A new medium-scale proxy-SVAR for the UK economy

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A1 A structural VAR for the UK

We estimate a structural VAR for the UK using Bayesian methods, identified by a combination of sign, zero, and magnitude restrictions, as well as external instruments. As a small open economy, the UK is exposed to a combination of both domestic shocks, as well as spillovers from global shocks. In that spirit, we identify four domestic, and four global drivers. For each block, we consider demand and supply shocks, as well as shocks to the monetary policy stance and shocks to risk appetite.

We estimate the model with monthly data between July 1997 and August 2024, with shock identification following Arias, Rubio-Ramírez and Waggoner (2021). The novelty of this methodology is the combination of sign and zero restrictions with the use of multiple proxies for structural identification. This allows us to leverage external instruments previously identified in the literature where possible. Sign and zero restrictions are a widely used methodology for structural identification, which allows to impose theoretical priors on the direction and transmission of shocks in the data. However, it does not allow for data to contradict theoretical predictions. Therefore, our combination of sign and zero restrictions with external instruments provides a balance between a theoretical and more data-driven approach to identification.

Our estimated model is the structural form of a vector autoregression with two lags in nine endogenous variables and an intercept (omitted for simplicity):

$$\boldsymbol{A}_0\boldsymbol{Y}_t = \boldsymbol{A}_1\boldsymbol{Y}_{t-1} + \boldsymbol{A}_2\boldsymbol{Y}_{t-2} + \boldsymbol{\varepsilon}_t \qquad (1)$$

Here, $\boldsymbol{Y}_t$ is a $[9 \times 1]$ vector of endogenous variables at time t, $\boldsymbol{\varepsilon}_t$ a $[9 \times 1]$ vector of structural shocks, and $\boldsymbol{A}_i$ are $[9 \times 9]$ coefficient matrices associated with the i-th lag of $\boldsymbol{Y}_t$. The structural shocks are assumed to be contemporaneously uncorrelated such that their covariance matrix is diagonal (and can be normalised to be the identity matrix).

The structural form is not recoverable from the data but there exists a direct mapping to the fully identified reduced form:

$$\boldsymbol{Y}_t = \boldsymbol{B}_1\boldsymbol{Y}_{t-1} + \boldsymbol{B}_2\boldsymbol{Y}_{t-2} + \boldsymbol{u}_t \tag{2}$$

We have $\boldsymbol{B}_i = \boldsymbol{A}_0^{-1}\boldsymbol{A}_i$ and $\boldsymbol{u}_t = \boldsymbol{A}_0^{-1}\boldsymbol{\varepsilon}_t$. The residuals of the reduced form are allowed to be contemporaneously correlated with some covariance matrix $\boldsymbol{\Sigma} = E(\boldsymbol{u}_t\boldsymbol{u}_t') = \boldsymbol{A}_0^{-1}(\boldsymbol{A}_0^{-1})'$.

Because we add a number of external instruments to aid identification of some structural shocks, we work with the re-parameterisation of Arias, Rubio-Ramírez and Waggoner (2021), which imposes some block restrictions on both reduced and structural form. While the model is still the structural form in equation (1), we actually sample from the following extended SVAR:

$$\widetilde{\boldsymbol{A}}_0\widetilde{\boldsymbol{Y}}_t = \widetilde{\boldsymbol{A}}_1\widetilde{\boldsymbol{Y}}_{t-1} + \widetilde{\boldsymbol{A}}_2\widetilde{\boldsymbol{Y}}_{t-2} + \tilde{\boldsymbol{\varepsilon}}_t \tag{3}$$

