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EUROSYSTEM

Spreading the word or reducing the term spread? Assessing spillovers from euro area monetary policy

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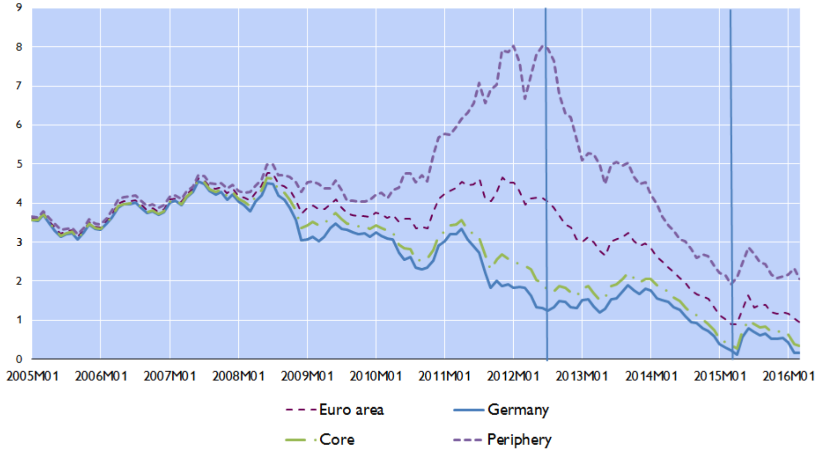
Compression of the yield curve?

10Y government bond yields

In %.

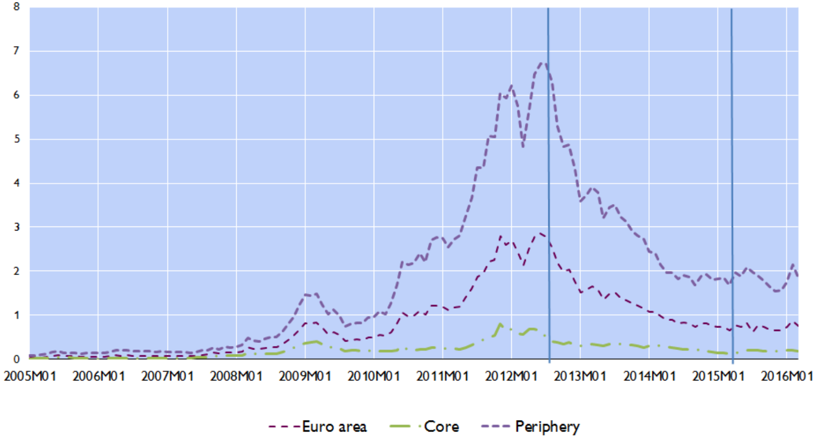


Source: Eurostat.

Narrowing of risk spreads?

Risk spread (spread of euro area country long-term yields over German long-term yields)

In %.



Source: Eurostat.

Motivation & Research Questions

- What are the likely **international effects** of these measures?
- **Monetary easing** in the euro area given an anti-inflationary and an already low interest rate environment **might trigger investors to reallocate capital** to more profitable regions, e.g., non-euro area EU member states / Central, Eastern and Southeastern Europe (CESEE).

⇒ These economies, in turn, may face **appreciation pressures** on their domestic currencies.

- On the other hand, an increase in euro area aggregate demand should spur exports from CESEE and thus overall GDP growth
  - **Which one of these two effects dominates?**
  - **Through which channels does the shock transmit?**

Literature review

1. **Within euro area spillovers**
   - **Gambacorta et al. (2014)**: estimate a structural panel vectorautoregression (PVAR) for eight advanced euro area countries; exogenous increase in central banks' assets ⇒ temporary rise in economic activity, smaller effect on prices
   - **Burriel and Galesi (2016)**: use a global vector autoregressive model; shock to central banks' balance sheet ⇒ rise in output, inflation, equity prices and new credit operations and a depreciation of the effective exchange rate; no effects on inflation expectations.
2. **Spillovers to non-euro area countries**
   - **Bluwstein and Canova (2016)** use two-country mixed frequency structural vector autoregressions ⇒ positive but heterogeneous effects on output; evidence for financial channel
   - **Hálová and Horváth (2015)** use a panel VAR framework ⇒ strong effects on output, while spillovers to prices are rather weak

Our contribution

- We assess **spillovers** of euro area monetary policy **to non-euro area EU member states**
- For that purpose we use a Bayesian and flexible version of the **G**lobal **V**ector **A**uto**R**egressive framework that
  - explicitly takes **country-specifics** into account
  - models **second-round effects**
  - reduces estimation uncertainty by using **shrinkage priors**
  - features **stochastic volatility**
- We look at **two different angles** through which **recent euro area monetary policy** can affect the real economy.
- **Bayesian stance** allows to include **a broad set of macro- and financial variables** that should cover a range of different transmission channels.

