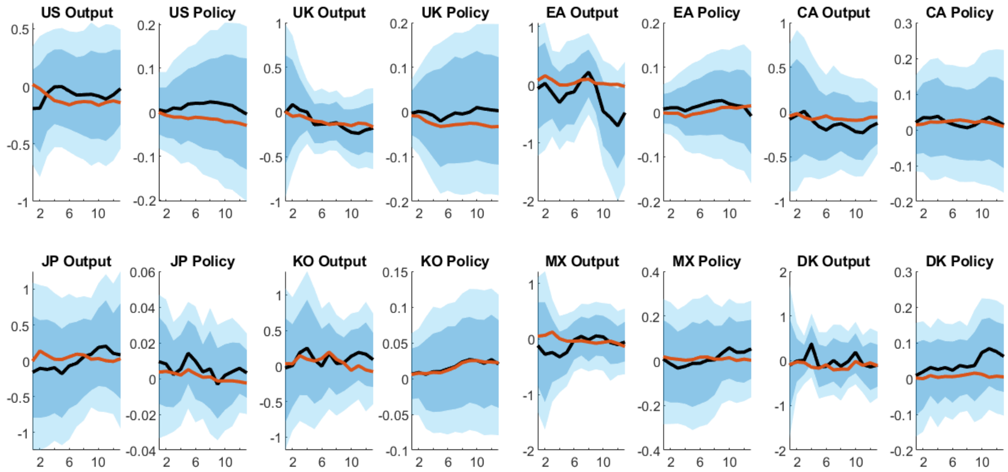
Notes: The solid black line represents the median response, the dark blue shaded area represents the 68% confidence band, while the light blue shaded areas represent the 95% confidence bands. The solid orange line represents the counterfactual with the domestic food inflation channel shut off. US = United States; UK = United Kingdom; EA = euro area; CA = Canada; JP = Japan; KO = South Korea; MX = Mexico; DK = Denmark.

Figure A2. Output and policy rate responses to real food price shocks

Panel A – Response to real food price mean shock



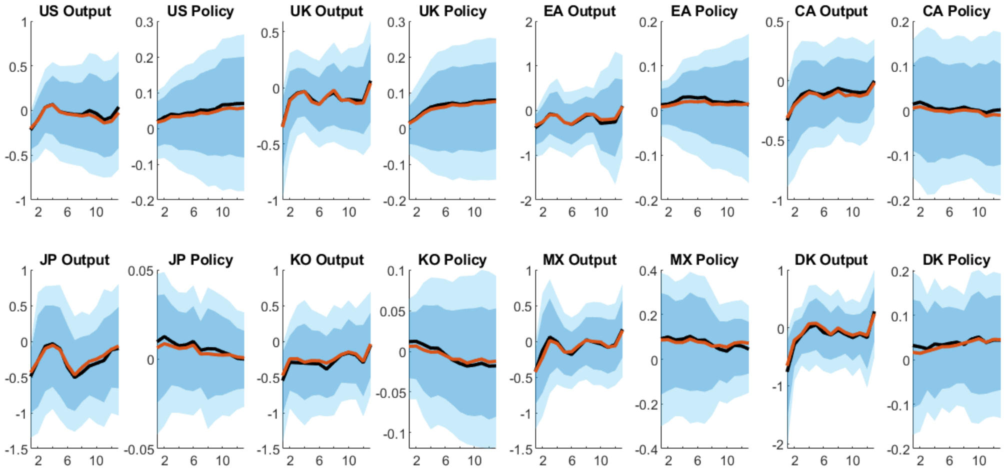
Panel B – Response to real food price volatility shock



