International vulnerability of domestic headline, core, energy and food inflation

Workshop on Time Series Econometrics

Ignacio Garrón

Universidad Carlos III de Madrid (UC3M)

joint with
Gian Pietro Bellocca (UC3M) Esther Ruiz (UC3M)

April 3, 2025

Why study International Inflation?

Draghi (2015 Speech to the Economic Club of NY):

Over the last decade there has been a growing interest in the concept of global inflation. This is the notion that in a globalized world inflation is becoming less responsive to domestic economic conditions and is instead increasingly determined by global factors.

Consensus on the importance of Global Inflation for domestic inflation:

- Medeiros et al. (WP 2024)
- Ha et al. (J. Intern. Money and Finance 2023)
- Mumtaz and Musso (JBES 2021)
- Kamber and Wong (J. Inter. Economics 2020)
- Ahmad and Staveley-O'Carroll (J. Inter. Money and Finance 2017)
- Kabukcuoglu and Marínez-García (J. Econom. Dyn. Control 2018)
- Eickmeier and Pijnenburd (OBES 2013)

Why study International Inflation?

Draghi (2015 Speech to the Economic Club of NY):

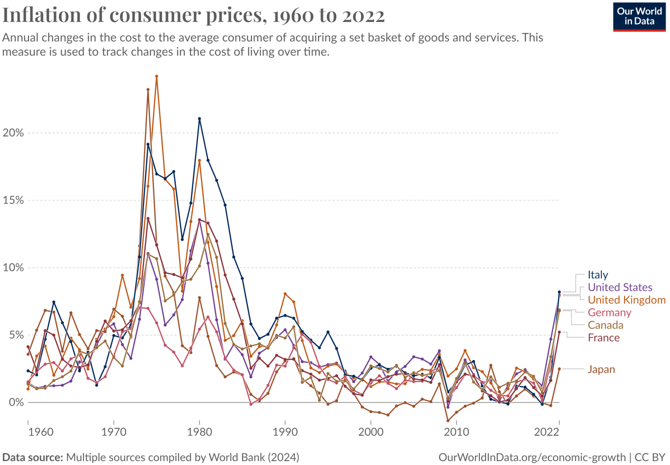
Over the last decade there has been a growing interest in the concept of global inflation. This is the notion that in a globalized world inflation is becoming less responsive to domestic economic conditions and is instead increasingly determined by global factors.

Consensus on the importance of Global Inflation for domestic inflation:

- Medeiros et al. (WP 2024)
- Ha et al. (J. Intern. Money and Finance 2023)
- Mumtaz and Musso (JBES 2021)
- Kamber and Wong (J. Inter. Economics 2020)
- Ahmad and Staveley-O'Carroll (J. Inter. Money and Finance 2017)
- Kabukcuoglu and Marínez-García (J. Econom. Dyn. Control 2018)
- Eickmeier and Pijnenburd (OBES 2013)

Why study International Inflation?

Clearer picture if we plot headline inflation for advanced economies (G7).



Why Vulnerability?

- Relevant for policy-makers and central banks to assess the risk of having either very low or very high inflation (Kilian and Manganelli, J. Inter. Money Credit and Banking 2008).

Growing literature on measuring risk to inflation:

- with domestic macroeconomic indicators: Manzan and Zerom (IJF 2013), Adams et al. (IJF 2021), Korobilis et al. (WP 2021), Tabliabracci (WP 2020), López-Salido and Loria (JME 2024).
- with global factors:
  Zheng et al. (Energy Economics 2023) use global energy connectedness index,
  Banerjee et al. (J. of Intern. Money and Finance 2024) uses as regressor oil prices.
- with international factors of inflation: Garrón, Rodríguez-Caballero, and Ruíz (WP 2024).

Why Vulnerability?

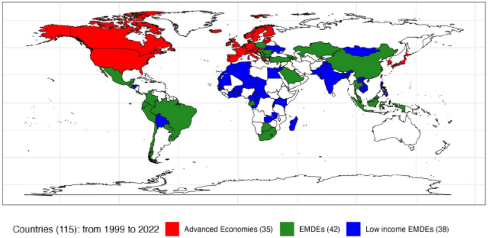
- Relevant for policy-makers and central banks to assess the risk of having either very low or very high inflation (Kilian and Manganelli, J. Inter. Money Credit and Banking 2008).