Normal-**G**amma GVAR with **S**tochastic **V**olatility I

Ingredients: N countries, a vector $\boldsymbol{x}_{i,t}$ of macroeconomic time series, a link matrix $\boldsymbol{W}_i$, $\boldsymbol{x}^*_{i,t}$, to approximate global factors

1. For each country i, specify a VARX*(p,q) model:

$$\boldsymbol{x}_{it} = \sum_{j=1}^{p} \underbrace{\boldsymbol{A}_{ij}\boldsymbol{x}_{it-j}}_{domestic} + \sum_{s=0}^{q} \underbrace{\boldsymbol{B}_{is}\boldsymbol{x}^*_{it-s}}_{international} + \varepsilon_{it} \quad (1)$$

where $x^*_{it} = \sum_{j=0}^{N} w_{ij} x_{jt}$, for $i \in \{0, \dots, N\}$, w_{ij} a set of bilateral weights $\varepsilon_{it} \sim N(0, \boldsymbol{\Sigma}_{it})$

The **time varying** variance-covariance matrix $\boldsymbol{\Sigma}_{it}$ can be decomposed into:

$$\boldsymbol{\Sigma}_{it} = \boldsymbol{U}_i \boldsymbol{H}_{it} \boldsymbol{U}_i'$$

with $\boldsymbol{U}_i$ is lower triangular matrix with unit diagonal and $\boldsymbol{H}_{it}$ a diagonal matrix with $\boldsymbol{H}_{it} = \text{diag}(e^{h_{i1,t}}, \dots, e^{h_{ik_i,t}})$.

For the **log-volatilities** we specify:

$$h_{ij,t} = \mu_{ij} + \rho_{ij}(h_{ij,t-1} - \mu_{ij}) + \kappa_{ij,t}, \tag{2}$$

where $\kappa_{ij,t}$ denotes a white noise error with variance ς_{ij}^2.

2. After some straightforward algebra, **single models** can be **stacked** to yield the **GVAR** representation:

$$\boldsymbol{G}\boldsymbol{x}_t = \sum_{n=1}^{\max(p,q)} \boldsymbol{F}_n \boldsymbol{x}_{t-n} + \boldsymbol{\eta}_t. \tag{3}$$

with $\boldsymbol{x}_t = (\boldsymbol{x}'_{0t}, \dots, \boldsymbol{x}'_{Nt})'$ and $\boldsymbol{\eta}_t$ is a k-dimensional vector white noise process with a block-diagonal matrix $\boldsymbol{\Sigma}_t = \text{diag}(\boldsymbol{\Sigma}_{0t}, \dots, \boldsymbol{\Sigma}_{Nt})$

Bayesian inference - prior setup I

Rewrite Eq. (1) into a standard regression model:

$$\boldsymbol{x}_{it} = \boldsymbol{C}_i \boldsymbol{z}_{it} + \varepsilon_{it}, \tag{4}$$

with $\boldsymbol{z}_{it} = (\boldsymbol{x}'_{it-1}, \ldots, \boldsymbol{x}'_{it-p}, \boldsymbol{x}^{*'}_{it}, \ldots, \boldsymbol{x}^{*'}_{it-q})'$ a $K_i = k_i p + k_i^* q$-dimensional vector and $\boldsymbol{C}_i = (\boldsymbol{A}_{i1}, \ldots, \boldsymbol{A}_{ip}, \boldsymbol{B}_{i0}, \ldots, \boldsymbol{B}_{iq})$ a $k_i \times K_i$ matrix of stacked coefficients.

Akin to Huber and Feldkircher (JBES, 2016), **Normal-Gamma (NG)** prior on each element of $c_i = \text{vec}(C_i)$,

$$c_{ij}|\tau_{ij}^2 \sim \mathcal{N}(0, 2/\lambda_i^2 \tau_{ij}^2),\ \lambda_i^2 \sim \mathcal{G}(n_i, n_i),\ \tau_{ij}^2 \sim \mathcal{G}(\vartheta_i, \vartheta_i) \tag{5}$$

Hereby we assume that the prior on c_{ij} depends on a **local scaling** parameter τ_{ij}^2, a **country specific overall shrinkage** parameter λ_i^2, and ϑ_i governing **excess kurtosis** of the marginal prior.