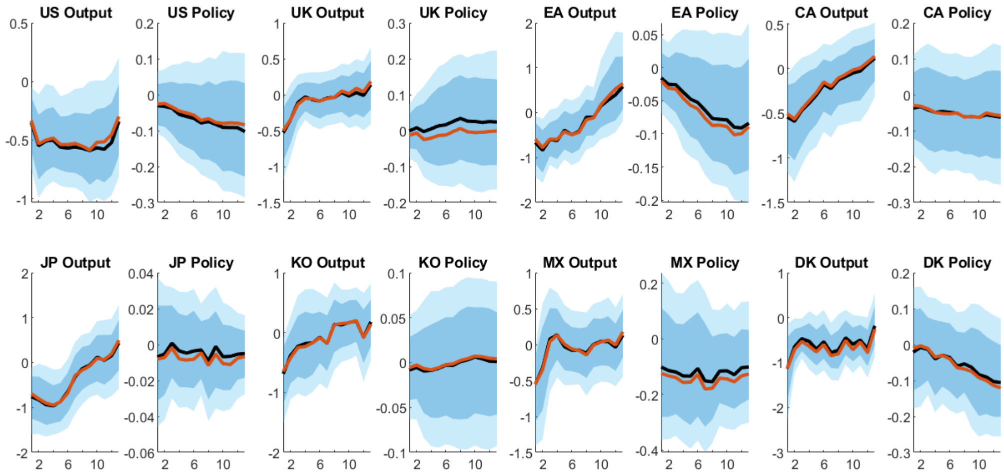
Notes: The solid black line represents the median response, the dark blue shaded area represents the 68% confidence band, while the light blue shaded areas represent the 95% confidence bands. The solid orange line represents the counterfactual with the domestic food inflation channel shut off. US = United States; UK = United Kingdom; EA = euro area; CA = Canada; JP = Japan; KO = South Korea; MX = Mexico; DK = Denmark.

Figure A3. Output and policy rate responses to other global shocks

Panel A – Response to oil price shock



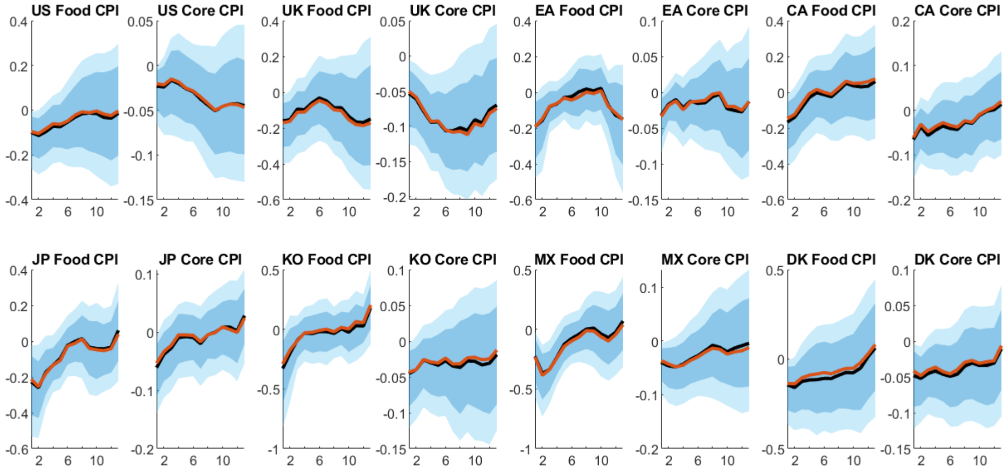
Panel B – Response to exchange rate shock



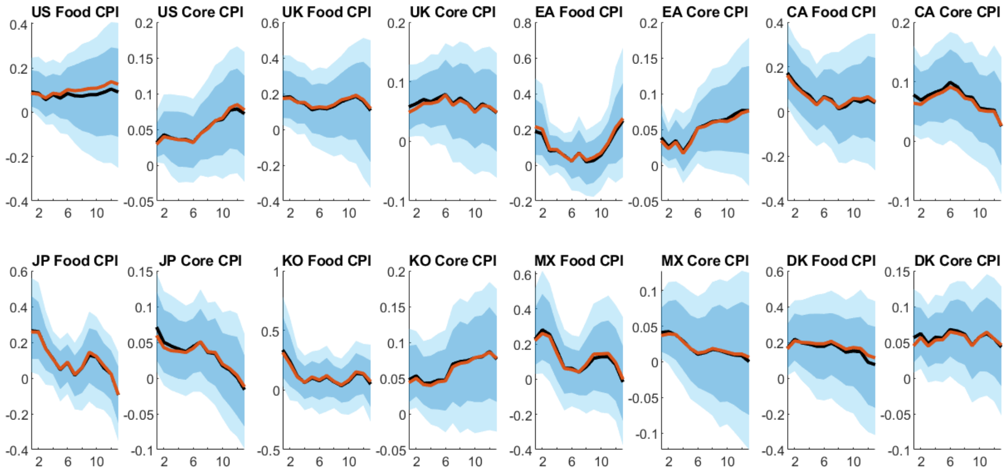
Notes: The solid black line represents the median response, the dark blue shaded area represents the 68% confidence band, while the light blue shaded areas represent the 95% confidence bands. The solid orange line represents the counterfactual with the domestic food inflation channel shut off. US = United States; UK = United Kingdom; EA = euro area; CA = Canada; JP = Japan; KO = South Korea; MX = Mexico; DK = Denmark.