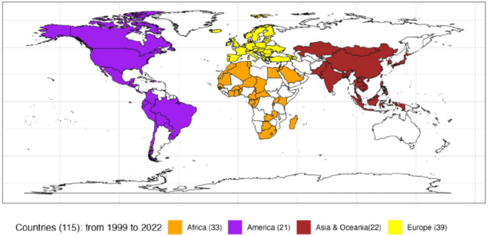
Growing literature on measuring risk to inflation:

- with domestic macroeconomic indicators: Manzan and Zerom (IJF 2013), Adams et al. (IJF 2021), Korobilis et al. (WP 2021), Tabliabracci (WP 2020), López-Salido and Loria (JME 2024).
- with global factors:
  Zheng et al. (Energy Economics 2023) use global energy connectedness index,
  Banerjee et al. (J. of Intern. Money and Finance 2024) uses as regressor oil prices.
- with international factors of inflation: Garrón, Rodríguez-Caballero, and Ruíz (WP 2024).

International vulnerability of inflation

Garrón, Rodríguez-Caballero and Ruiz (WP 2024) → international factors are relevant to explain the right tail of the inflation distribution.





Is core inflation an adequate measure?

- An ongoing debate among central bankers is if monetary policy should rely on core inflation, or on headline inflation that includes energy and food.

Some recent evidence:

- Alternatives measures of core inflation (Ball et al., IJMF 2024).
- US headline inflation in the US is weakly correlated with core inflation, while its correlation with energy inflation is strong (Giri, EL 2022).
- Mean level convergence of headline and core inflation (since 1990s inflation targeting), while short run dynamics (*mom*) driven by food and energy (Altansukh et al., JEDC 2024).
- Evidence of global and group-specific factors related to domestic energy inflation (Camacho et al., EM 2023)

Is core inflation an adequate measure?

- An ongoing debate among central bankers is if monetary policy should rely on core inflation, or on headline inflation that includes energy and food.

  Some recent evidence:

- Alternatives measures of core inflation (Ball et al., IJMF 2024).
- US headline inflation in the US is weakly correlated with core inflation, while its correlation with energy inflation is strong (Giri, EL 2022).
- Mean level convergence of headline and core inflation (since 1990s inflation targeting), while short run dynamics (*mom*) driven by food and energy (Altansukh et al., JEDC 2024).
- Evidence of global and group-specific factors related to domestic energy inflation (Camacho et al., EM 2023)

Contribution of the paper

1. Analyze the differences and similarities of core, food, and energy international factors with headline international factors.
2. Understanding the sources of international movements in the distribution of headline, core, food, and energy prices.

Methodology (Garrón, Rodríguez-Caballero and Ruiz, WP 2024):

- Factor augmented quantile regressions: Estimate the density of inflation in a given country as a function of international common factors.

- Multi-level DFMs: Considering global common factor and block factors defined by development level.

Data Set

- Monthly observations of headline, core, food, and energy PI from January 2005 to December 2022 (T=216) for a set of N = 47 countries.
- Data from the novel Global Database on Inflation by Ha et al. (JIMF, 2023a).

  Price indexes are transformed to annualized month-on-month (mom) inflation.

- Each series is sequentially cleaned

  $\rightarrow$ Seasonal components: KF; Harvey (Handbook of Forecasting, 2006)
  $\rightarrow$ Outliers: 10 x inter-quartile range as in McCracken and Ng (JBES, 2016)

Data Set

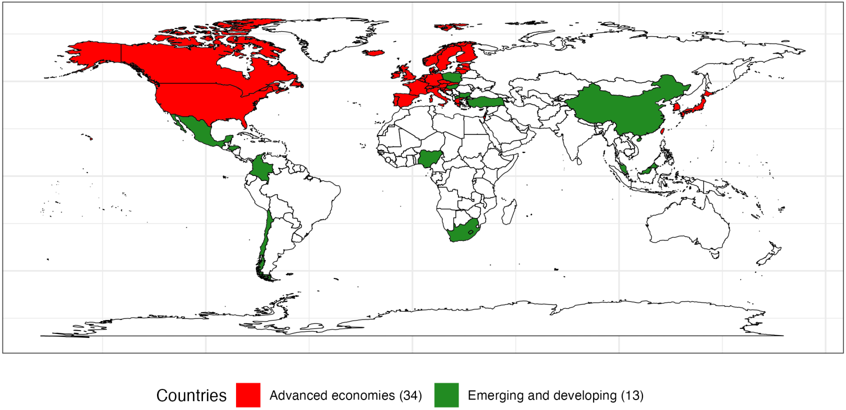


Figure 2: Countries grouped by economic development

Factor-Augmented Quantile Regression and Multi-level DFM

Let y_{it} be the inflation observed in country i at time t, for $i = 1, ..., N$, and $t = 1, ..., T$. The one-step-ahead τ-quantile of the conditional distribution of y_{it} is obtained by estimating the following FA-QR model

$$q_\tau(y_{it+1}|y_{it}, F_t^{(G)}, F_t^{(A\wedge E)}) = \mu(\tau, i) + \phi(\tau, i)y_{it} + \sum_{k=1}^{r} \beta_k^{(G)}(\tau, i)F_{kt}^{(G)} + \beta_1^{(A\wedge E)}(\tau, i)F_t^{(A\wedge E)},$$

- The model has $(r + 3) \times 1$ vector of parameters.
- The underlying factors are replaced by estimated factors, $\hat{F}_t$, which are extracted from the ML-DFM.