Bayesian inference - prior setup II

Similarly we impose a NG prior on the **off-diagonal elements of $\boldsymbol{U}_i$**

$$u_{i,jn}|\kappa^2_{i,jn} \sim \mathcal{N}(0, 2/\zeta^2_i \kappa^2_{i,jn}),\ \zeta^2_i \sim \mathcal{G}(l_i, l_i),\ \kappa^2_{i,jn} \sim \mathcal{G}(\upsilon_i, \upsilon_i), \tag{6}$$

For the **log-volatilities** we specify (Kastner and SFS, 2014):

$$\mu_{ij} \sim \mathcal{N}(0, v_\mu) \tag{7}$$

$$\frac{\rho_{ij}+1}{2} \sim \mathcal{B}(a_0, b_0) \tag{8}$$

$$\varsigma^2_{ij} \sim \mathcal{G}(1/2, 1/2B_\varsigma). \tag{9}$$

Data & country coverage

Euro area (12) : AT, BE, DE, FI, FR, NL, SK (= core)
ES,IE, IT, PT, GR (= periphery)

Non-euro area EU member states + TR and RU (11) : GB, SE, DK, CZ, HU, PL, BG, SI, HR, RO, RU, TR.

Other (4) : US, CN, JP, CA.

⇒ good coverage of the euro area, non-euro area EU-member states and the G-8 industrialized advanced economies

Monthly data from 2000m1-2015m12:

y . . . industrial production
p . . . consumer prices
eq . . . equity prices
i_s/i_l . . . short- /long-term interest rates
er . . . exchange rate vis-a-vis the euro ("-" depreciation of euro)
sp . . . term spread / risk spread

Shock identification

- Two shocks
  1. **Term spread shock**: simultaneous shock to EA term spreads on average by 100 basis points
  2. **Risk spread shock**: simultaneous shock to EA risk spreads (defined as the spread of euro area long-term yields over German long-term yields) on average by 100 basis points

- Two sets of impulse responses
  1. **Structural impulse responses** (SIRF) based on recursive ordering in euro area country models $x = (y, p, sp, eq)$ (see Walentin, 2014).
  2. **Generalized impulse response functions** (GIRF), no ordering assumed but no structural interpretation of responses (see Pesaran and Shin, 1998)

Model specification

Term spread shock

Country	y	p	i_s	i_l	sp	er	eq	y^*	p^*	$i_s{}^*$	$i_l{}^*$	sp^*	er^*	eq^*
DE	√	√	√	–	√	–	√	√	√	√	–	√	√	√
EA (excl., DE)	√	√	–	–	√	–	√	√	√	√	–	√	√	√
Non-EA	√	√	√	–	√	√	√	√	√	√	–	√	–	√

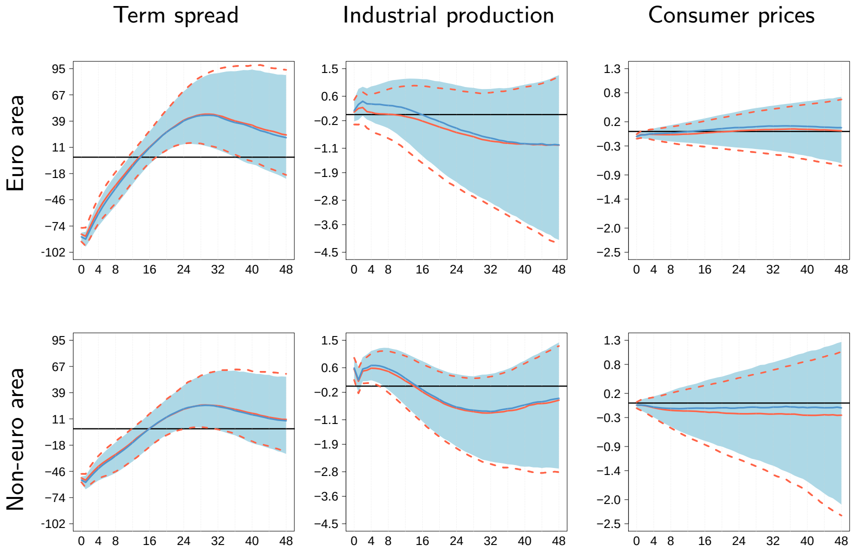
Risk spread shock

Country	y	p	i_s	i_l	sp	er	eq	y^*	p^*	$i_s{}^*$	$i_l{}^*$	sp^*	er^*	eq^*
DE	√	√	√	√	–	–	√	√	√	√	√	√	√	√
EA (excl., DE)	√	√	–	–	√	–	√	√	√	√	√	√	√	√
Non-EA	√	√	√	√	–	√	√	√	√	√	√	√	–	√

In the spirit of Baumeister and Benati (2013) we **zero out** responses i_s for the term spread shock and i_l for the risk spread shock in the German country model.