Here, we collect both the endogenous variables and the external instruments in a single vector such that $\widetilde{\boldsymbol{Y}}_t = [\boldsymbol{Y}_t', \ \boldsymbol{Z}_t']'$. In our case, $\boldsymbol{Z}_t$ is a $[4 \times 1]$ vector of instruments (see **Section A2** for details). Since the instrumented shocks are assumed to be uncorrelated with all other shocks in the model, the parameter matrices can be partitioned as follows:

$$\widetilde{\boldsymbol{A}}_i = \begin{bmatrix} \boldsymbol{A}_i & \boldsymbol{0}_{9\times 4} \\ \boldsymbol{\Gamma}_{i,1} & \boldsymbol{\Gamma}_{i,2} \end{bmatrix} \tag{4}$$

Of these, the matrix $\widetilde{\boldsymbol{A}}_0$ is of special interest in the proxy-SVAR framework since it carries information on the contemporaneous relations between the endogenous variables. It is restricted such that its inverse, which includes the on-impact response of $\boldsymbol{Y}_t$ to the structural shocks $\boldsymbol{\varepsilon}_t$, has a certain structure embodying the exogeneity restrictions implied by identification with external instruments.

$$\begin{aligned} \widetilde{\boldsymbol{L}}_0 &= \widetilde{\boldsymbol{A}}_0^{-1} \\ \widetilde{\boldsymbol{L}}_0 &= \begin{bmatrix} \multicolumn{2}{c}{\boldsymbol{L}_0} & \boldsymbol{0}_{9\times 4} \\ \boldsymbol{0}_{4\times 5} & \boldsymbol{V}_{4\times 4} & \boldsymbol{\Gamma}_{i,2}^{-1} \end{bmatrix} \end{aligned} \tag{5}$$

For joint relevance of the instruments, we require the matrix $\boldsymbol{V}_{4\times 4}$ to be full rank.

Finally, as we suspect that some of the endogenous variables have common stochastic trends, we estimate the model in levels following Sims, Stock and Watson (1990). We do not explicitly model the co-integrating relationships, but all variables enter in log-levels, except for interest rates which are already expressed in percentages.

A2 Data

To estimate the model, we use monthly data for a range of macroeconomic variables for the UK and the world. Our sample starts in July 1997, marking the establishment of the Monetary Policy Committee, and the beginning of Bank of England's operational independence for the conduct of monetary policy, and ends in August 2024.

We use ONS data on UK real GDP[1], and the headline UK consumer price index (CPI), both seasonally-adjusted.[2] Following Cesa-Bianchi, Thwaites and Vicondoa (2020), we use the 1-year UK nominal government bond yield as a measure of the prevailing risk-free rate rather than Bank Rate in order to also capture changes in interest rate expectations and to address the issue of the effective lower bound on the nominal policy rate in the post-GFC period.[3] We include the narrow sterling nominal exchange rate index (£ERI) produced by the Bank of England where an increase (decrease) denotes an appreciation (depreciation) of sterling relative to a basket of currencies. We then follow Forbes, Hjortsoe and Nenova (2018) by including UK import prices, and world export prices. We use the import price deflator (encompassing all goods and services) and a series of world export prices (excluding the UK), an index constructed as a trade-weighted average of export prices of UK trading partners. We consider this a measure of world prices.[4] To account for global interest rates, we use 1-year US nominal government bond yields, motivated by the role of the US in driving the global financial cycle, as documented in a large body of literature (e.g. Miranda-Agrippino and Rey, 2020 and Boehm and Kroner, 2023). This is also consistent with our choice to instrument a global monetary policy shock with a US monetary policy surprise series, detailed in **Section A2.2**. To reflect the pricing of global risk we include the VIX, an index measuring 30-day expected volatility in the S&P500 stock index. Finally, to explicitly capture expectations of future economic activity,