Figure A4. Inflation responses to domestic shocks

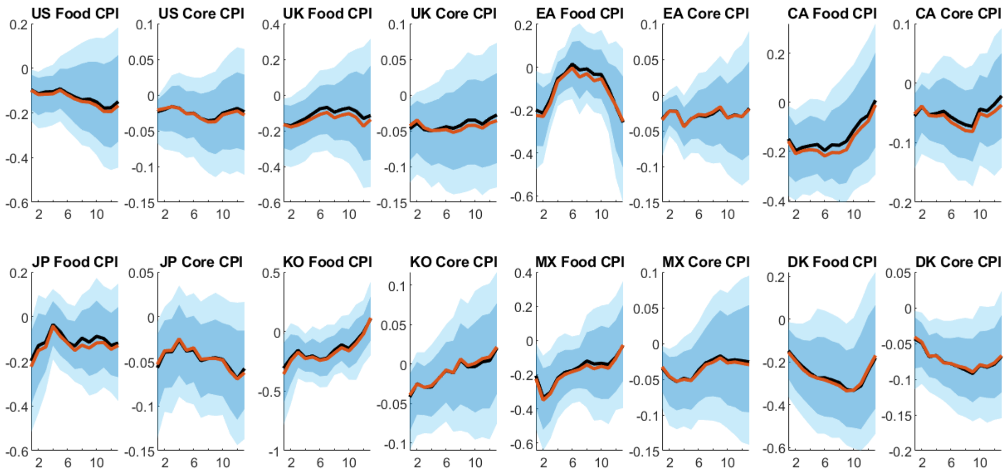
Panel A – Response to supply shock



Panel B – Response to demand shock



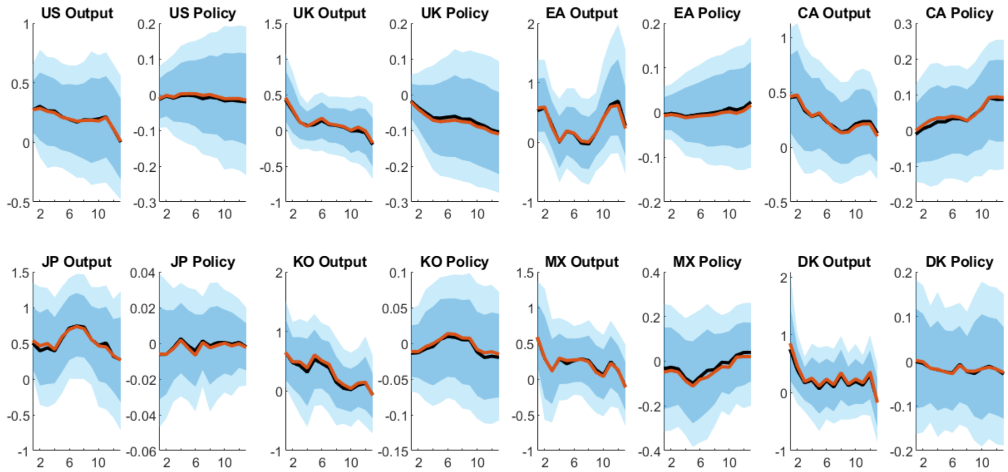
Panel C – Response to policy shock



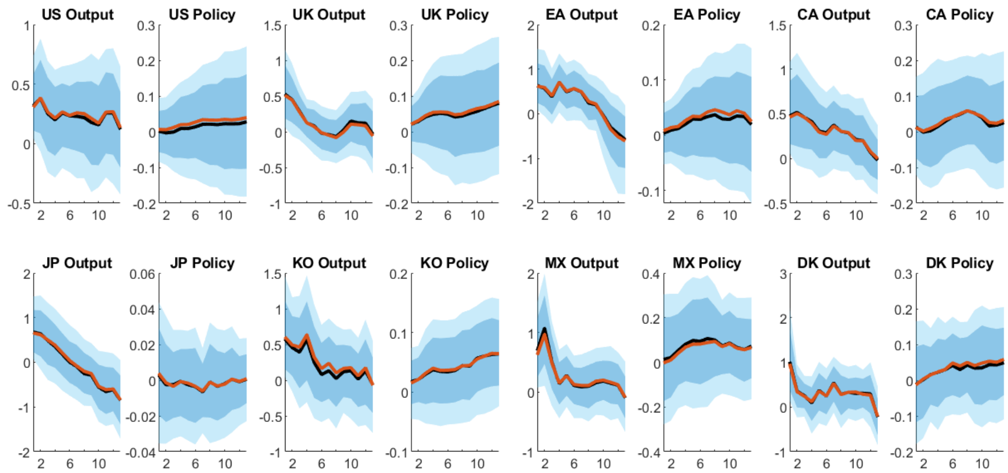
Notes: The solid black line represents the median response, the dark blue shaded area represents the 68% confidence band, while the light blue shaded areas represent the 95% confidence bands. The solid orange line represents the counterfactual with the domestic food inflation channel shut off.