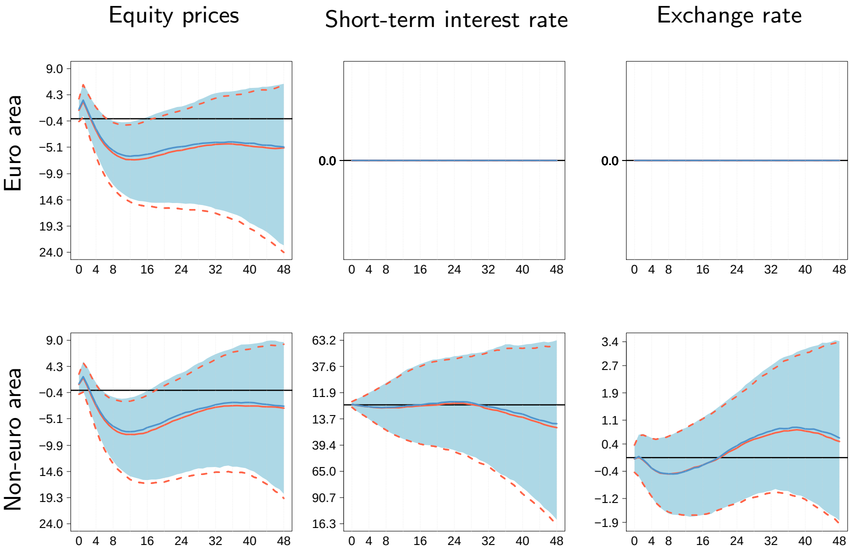
Term spread shock I

SIRF in blue, GIRF in orange, 50% credible sets



Term spread shock II

SIRF in blue, GIRF in orange, 50% credible sets



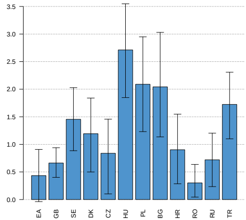
Remarks: Term spread shock

- Spillovers to long-term yields (about half of the size of within euro area effects)
- Positive and significant spillovers to industrial production in the short-run (although within euro area effects fraught with estimation uncertainty)
- No positive effects on consumer prices
- Reduction in long-term yields drive up equity prices
- Exchange rates in non-euro area EU member states strengthen against the euro in the short-run, but not significantly so
- Albeit overall effect on output within euro area non-significant, spillovers to non-euro area EU member states significant (in the short-run).

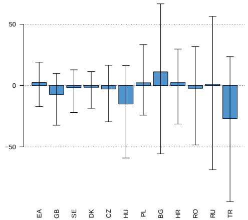
Term spread shock III

Peak effects (SIRF, whiskers denote 50% credible intervals)