[1] To account for measurement issues in economic activity through the Covid pandemic, we adjust the ONS' real GDP series in 2020 and 2021 by forcing GDP to follow the profile of the Monetary Policy Committee's estimate of the output gap during that time. This implies a linear trend in potential supply and a relatively smooth profile of demand over this period instead of highly volatile demand and supply. We consider this a measure of underlying domestic demand in the UK which was masked by Covid volatility.
[2] We use the X-12-ARIMA programme for seasonal adjustment, as provided by the US Census Bureau and documented in Findley et al. (1998).
[3] Capturing interest rate expectations is important, because it also makes our assumption that interest rates move on impact in response to a shock more realistic. While a monetary policymaker in practice may not be able to change policy rates within the same month of observing the shock, financial markets may anticipate a future central bank response, causing 1-year interest rates to change on impact.
[4] The import price deflator and world export prices series are only available at quarterly frequency. The next best alternative, the ONS' producer price index (seriesID GD74), available at monthly frequency, is only available from end-2008 onwards. We therefore linearly interpolate the quarterly series to obtain monthly data points. The trade-off we faced related to the use of surprises series to instrument structural shocks, because the information content of surprises series, typically computed at a daily frequency, decreases with aggregation. We therefore do not aggregate further up than monthly frequency.

we use a measure of short-term UK GDP growth expectations from Consensus Economics.[5]

A2 Identification scheme

We use a combination of zero and sign restrictions, as well as external instruments to identify eight structural shocks relevant to the UK, following the methodology developed by Arias, Rubio-Ramírez and Waggoner (2021). In order for the results of the SVAR to be a good representation of the UK economy, the selection of shocks should encompass a large part of the relevant driving forces behind fluctuations in macroeconomic variables of interest to monetary policymakers, most notably, measures of inflation and output.

Specifically, we consider four domestic, and four global structural shocks. For each block, we consider demand and supply shocks, as well as shocks to the monetary policy stance and shocks to risk appetite. Additionally, we allow for one unidentified shock which we treat as a UK-specific residual. The identification scheme is outlined in **Table 1**. Restrictions are applied to the impulse response function on-impact only.

[5] As in Jarocinski and Karadi (2020), we transform the current and next year horizons of the Consensus expectations into a constant 1-year horizon, as follows: $x^e_{12m} = \frac{1-(i-1)}{12} \cdot x^e_{y_0} + \frac{(i-1)}{12} * x^e_{y_1}$ where x^e_{12m} is the expectation in month $i \in \{1, \dots, 12\}$ of year-on-year growth one year ahead and $x^e_{y_0}$ and $x^e_{y_1}$ are current calendar year and next calendar year expectations.

Table 1: SVAR identification scheme

	Sign and zero restrictions block					Proxy block			
	UK risk	UK demand	UK supply	UK residual	Global demand	UK MP	Global risk	Global supply	Global MP
UK real GDP	-	+	+						
UK CPI	-	+	-						
UK 1y yield	-	+				+			
£ERI	+	+							
UK import prices									
UK GDP expectations	-		+						
World export prices	0	0	0	0	+			+	
US 1y yield						0			+
VIX							+		

Notes: An empty cell denotes an unrestricted parameter. A "0" indicates that the impulse response function of a given variable to a given shock is restricted to be zero on impact. A "+" and "-" indicates a restriction on the impulse response function to respond positively or negatively, respectively, on impact in response to a shock. This table does not reflect the magnitude restrictions within the proxy block.

A2.1 Sign and zero restrictions block

For the sign and zero restrictions block, we largely follow Forbes, Hjortsoe and Nenova (2018). We begin with a small open economy condition, which means that UK shocks are restricted to have no effect on world export prices within the month of the shock (in other words, as a small open economy, the UK is assumed to be a price-taker in world markets). This is a necessary condition to identify domestic shocks and implies that only global shocks can impact world prices directly.

We considered adding more zero restrictions to tighten the small open economy conditions, for instance by also restricting the response of the other global endogenous variables (in this case the US 1-year interest rate, and the VIX), to not respond to domestic UK shocks. We do not do this for two reasons. First, these restrictions are not necessary for identification, as each shock is uniquely identified with the zero restriction only on world export prices. Secondly, the parameterisation in Arias, Rubio-Ramírez and Waggoner (2021lves a binding constraint on the amount of zero restrictions that can be applied for each shock beyond the block zero restrictions already implied by the external instruments.