Figure A4. Output and policy rate responses to domestic shocks

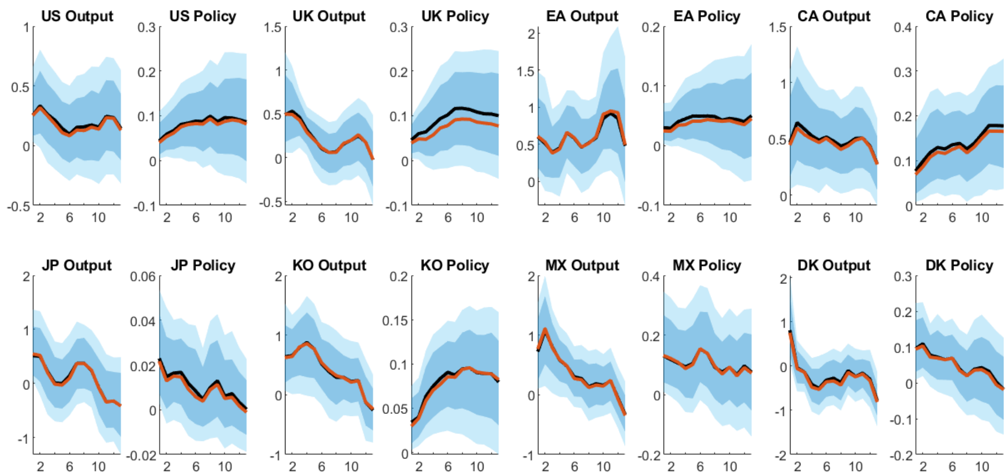
Panel A – Response to supply shock



Panel B – Response to demand shock



Panel C – Response to policy shock

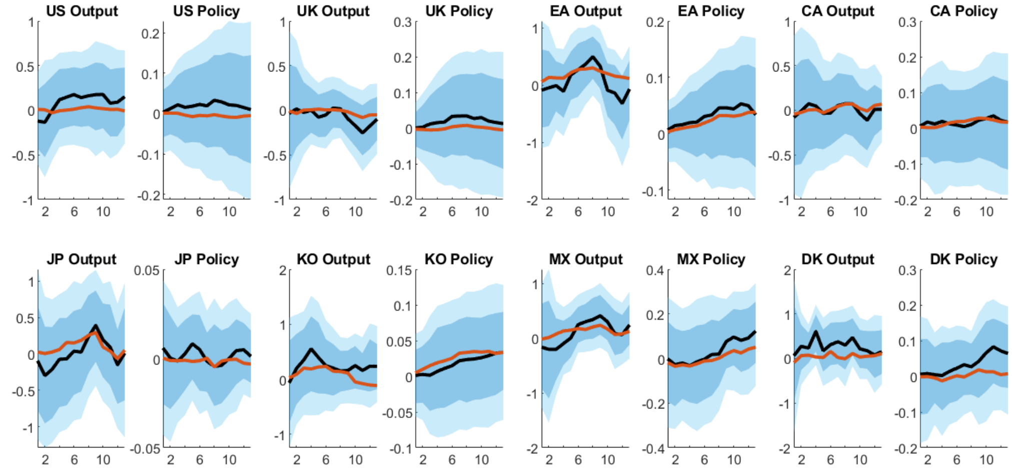


Notes: The solid black line represents the median response, the dark blue shaded area represents the 68% confidence band, while the light blue shaded areas represent the 95% confidence bands. The solid orange line represents the counterfactual with the domestic food inflation channel shut off.