Predictive accuracy

- The Information Criteria for FA-QR proposed by Ando & Tsay (EJ, 2011).

Factor-Augmented Quantile Regression and Multi-level DFM

After estimating the FA-QR models, the inflation densities in each country are estimated using the Skewed-t distribution of Azzalini and Capitanio (JRSS-B, 2003), obtaining $\tilde{k}\left(y_{it+h}\right)$.

Compute

1. Probability of high inflation ($\text{Prob}\left(y_{it+h} \geq \pi^*\right)$)

$$\text{IaR}_{i,t+h}\left(\pi^*\right) = \int_{\pi^*}^{\infty} \tilde{k}\left(y_{i,t+h}\right) \mathrm{d}y_{i,t+h}$$

2. Probability of low inflation ($\text{Prob}\left(y_{it+h} \leq \pi^*\right)$)

$$\text{DaR}_{i,t+h}\left(\pi^*\right) = \int_{-\infty}^{\pi^*} \tilde{k}\left(y_{i,t+h}\right) \mathrm{d}y_{i,t+h}$$

Tabliabracci (WP, 2020) proposes measuring DaR and IaR with $\pi = 0$ and 2, respectively.

Extracting International Factors: Multi-Level DFM

We extract factors separately from each system of headline, core, energy and food inflations.

$$Y_t = \Lambda F_t + \varepsilon_t$$

case $r = 1$ (headline, core, and food) :

$$\begin{bmatrix} Y_{1t} \\ Y_{2t} \end{bmatrix} = \begin{bmatrix} \lambda_{11} & \lambda_{12} & 0 \\ \lambda_{21} & 0 & \lambda_{23} \end{bmatrix} \begin{bmatrix} F_t^{(G)} \\ F_t^{(A)} \\ F_t^{(E)} \end{bmatrix} + \varepsilon_t,$$

case $r = 2$ (energy) :

$$\begin{bmatrix} Y_{1t} \\ Y_{2t} \end{bmatrix} = \begin{bmatrix} \lambda_{11} & \lambda_{12} & \lambda_{13} & 0 \\ \lambda_{21} & \lambda_{22} & 0 & \lambda_{24} \end{bmatrix} \begin{bmatrix} F_{1t}^{(G)} \\ F_{2t}^{(G)} \\ F_t^{(A)} \\ F_t^{(E)} \end{bmatrix} + \varepsilon_t.$$

- Global factor, $F_t^{(G)}$, which loads in all inflations in the system;
- Development block, $F_t^{(A)}$ and $F_t^{(E)}$ for emerging economies, which loads in inflations of advanced and emerging economies, respectively.

Extracting International Factors: Multi-Level DFM

Identification:

- Within each block (development): $(F'F)/T = I$ and $\Lambda'\Lambda$ is diagonal with distinct entries. Needed to allow sequential estimation of the factors within each block; see Choi et al. (JAE, 2018) and Breitung and Eickmeier (Advances in Econometrics, 2016).
- All block factors are orthogonal with the global factor.

Estimation:

- Sequential Least Squares (LS) procedure by Breitung and Eickmeier (Advances in Econometrics, 2016) and implemented by Bellocca et al. (mimeo).
- Confidence bands for factors and loadings are obtained based on the asymptotic distribution of Bai (Econometrics, 2003) and implemented by Bellocca et al. (mimeo).

Implementation through FARS

"fars: Factor Augmented Regression Scenarios in R" (mimeo), G. P. Bellocca I. Garrón, V. Rodríguez-Caballero and E. Ruiz.

https://github.com/GPEBellocca/FARS

(i) Extract global and block-specific factors using a flexible multilevel factor structure.
(ii) Compute asymptotically valid confidence regions for the estimated factors, accounting for uncertainty in the factor loadings.
(iii) Estimate factor-augmented quantile regressions.
(iv) Recover full predictive densities from these quantile forecasts.
(v) Estimate the density when the factors are stressed.

The distribution of inflation: International underlying factors

Estimated factors analysis:

- Headline: Factors , loadings , idiosyncratic residuals .
- Core: Factors , loadings , idiosyncratic residuals .
- Energy: Factors , loadings , idiosyncratic residuals .
- Food: Factors , loadings , idiosyncratic residuals .
- Correlations of international inflation factors .