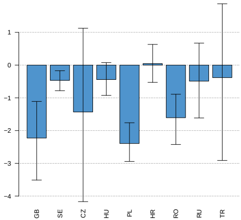
Industrial production



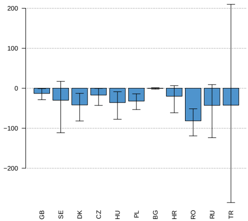
Consumer prices



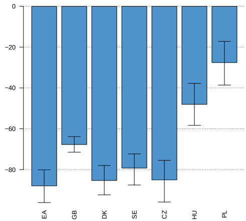
Exchange rate



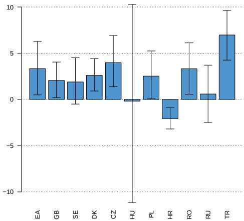
Short-term int. rates



Term spread



Equity prices

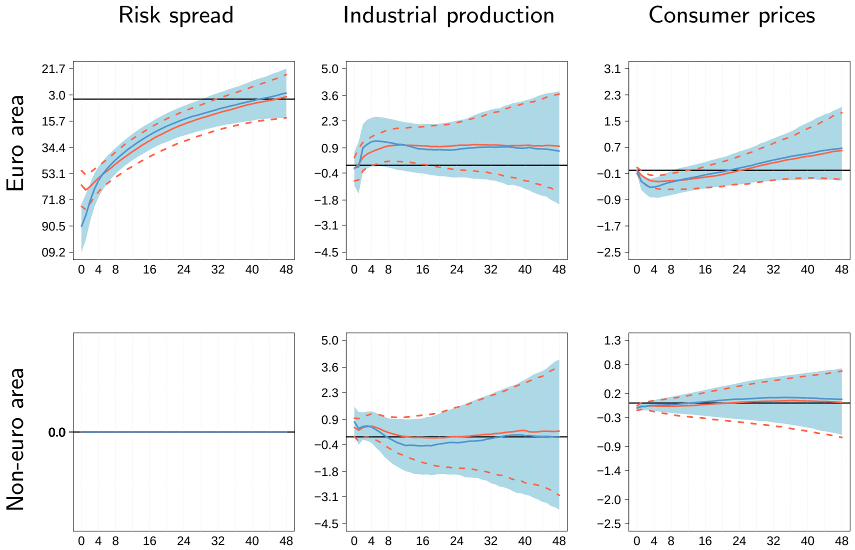


Regional remarks: Term spread shock

- Peak effects of industrial production significant throughout the region; HU, PL, BG, but also TR benefit most strongly
- Significant peak effects of the exchange rate (appreciation of local currency); most pronounced for PL, GB and RO, marked uncertainty for CZ
- To ease pressure on the exchange rate, policy rates decrease
- Significant peak effects of the term spread; in HU and PL smaller compared to other economies
- For most economies, equity prices tick up significantly; most pronounced for TR