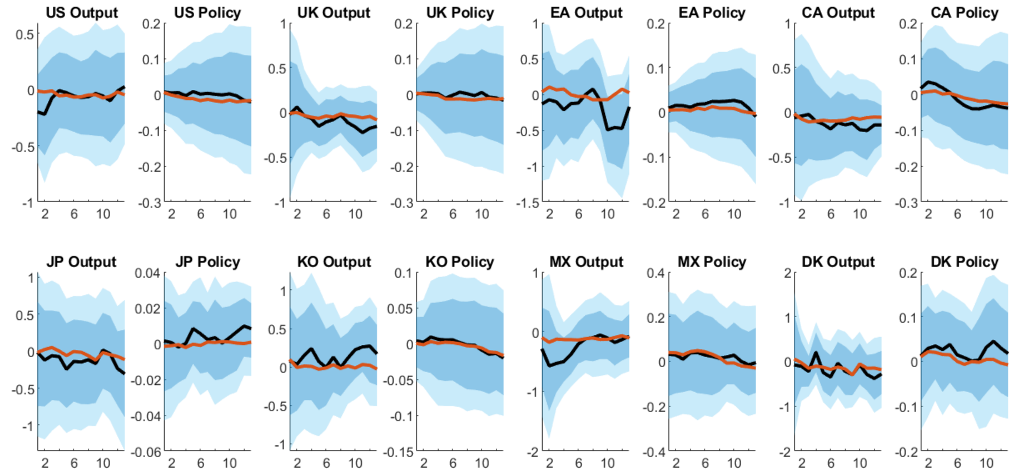
Appendix B. Output and policy rate responses to disaggregate food price shocks

Figure B1. Output and policy rate responses to cereal price shocks

Panel A – Response to cereal price mean shock



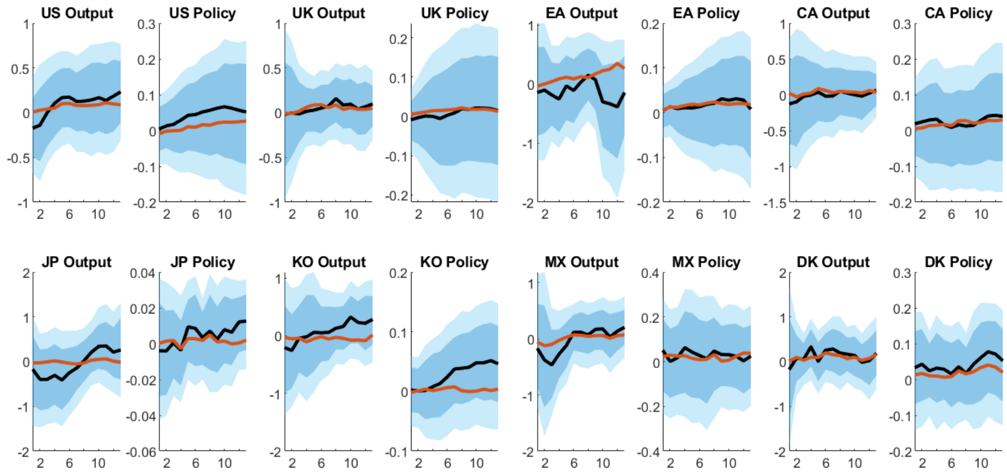
Panel B – Response to cereal price volatility shock