FA-QR:

- Estimated parameters of FA-QR model: US and South Africa .
- Estimated densities for the US and South Africa .
- Inflation probabilities for the US, France, and South Africa .

Conclusions

We show the importance of international factors in the distribution of domestic headline, core, food, and energy prices.

- **Global factors:** The loadings on domestic inflation for energy, headline and core are substantial and positive for most economies. However, the global factor loadings for food are relatively small for a significant number of countries.
- **Local factors:** The local component in headline and food inflation is affecting mainly European countries.
- **Interesting correlation patterns among global factors**:
  - Headline inflation and the first global factor for energy inflation have been stable and moderate over time.
  - Food inflation and headline inflation have been declining over time since 2009, with a spike due to the Russian-Ukrainian war.

International vulnerability of domestic headline, core, energy and food inflation

Workshop on Time Series Econometrics

Ignacio Garrón

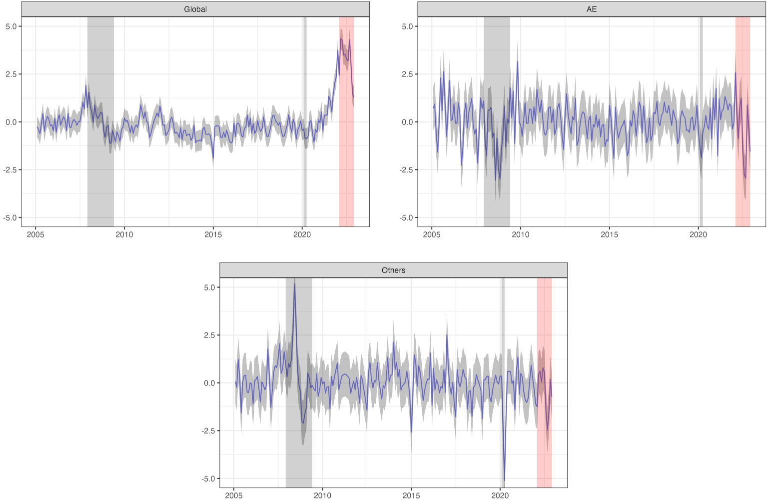
Universidad Carlos III de Madrid (UC3M)

joint with
Gian Pietro Bellocca (UC3M) Esther Ruiz (UC3M)

April 3, 2025

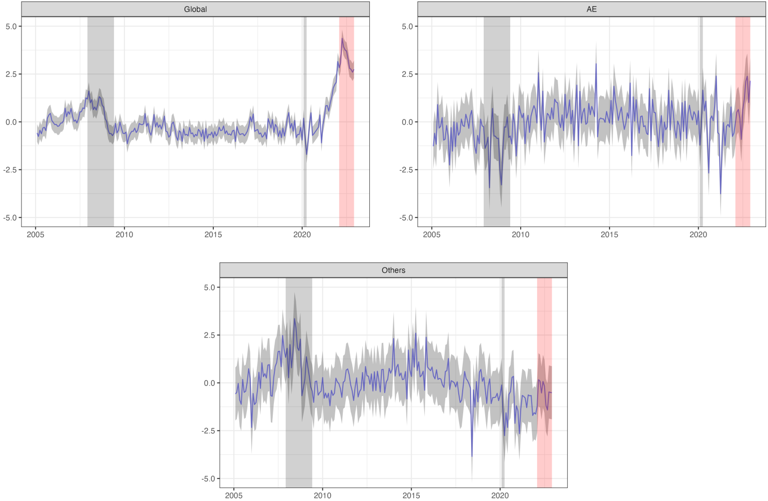
Headline international factors

Figure 3: Estimated factors (blue lines) of ML-DFM together with 95% confidence bounds (grey areas) for headline. back



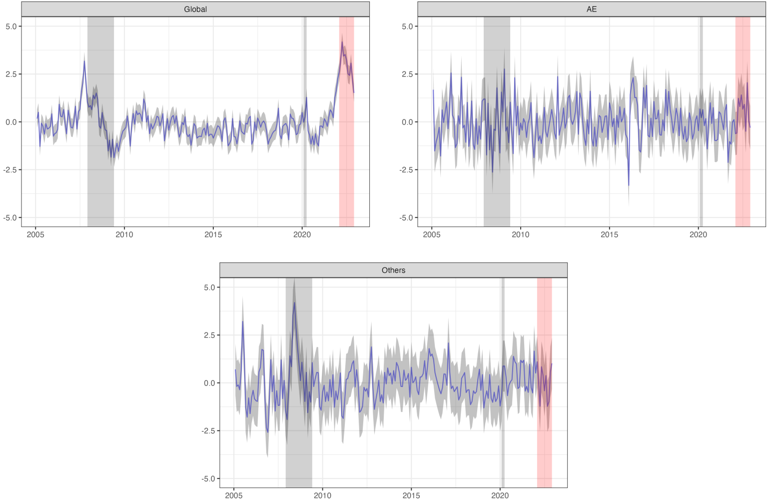
Core international factors

Figure 4: Estimated factors (blue lines) of ML-DFM together with 95% confidence bounds (grey areas) for core. back