We now explain the identified shocks in turn.

UK risk shock. This shock should be interpreted as a UK-specific "risk-on" shock – that is, a shock which increases the incentive to hold UK assets (or appetite to hold sterling), above and beyond macroeconomic conditions. It is similar in spirit to the ‘exogenous FX’ shock of Forbes, Hjortsoe and Nenova (2018). We assume that a positive change in risk sentiment towards sterling assets causes an appreciation of sterling, lowers consumer prices, and, in the near term, lowers economic activity and expectations.

Domestic demand and supply shocks. In line with theoretical predictions and other empirical papers, such as Ellis, Mumtaz and Zabczyk (2014), we impose that domestic demand shocks move GDP and CPI in the same direction, and in the opposite direction for domestic supply shocks. Domestic demand shocks also feature a contractionary monetary policy response and an exchange rate index appreciation. For a domestic supply shock, we leave the interest rate response unrestricted, as there is no obvious response, for instance, if monetary policymakers decide to look through temporary a domestic supply shock.

UK residual. The UK residual shock captures anything the other defined domestic shocks do not capture. We define this as a UK residual specifically (through the same small open economy zero restriction on world export prices), which also helps more clearly define the global demand shock.

Global demand shock. An expansionary global demand shock is assumed to cause an increase in UK-facing world prices, but otherwise remains unrestricted.

A2.2 Proxy block

Where available, we use external instruments rather than pure sign and zero restrictions for identification. We use four instruments: a series of UK monetary policy surprises, proxying the UK monetary policy shock; an instrument for a global uncertainty shock using high-frequency gold prices; an oil supply shock series to proxy the global supply shock; and a US monetary policy surprises series as an instrument for the global monetary policy shock.

The proxy block is distinguished from the sign and zero restriction block through the exogeneity condition. In other words, the two shocks are split into two blocks: one that is correlated with the proxies and one that is not. But this does not disentangle the shocks within the proxy block requiring further identifying restrictions.

We therefore combine the use of external instruments with additional zero, sign as well as magnitude restrictions.

UK monetary policy shock. We use the Cesa-Bianchi, Thwaites and Vicondoa (2020) high-frequency monetary policy surprises series. The interest rate surprises are identified using intra-day changes in the price of the second front contract of the 3-month sterling futures contracts, computed using a 30-minute window on MPC announcement days. It is available at daily frequency from July 1997 – March 2021. The surprise series is cumulated to a monthly frequency. The main identification assumption distinguishing the UK monetary policy shock from other proxied shocks is a zero restriction on US short-term interest rates – as a small open economy, domestic monetary policy shocks cannot impact global interest rates, only domestic interest rates.

Global risk shock. We use the proxy for an uncertainty shock constructed by Piffer and Podstawski (2018). The authors identify events that are exogenous to other macroeconomic shocks, and were unanticipated, for instance natural disasters and armed conflicts. They use intraday data on the spot price of physical gold and compute the proxy by looking at the percentage variation in the price around the identified events. It is available at daily frequency from January 1979 – April 2021, including a total of 38 events, cumulated to a monthly frequency. We label this our "global risk" shock. We assume that the VIX responds positively to the global risk shock, and impose cross-column magnitude restrictions. In particular, the response of the VIX to a global risk shock is strictly larger than it is to the appropriately scaled global supply and US and UK monetary policy shocks.

Global supply shock. We use the Känzig (2021) oil supply news shock series as an instrument for a global supply shock. This news series is constructed using high-frequency variation in oil futures prices around OPEC production announcements, to capture exogenous news about future oil supply. We impose that the global supply shock increases world export prices. We again impose cross-column magnitude restrictions – the response of world export prices must be larger to the global supply shock than to the global risk and US and UK monetary policy shocks.