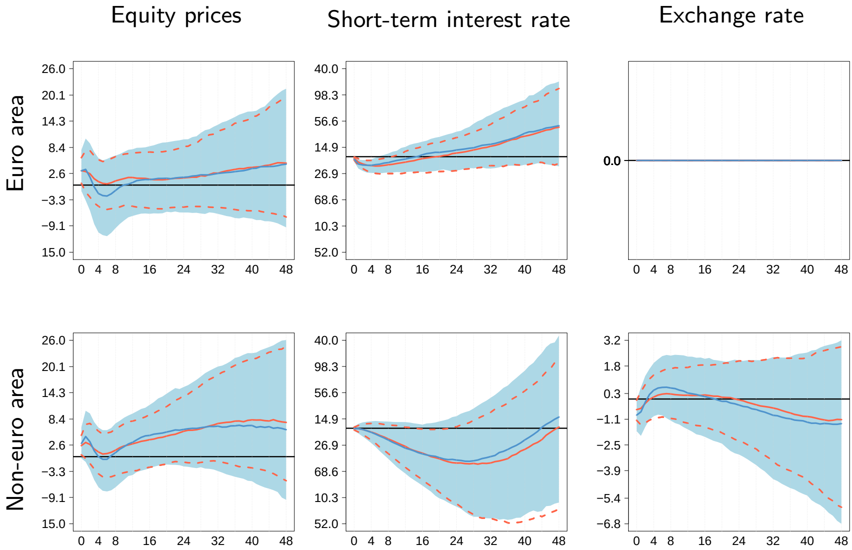
Risk spread shock I

SIRF in blue, GIRF in orange, 50% credible sets



Risk spread shock II

SIRF in blue, GIRF in orange, 50% credible sets

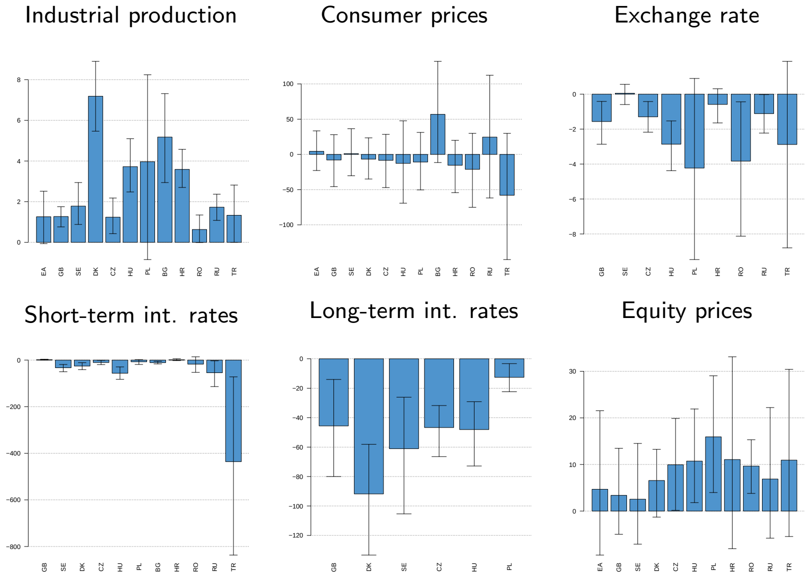


Remarks: Risk spread shock

- Overall effects of the risk spread shock on industrial production are positive but not significant
- No positive effects on consumer prices
- Positive domestic and international effects on equity prices
- Local currencies tend to strengthen in the short-run; rebound in the medium-term
- Negative spillovers to long-term interest rates (not shown) $\Rightarrow$ non-euro area EU member states benefit from a reduction in uncertainty and risk in the euro area

Risk spread shock III

Peak effects (SIRF, whiskers denote 50% credible intervals)



Regional remarks: Risk spread shock

- Peak effects of industrial production significant for most economies (BG, HU and PL again benefit strongly, but also HR)
- Significant peak effects of the exchange rate (appreciation of local currency); most pronounced for PL and RO
- To ease pressure on the exchange rate, policy rates decrease; most pronounced for TR and to a lesser extent RU and HU
- Significant reductions in long-term interest rates; effects more pronounced for advanced economies
- For most economies, equity prices tick up significantly, especially so in CEE economies

Conclusions I

- For both shocks, we find **positive and significant spillovers to industrial production** in non-euro area EU member states in the short-run, although to a varying degree
- **Heterogeneity of spillovers** partially explained by different within euro area spillovers (reduction of euro area term spreads stronger effects on euro area core, while narrowing of euro area long-term interest rates, stronger effects on periphery)
- Spillovers are transmitted via the **financial channel** (through interest rates and equity prices)

Conclusions II

- Also, currencies tend to strengthen against the euro in the short-run (**exchange rate / trade channel**)
- Since overall effects on output positive, **benefits from euro area expansion seem to outweigh costs from appreciation of local currencies**
- We **do not find evidence of spillovers to consumer prices**.

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- Current Position: Senior Economist, Foreign Research Division (AUSA), Oesterreichische Nationalbank (OeNB)
- Research interests: Empirical macroeconomics, multicountry models, forecasting, Bayesian analysis

VARs & GVARs- Selected Readings I

Baumeister C. and Benati L. 2013.
Unconventional Monetary Policy and the Great Recession: Estimating the Macroeconomic Effects of a Spread Compression at the Zero Lower Bound
International Journal of Central Banking, Vol.9(2), pp 165–212.

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Forecasting with Global Vector Autoregressive Models: a Bayesian Approach
Journal of Applied Econometrics, forthcoming.

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Journal of Economic Dynamics and Control, 70, pp 86–100.

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International Spillovers from Euro Area and US Credit and Demand Shocks: A focus on Emerging Europe
Journal of International Money and Finance, Vol. 70, pp 1-25.

VARs & GVARs- Selected Readings II

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A Global Macro Model for Emerging Europe.
Journal of Comparative Economics, Vol. 43, Issue 3, pp. 706-726.

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The international transmission of US shocks – Evidence from Bayesian global vector autoregressions
European Economic Review, Vol. 81, pp 167–188.

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Adaptive Shrinkage in Bayesian Vector Autoregressive Models.
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Kastner G. and Frühwirth-Schnatter S. 2014.
Ancillarity-sufficiency interweaving strategy (ASIS) for boosting MCMC estimation of stochastic volatility models.
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Pesaran H. and Shin Y. 2011.
Generalized impulse response analysis in linear multivariate models.
Economics Letters, Vol. 58(1), pp 17–29.

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Beggar-thy-neighbor? The international effects of ECB unconventional monetary policy measures.
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Journal of Money, Credit and Banking, 2014, 46 (4), 615–642.