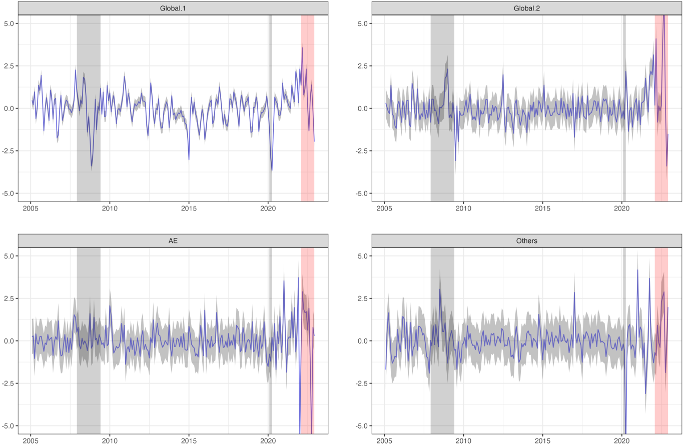
Food international factors

Figure 5: Estimated factors (blue lines) of ML-DFM together with 95% confidence bounds (grey areas) for food. back



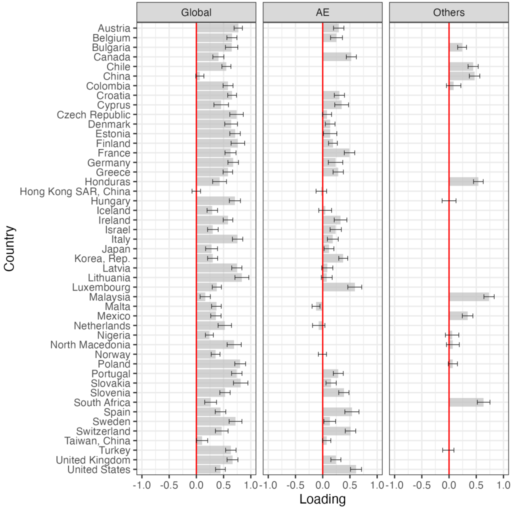
Energy international factors

Figure 6: Estimated factors (blue lines) of ML-DFM together with 95% confidence bounds (grey areas) for energy. back



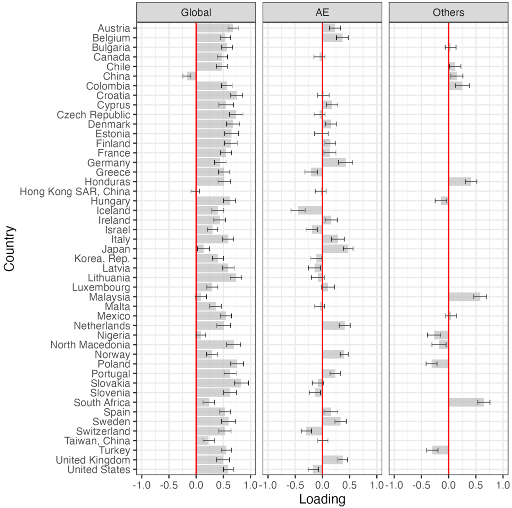
Estimated loadings for headline

Figure 7: Estimated factor loadings of ML-DFM together with 95% confidence bounds for headline ◂ back



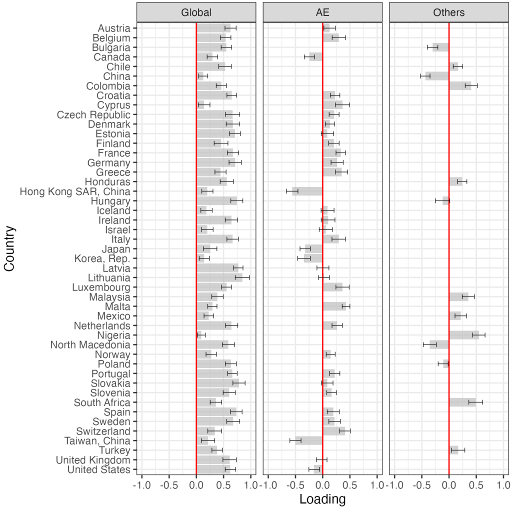
Estimated loadings for core

Figure 8: Estimated factor loadings of ML-DFM together with 95% confidence bounds for core ◂ back