Global monetary policy shock. We motivate the inclusion of this shock with literature on the importance of international monetary spillovers, such as that documented originally by Calvo, Leiderman and Reinhart (1996). This is particularly relevant for a small open economy such as the UK, where domestic financial conditions may be largely affected by international spillovers. We use the Bauer and Swanson (2023) high-frequency monetary surprises series for the US. The interest rate surprises are identified using changes in US treasury yields and stock prices, computed during a 30-minute window around Fed policy events, in particular FOMC policy announcements, post-FOMC press conferences, and speeches made by the Fed Chair. The surprises are orthogonalised with respect to macroeconomic and financial data. We use a US monetary policy shock to instrument a global monetary policy shock, motivated by the role of the US in driving the global financial cycle, as documented in a large and growing body of literature (e.g. Miranda-Agrippino and Rey, 2020). We impose that the global monetary policy shock increases US interest rates. We also impose cross-column magnitude restrictions – the response of world interest rates must be larger to the global monetary policy shock, compared to the global risk and supply shocks, as well as the UK monetary policy shock.

The identified shocks may not be all-encompassing - i.e. they may not cover the entirety of shocks that affect UK macroeconomic variables. However, the identification scheme is general enough that several of the identified shocks capture a wide range of similar shocks. For instance, the UK supply shock would also encompass a productivity shock.

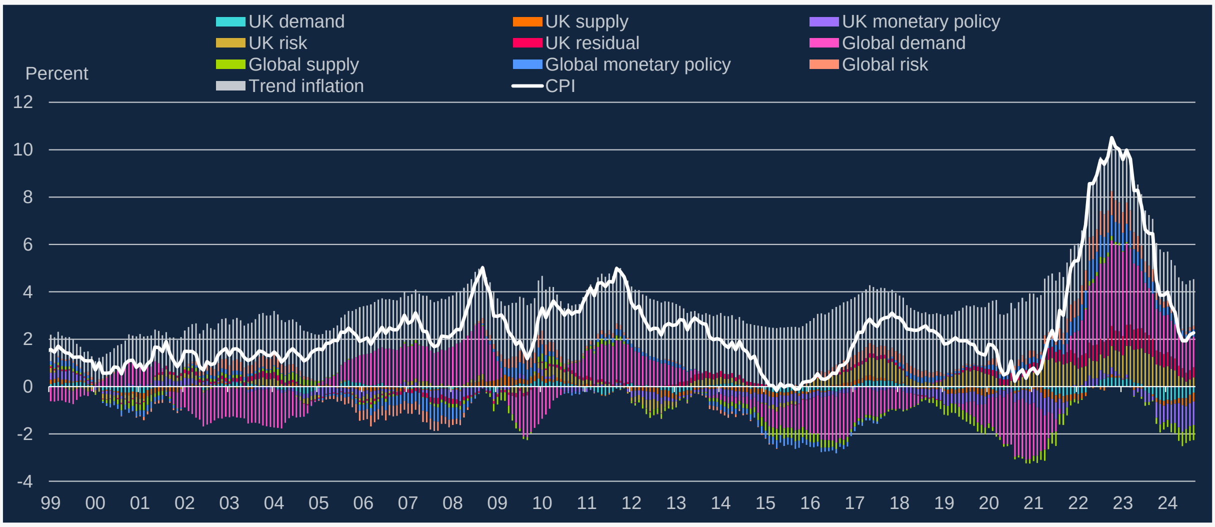
A4 Results

We find that fluctuations in UK inflation throughout the sample period have been driven mostly by global factors (see **Charts A1 and A2**), especially changes in global demand. This is consistent with findings for the euro area by Giannone and Primiceri (2024).