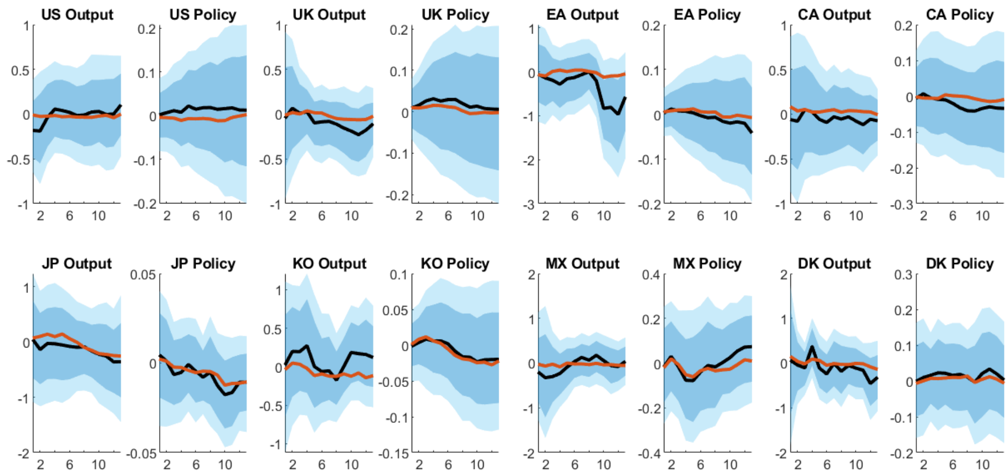
Notes: The solid black line represents the median response, the dark blue shaded area represents the 68% confidence band, while the light blue shaded areas represent the 95% confidence bands. The solid orange line represents the counterfactual with the domestic food inflation channel shut off. US = United States; UK = United Kingdom; EA = euro area; CA = Canada; JP = Japan; KO = South Korea; MX = Mexico; DK = Denmark.

Figure B2. Output and policy rate responses to meat price shocks

Panel A – Response to meat price mean shock



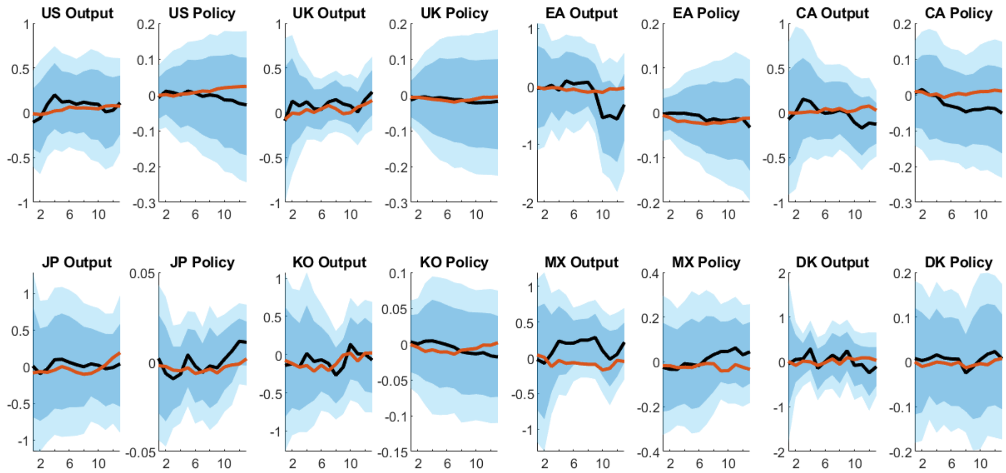
Panel B – Response to meat price volatility shock



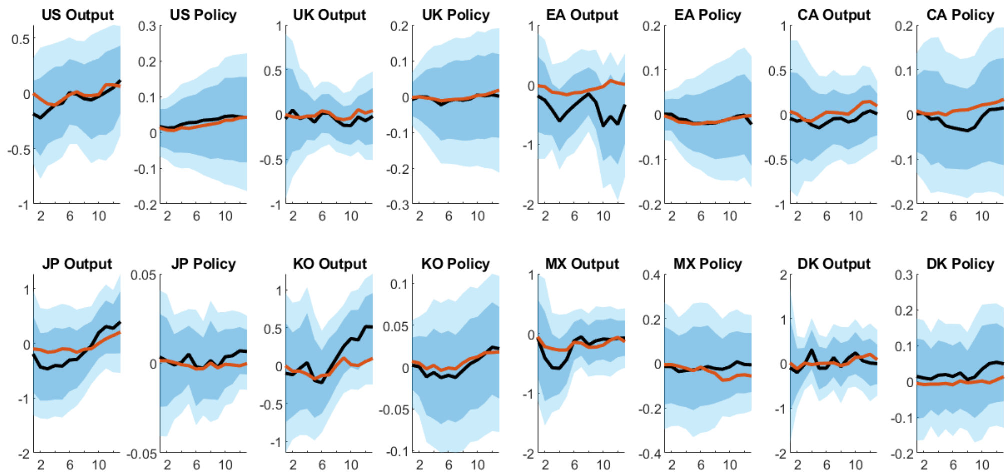
Notes: The solid black line represents the median response, the dark blue shaded area represents the 68% confidence band, while the light blue shaded areas represent the 95% confidence bands. The solid orange line represents the counterfactual with the domestic food inflation channel shut off. US = United States; UK = United Kingdom; EA = euro area; CA = Canada; JP = Japan; KO = South Korea; MX = Mexico; DK = Denmark.