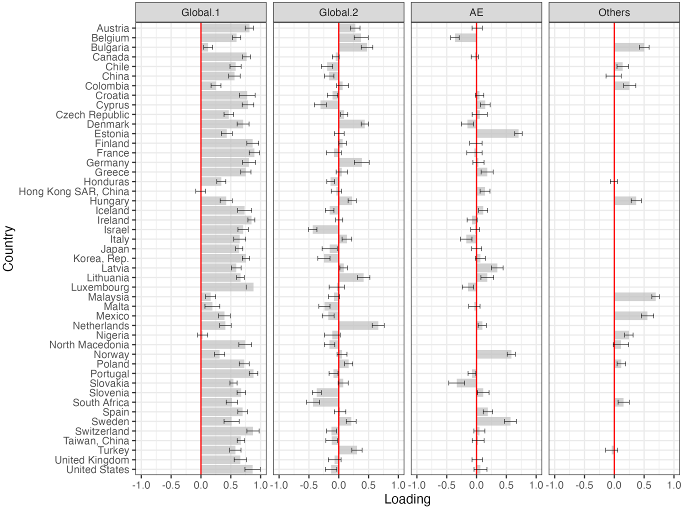
Estimated loadings for food

Figure 9: Estimated factor loadings of ML-DFM together with 95% confidence bounds for food ◂ back



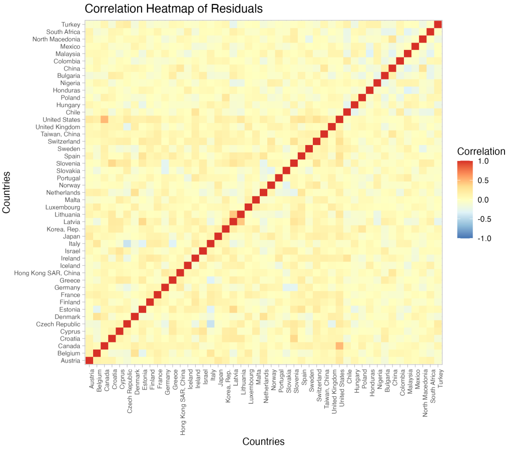
Estimated loadings for energy

Figure 10: Estimated factor loadings of ML-DFM together with 95% confidence bounds for food ◂ back



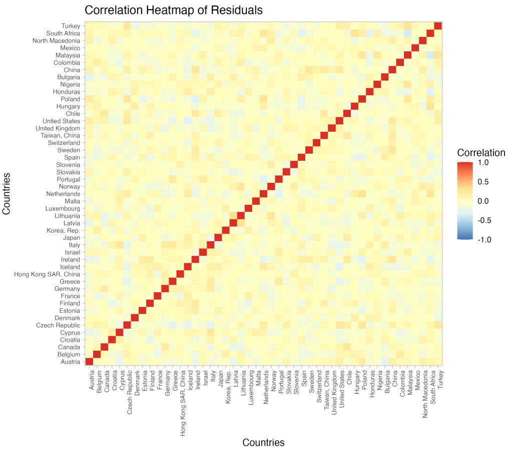
Estimated idiosyncratic residuals for headline

Figure 11: Estimated correlations of idiosyncratic residuals of ML-DFM for headline ◂ back



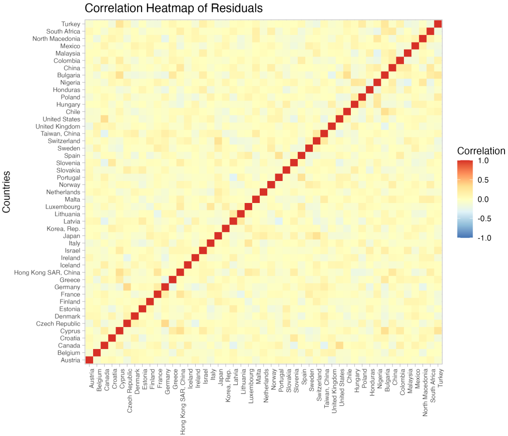
Estimated idiosyncratic residuals for core

Figure 12: Estimated correlations of idiosyncratic residuals of ML-DFM for core ◂ back



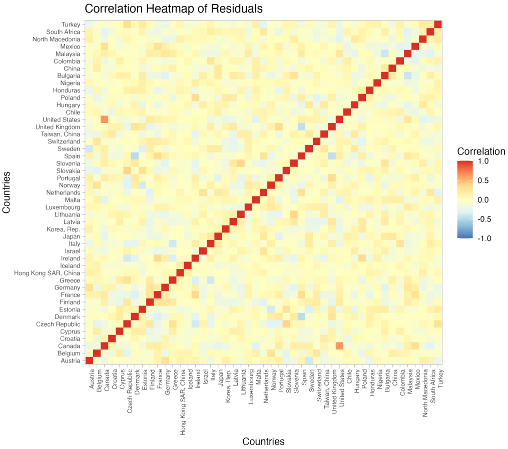
Estimated idiosyncratic residuals for food