We find that, following the dotcom crisis, global demand acted as a disinflationary force on UK inflation. From the mid-2000s up until the Global Financial Crisis (GFC), while global demand pushed up on UK inflation, other global forces provided disinflationary offset, in particular international monetary policy and global risk. Overall, the global demand contributions display intuitive business cycle dynamics. The global risk shock has its largest in-sample contribution around the GFC. Following the Brexit referendum in 2016, the UK risk shock contributes positively to UK inflation which is consistent with a sudden loss in attractiveness for sterling assets. Finally, during the inflation peak of 2022-23, inflation is driven by a combination of shocks with global demand dominating. Monetary policy, both UK and global, at first contributed positively to UK inflation, reflecting the fact that while interest rates were rising, the monetary policy stance took a while to become restrictive.

Chart A1: Decomposition of UK headline CPI inflation

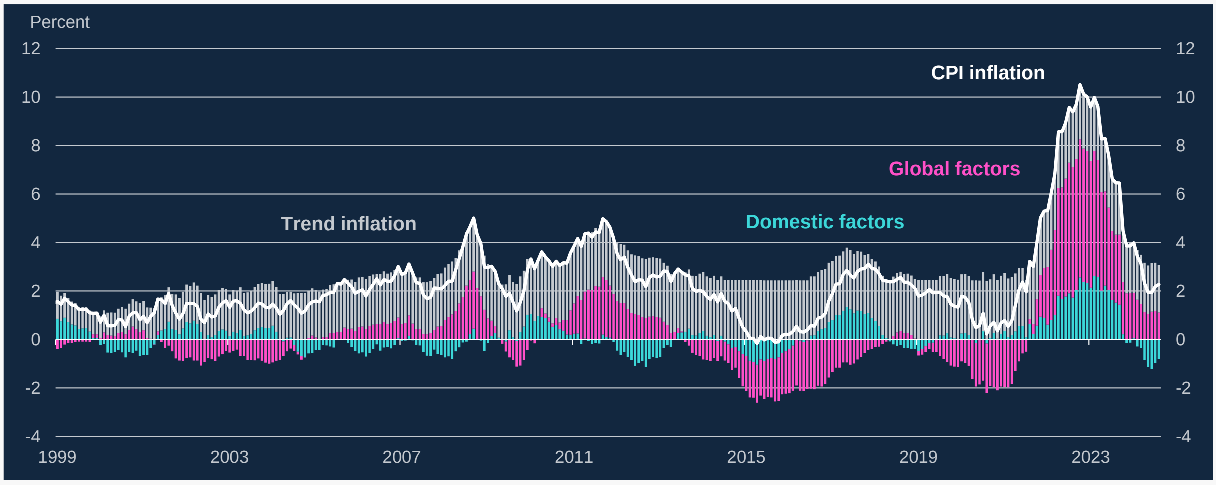
Year-on-year percentage changes



Notes: The chart shows the historical decomposition implied by the pointwise mean across accepted draws from the posterior density. Data are monthly from 1999 to August 2024. The grey 'trend inflation' bars reflect the model's deterministic component.