Figure B3. Output and policy rate responses to vegetable oil price shocks

Panel A – Response to vegetable oil price mean shock



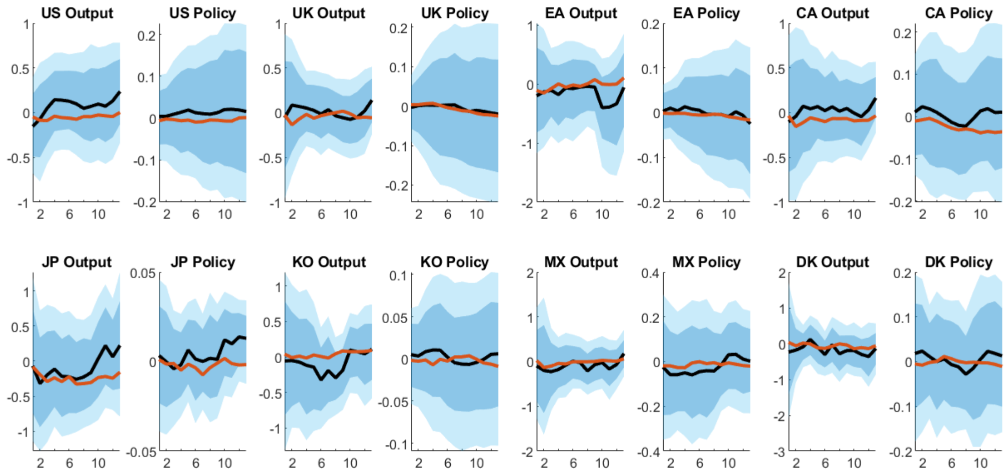
Panel B – Response to vegetable oil price volatility shock



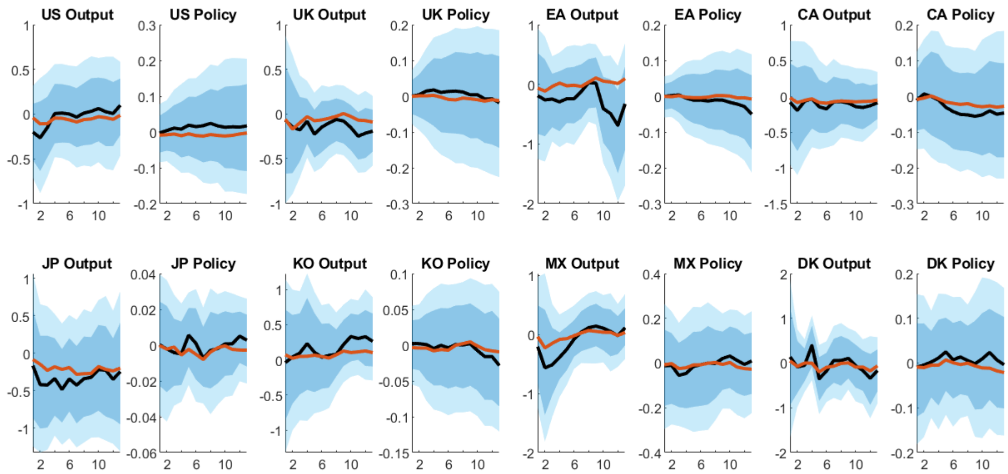
Notes: The solid black line represents the median response, the dark blue shaded area represents the 68% confidence band, while the light blue shaded areas represent the 95% confidence bands. The solid orange line represents the counterfactual with the domestic food inflation channel shut off. US = United States; UK = United Kingdom; EA = euro area; CA = Canada; JP = Japan; KO = South Korea; MX = Mexico; DK = Denmark.