Figure 13: Estimated correlations of idiosyncratic residuals of ML-DFM for food ◂ back



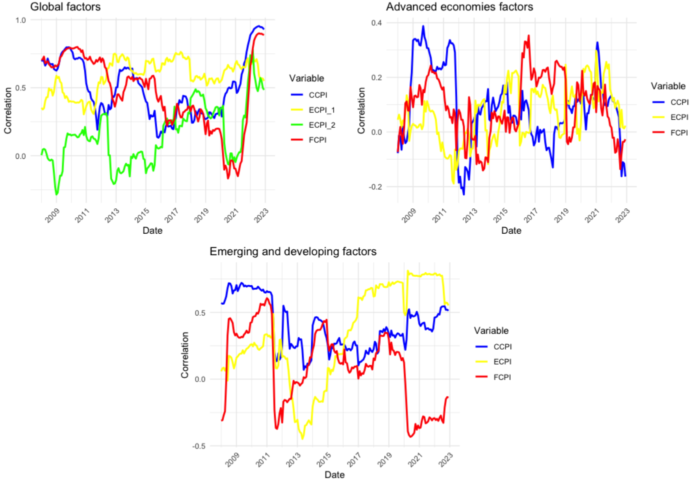
Estimated idiosyncratic residuals for energy

Figure 14: Estimated correlations of idiosyncratic residuals of ML-DFM for energy ◂ back



Rolling correlations with headline

Figure 15: 3-year rolling window correlations of international inflation factors for global (top left), AE (top right) and Others (bottom). ◂ back



FA-QR parameters for United States

Figure 16: Estimated parameters of FA-QR model, for quantiles of headline (H), core (C), energy (E) and food (F) inflation, for $\tau = 0.05, 0.50, 0.95$, and United States. *p*-values in parenthesis. In bold, estimates significant at the 10% level. The table also reports the $R1$ coefficient and the values of the AIC together with the corresponding values of the AR-QR model (AIC-AR). In bold the smallest value when the difference is greater than 10. back

τ	0.05				0.50				0.95			
	H	C	E	F	H	C	E	F	H	C	E	F
	United States											
μ	**-4.70**	-0.34	**-69.64**	**-4.30**	**1.96**	**0.88**	3.55	**1.53**	**7.01**	**2.66**	**54.99**	**7.09**
	(0.00)	(0.15)	(0.00)	(0.00)	(0.00)	(0.00)	(0.33)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
ϕ	0.26	**0.46**	**0.86**	**0.48**	**0.28**	**0.60**	0.43	**0.41**	0.12	**0.62**	0.34	**0.47**
	(0.29)	(0.00)	(0.00)	(0.00)	(0.05)	(0.00)	(0.06)	(0.00)	(0.28)	(0.00)	(0.14)	(0.00)
$\beta_1^{(G)}$	-0.05	0.11	-13.67	**1.08**	0.81	0.24	-2.81	**1.18**	**1.55**	**0.25**	3.27	**2.07**
	(0.96)	(0.57)	(0.23)	(0.03)	(0.13)	(0.18)	(0.74)	(0.02)	(0.00)	(0.05)	(0.69)	(0.00)
$\beta_2^{(G)}$			10.52				6.04				4.93	
			(0.17)				(0.11)				(0.20)	
$\beta_1^{(A)}$	**1.43**	**0.19**	**-7.84**	0.24	0.80	0.03	0.67	0.06	**1.39**	-0.08	5.32	0.17
	(0.04)	(0.04)	(0.02)	(0.55)	(0.12)	(0.83)	(0.85)	(0.88)	(0.00)	(0.58)	(0.20)	(0.69)
R^1	0.17	0.19	0.17	0.19	0.13	0.26	0.08	0.25	0.29	0.45	0.12	0.38
AIC	**1357**	**847**	**2354**	**1333**	1133	669	2140	**1156**	**1255**	929	**2279**	**1365**
AIC-AR	1376	859	2359	1354	1135	674	2140	1172	1312	936	2291	1395