Chart A2: Decomposition of UK headline CPI inflation - global/domestic split

Year-on-year percentage changes

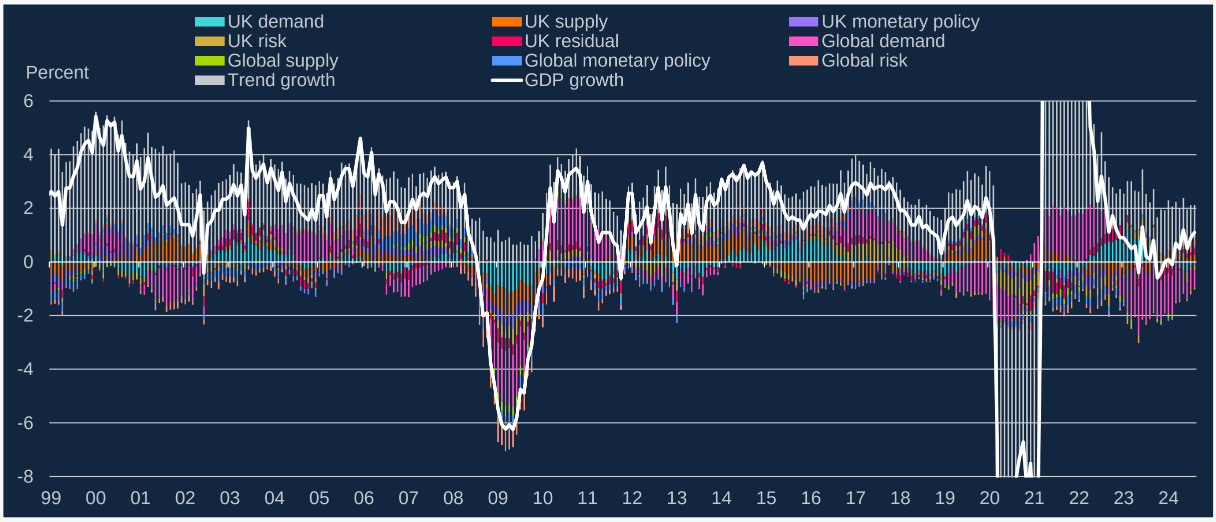


Notes: The chart shows the historical decomposition implied by the pointwise mean across accepted draws from the posterior density. Data are monthly from 1999 to August 2024. The aqua 'domestic' bars sum the effects of the UK demand, supply, monetary policy, risk, and the residual shock. The pink 'global' bars sum the effects of the global demand, supply, monetary policy, and risk shocks. The grey 'trend inflation' bars reflect the model's deterministic component.

In contrast, the picture for economic activity is more mixed (see **Charts A3 and A4**). Through the lens of this model, while global demand conditions are still important domestic factors, much less so than for inflation. Before the GFC, a mix of global shocks buoyed UK GDP growth: global demand, monetary policy and positive risk sentiment. The contraction following the GFC is interpreted as a combination of UK and global shocks, although the negative global demand shock dominates, including the rebound in the early 2010s. In the first half of the 2010s, positive domestic shocks drove GDP growth, first led by supply, followed by demand. Estimating the model with a smoothed GDP series means a large part of the Covid trough and peak in GDP growth is unexplained. However, a fall in global demand has weighed on UK GDP growth in the last two years, with little positive domestic news to counteract.