Hálová K. and Horváth R. 2015.
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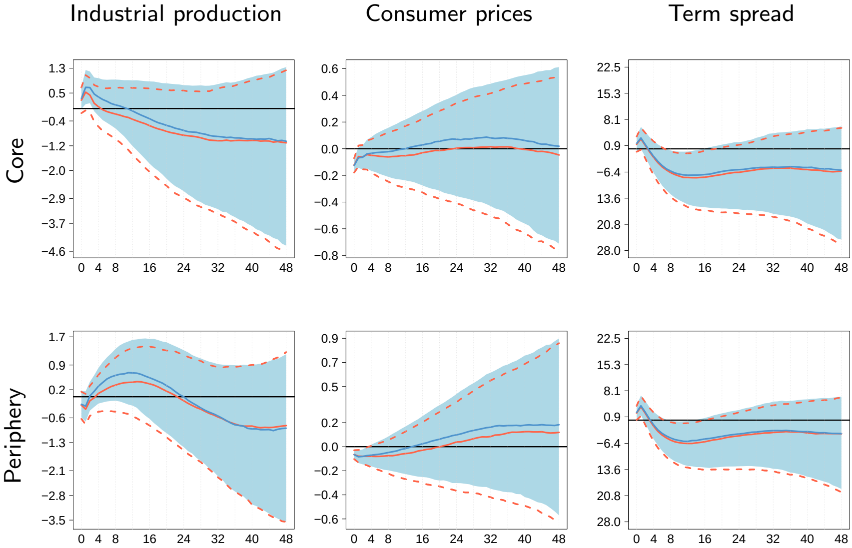
Business cycle implications of mortgage spreads.
Journal of Monetary Economics, 67, pp.62–77.

BACKUP SLIDES

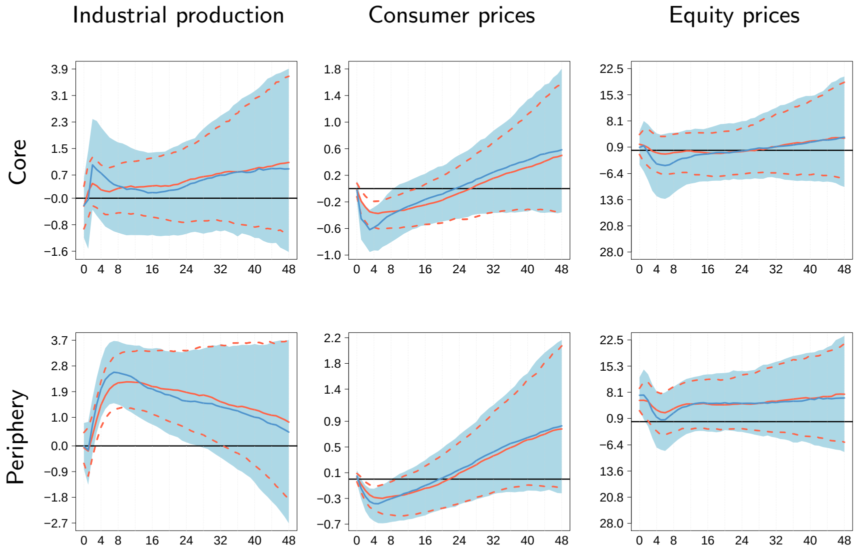
Term spread shock

Core vs. periphery; SIRF in blue, GIRF in orange, 50% credible sets



Risk spread shock

Core vs. periphery; SIRF in blue, GIRF in orange, 50% credible sets



First Layer: Estimation of single model

- Each country is modeled as a country-specific VAR augmented with the foreign variables (VARX)
- VARX(1,1) is

$$\boldsymbol{x}_{it} = \underbrace{c_0 + c_1 \boldsymbol{t} + \Psi_{i0} \boldsymbol{d}_t}_{\text{Deterministics}} + \Phi \boldsymbol{x}_{i,t-1} + \Lambda_{i0} \boldsymbol{x}^*_{it} + \Lambda_{i1} \boldsymbol{x}^*_{it-1} + \boldsymbol{u}_{it}$$

- In our example the model for the euro area would look like

$$\begin{bmatrix} \boldsymbol{y}_t \\ \boldsymbol{Dp}_t \end{bmatrix} = \Phi \begin{bmatrix} \boldsymbol{y}_{t-1} \\ \boldsymbol{Dp}_{t-1} \end{bmatrix} + \Lambda_{i0} \begin{bmatrix} \boldsymbol{y}^*_t \\ \boldsymbol{Dp}^*_t \end{bmatrix} + \Lambda_{i1} \begin{bmatrix} \boldsymbol{y}^*_{t-1} \\ \boldsymbol{Dp}^*_{t-1} \end{bmatrix} + \begin{bmatrix} \boldsymbol{u}_{y,t} \\ \boldsymbol{u}_{i,t} \end{bmatrix}$$

First Layer: Estimation of Single Model

This model is then written in VECM form and estimated for $i \in 1, \ldots, N$

$$\Delta \boldsymbol{x}_t = c_0 + c_1 \boldsymbol{t} + \Phi_i \boldsymbol{x}_{t-1} + \Lambda_{i0} \Delta \boldsymbol{x}^*_{it} + \Psi_{i0} \Delta \boldsymbol{d}_t + \boldsymbol{u}_{it}$$

with $\boldsymbol{u}_t \sim N(\mathbf{0}, \boldsymbol{\Sigma}_u)$, $\boldsymbol{d}_t$ denoting global variables (e.g., oil prices) and t a deterministic trend component.