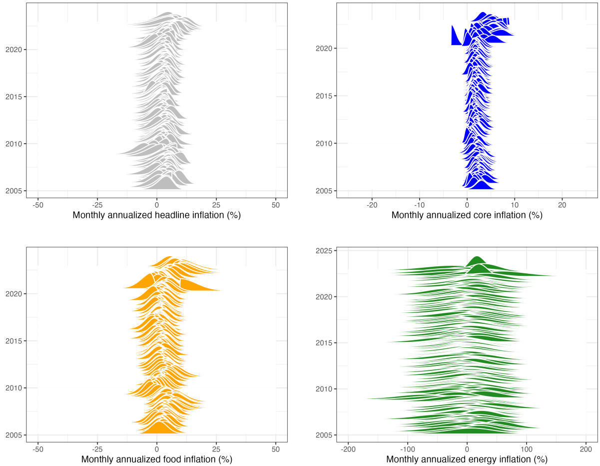
FA-QR parameters for South Africa

Figure 17: Estimated parameters of FA-QR model, for quantiles of headline (H), core (C), energy (E) and food (F) inflation, for $\tau = 0.05, 0.50, 0.95$ for South Africa. *p*-values in parenthesis. In bold, estimates significant at the 10% level. The table also reports the $R1$ coefficient and the values of the AIC together with the corresponding values of the AR-QR model (AIC-AR). In bold the smallest value when the difference is greater than 10. ◂ back

τ	0.05				0.50				0.95			
	H	C	E	F	H	C	E	F	H	C	E	F
					South Africa							
μ	-1.04	**-1.33**	**-22.33**	**-1.16**	**4.16**	**2.26**	**12.04**	**4.37**	**9.52**	**4.43**	**42.80**	**11.03**
	(0.16)	(0.01)	(0.00)	(0.05)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
ϕ	**0.27**	**0.68**	**-0.35**	0.09	**0.24**	**0.50**	**-0.25**	**0.31**	**0.22**	**0.69**	-0.17	**0.69**
	(0.02)	(0.00)	(0.00)	(0.29)	(0.10)	(0.00)	(0.01)	(0.01)	(0.10)	(0.00)	(0.18)	(0.00)
$\beta_1^{(G)}$	**0.61**	-0.47	**30.91**	**1.63**	**0.91**	0.19	**25.59**	**1.43**	**0.70**	0.80	**20.23**	**1.82**
	(0.10)	(0.22)	(0.00)	(0.00)	(0.02)	(0.24)	(0.00)	(0.03)	(0.09)	(0.21)	(0.00)	(0.01)
$\beta_2^{(G)}$			**-15.99**				**-4.99**				-1.70	
			(0.00)				(0.03)				(0.79)	
$\beta_1^{(E)}$	**1.89**	-0.35	0.20	**1.73**	**0.92**	0.29	-2.11	0.82	**0.79**	-0.18	-3.10	-0.32
	(0.00)	(0.16)	(0.96)	(0.00)	(0.05)	(0.24)	(0.28)	(0.27)	(0.08)	(0.62)	(0.23)	(0.67)
R^1	0.2	0.31	0.41	0.12	0.1	0.22	0.33	0.17	0.2	0.23	0.24	0.28
AIC	**1273**	**958**	**2142**	**1397**	1122	822	**1906**	**1330**	1250	1030	**2063**	1551
AIC-AR	1303	970	2283	1422	1129	823	2061	1342	1251	1038	2172	1559

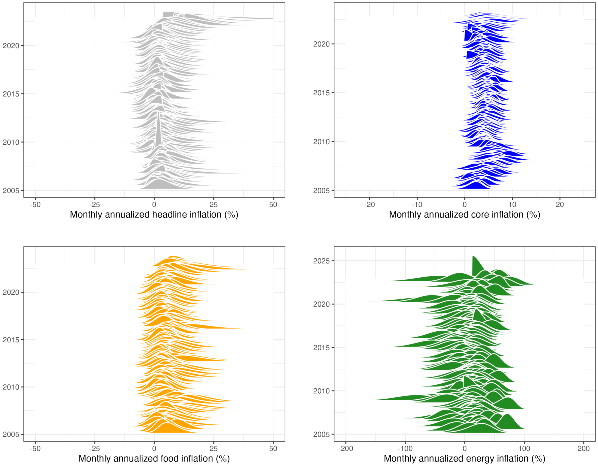
Inflation Densities: United States

Figure 18: Predicted domestic inflation densities in the US obtained using the FA-QR model for headline (gray), core (blue), energy (green) and food (yellow) inflation. The bullets represent the observed inflation. back



Inflation Densities: South Africa

Figure 19: Predicted domestic inflation densities in the South Africa obtained using the FA-QR model for headline (gray), core (blue), energy (green) and food (yellow) inflation. The bullets represent the observed inflation. back



Probabilities of high and low inflation of headline

Figure 20: Estimates of $IaR_{it+1}(3)$ (left) and $DaR_{it+1}(0)$ (right) for headline. back