Figure B4. Output and policy rate responses to sugar price shocks

Panel A – Response to sugar price mean shock



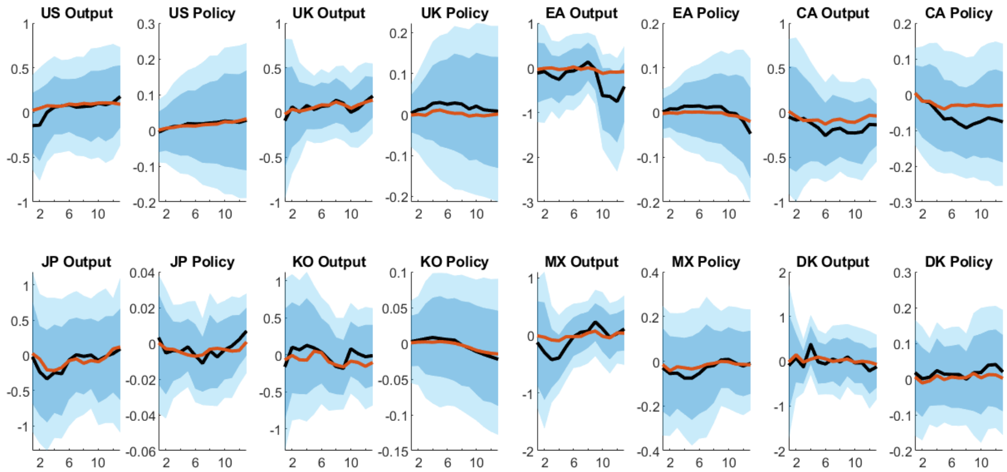
Panel B – Response to sugar price volatility shock



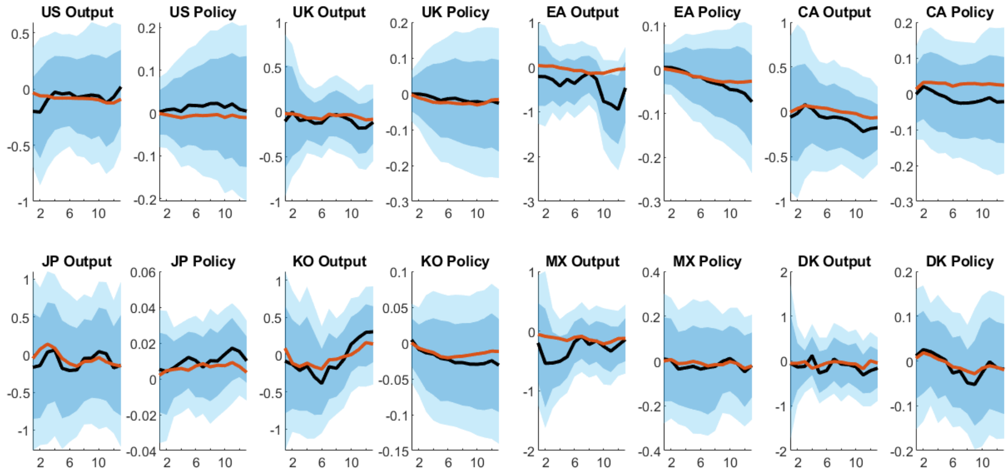
Notes: The solid black line represents the median response, the dark blue shaded area represents the 68% confidence band, while the light blue shaded areas represent the 95% confidence bands. The solid orange line represents the counterfactual with the domestic food inflation channel shut off. US = United States; UK = United Kingdom; EA = euro area; CA = Canada; JP = Japan; KO = South Korea; MX = Mexico; DK = Denmark.

Figure B5. Output and policy rate responses to dairy price shocks

Panel A – Response to dairy price mean shock



Panel B – Response to dairy price volatility shock



Notes: The solid black line represents the median response, the dark blue shaded area represents the 68% confidence band, while the light blue shaded areas represent the 95% confidence bands. The solid orange line represents the counterfactual with the domestic food inflation channel shut off. US = United States; UK = United Kingdom; EA = euro area; CA = Canada; JP = Japan; KO = South Korea; MX = Mexico; DK = Denmark.