Chart A3: Decomposition of UK GDP growth

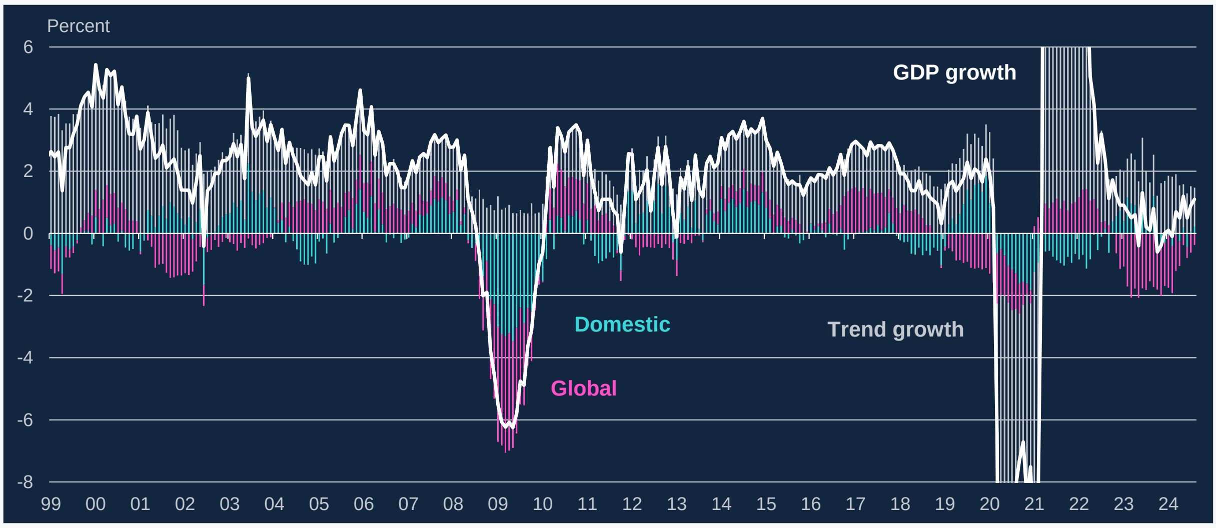
Year-on-year percentage changes



Notes: The chart shows the historical decomposition implied by the pointwise median across accepted draws from the posterior density. Data are monthly from 1999 to August 2024. The grey 'trend growth' bars reflect the model's deterministic component.

Chart A4: Decomposition of UK GDP growth – global/domestic split

Year-on-year percentage changes



Notes: The chart shows the historical decomposition implied by the pointwise median across accepted draws from the posterior density. Data are monthly from 1999 to August 2024. The aqua 'domestic' bars sum the effects of the UK demand, supply, monetary policy, risk, and the residual shock. The pink 'global' bars sum the effects of the global demand, supply, monetary policy, and risk shocks. The grey 'trend growth' bars reflect the model's deterministic component.

References

Arias, J.E., Rubio-Ramírez, J.F. and D. F. Waggoner (2021). **Inference in Bayesian Proxy-SVARs**. *Journal of Econometrics*, *225*(1), pp.88-106.

Bauer, M.D. and E. T. Swanson (2023). **A reassessment of monetary policy surprises and high-frequency identification**. *NBER Macroeconomics Annual*, *37*(1), pp.87-155.

Boehm, C.E. and T. N. Kroner (2023). ***The US, economic news, and the global financial cycle*** (No. w30994). National Bureau of Economic Research.

Calvo, G.A., Leiderman, L. and C. M. Reinhart (1996). **Inflows of Capital to Developing Countries in the 1990s**. *Journal of economic perspectives*, *10*(2), pp.123-139.

Cesa-Bianchi, A., Thwaites, G. and A. Vicondoa (2020). **Monetary policy transmission in the United Kingdom: A high frequency identification approach**. *European Economic Review*, *123*, p.103375.

Ellis, C., Mumtaz, H. and P. Zabczyk (2014). **What lies beneath? A time-varying FAVAR model for the UK transmission mechanism**. *The Economic Journal*, *124*(576), pp.668-699.

Findley, D.F., Monsell, B.C., Bell, W.R., Otto, M.C. and B. C. Chen (1998). **New capabilities and methods of the X-12-ARIMA seasonal-adjustment program**. *Journal of Business & Economic Statistics*, *16*(2), pp.127-152.

Forbes, K., Hjortsoe, I. and T. Nenova (2018). **The shocks matter: improving our estimates of exchange rate pass-through**. *Journal of international economics*, *114*, pp.255-275.

Giannone, D. and G. Primiceri (2024). **The drivers of post-pandemic inflation**. VoxEU/CEPR.

Jarociński, M. and P. Karadi (2020). **Deconstructing monetary policy surprises—the role of information shocks**. *American Economic Journal: Macroeconomics*, *12*(2), pp.1-43.

Känzig, D.R. (2021). **The macroeconomic effects of oil supply news: Evidence from OPEC announcements**. *American Economic Review*, *111*(4), pp.1092-1125.

Miranda-Agrippino, S. and H. Rey (2020). **US monetary policy and the global financial cycle**. *The Review of Economic Studies*, *87*(6), pp.2754-2776.

Piffer, M. and M. Podstawski (2018). **Identifying uncertainty shocks using the price of gold**. The Economic Journal, 128(616), pp.3266-3284.

Sims, C.A., Stock, J.H. and M. W. Watson (1990). **Inference in linear time series models with some unit roots**. *Econometrica: Journal of the Econometric Society*, pp.113-144.