Note: $\boldsymbol{d}_t$ and $\boldsymbol{x}_t$ allowed to enter the equation contemporaneously; $\boldsymbol{x}_t$ assumed to be long-run forcing for $\boldsymbol{y}_t$ (i.e., zero restrictions on Φ_i, small economy assumption)

Second Layer: Stacking the Single Models

- After the country-by-country estimation of the VECMX we can proceed to the second step of the GVAR modelling strategy

  1. Recover the parameters of the VARX models
  2. Combine the VARX into a global model

- The resulting model will have the form of a standard VAR where all variables will be "endogenous"

- This is a purely mechanical step: **no estimation is involved!**

Second Layer: Stacking the Single Models

- Define a selection matrix that singles out the country under consideration from the global vector of endogenous variables

$$\boldsymbol{S}_{ea} = \begin{pmatrix} 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \end{pmatrix} \quad \boldsymbol{x}_t = \begin{pmatrix} \boldsymbol{y}_{us,t} \\ \boldsymbol{Dp}_{us,t} \\ \boldsymbol{y}_{ea,t} \\ \boldsymbol{Dp}_{ea,t} \\ \boldsymbol{y}_{ru,t} \\ \boldsymbol{Dp}_{ru,t} \end{pmatrix}$$

- This implies that $\boldsymbol{x}_{ea,t} = \begin{pmatrix} \boldsymbol{y}_{ea} \\ \boldsymbol{Dp}_{ea} \end{pmatrix} = \boldsymbol{S}_{ea}\boldsymbol{x}_t$

Second Layer: Stacking the Single Models

- VARX(1,1)

$$\boldsymbol{x}_{it} = \Phi \boldsymbol{x}_{i,t-1} + \Lambda_{i0} \boldsymbol{x}^*_{it} + \Lambda_{i1} \boldsymbol{x}^*_{i,t-1} + \boldsymbol{u}_{it}$$

- Use link matrix $\mathcal{W}_i$ and selection matrix $\boldsymbol{S}_i$

$$\boldsymbol{S}_i \boldsymbol{x}_t = \Phi \boldsymbol{S}_i \boldsymbol{x}_{t-1} + \Lambda_{i0} \mathcal{W}_i \boldsymbol{x}_t + \Lambda_{i1} \mathcal{W}_i \boldsymbol{x}_{t-1} + \boldsymbol{u}_{it}$$

- Rearrange

$$(\boldsymbol{S}_i - \Lambda_{i0} \mathcal{W}_i) \boldsymbol{x}_t = (\Phi \boldsymbol{S}_i + \Lambda_{i1} \mathcal{W}_i) \boldsymbol{x}_{t-1} + \boldsymbol{u}_{it}$$

- Relabel

$$\boldsymbol{G}_i \boldsymbol{x}_t = \boldsymbol{H}_i \boldsymbol{x}_{t-1} + \boldsymbol{u}_{it}$$

The Global Model

- Stack all country-specific models

$$\begin{bmatrix} \boldsymbol{G}_{us} \\ \boldsymbol{G}_{ea} \\ \boldsymbol{G}_{ru} \end{bmatrix} \boldsymbol{x}_t = \begin{bmatrix} \boldsymbol{H}_{us} \\ \boldsymbol{H}_{ea} \\ \boldsymbol{H}_{ru} \end{bmatrix} \boldsymbol{x}_{t-1} + \begin{bmatrix} \boldsymbol{u}_{us,t} \\ \boldsymbol{u}_{ea,t} \\ \boldsymbol{u}_{ru,t} \end{bmatrix}$$

- More compact

$$\boldsymbol{G}\boldsymbol{x}_t = \boldsymbol{H}\boldsymbol{x}_{t-1} + \boldsymbol{u}_t$$

with

$$\boldsymbol{G} = \left(\boldsymbol{G}'_{us}, \boldsymbol{G}'_{ea}, \boldsymbol{G}'_{ru}\right)', \boldsymbol{G} = \left(\boldsymbol{H}'_{us}, \boldsymbol{H}'_{ea}, \boldsymbol{H}'_{ru}\right)', \boldsymbol{u} = \left(\boldsymbol{u}'_{us}, \boldsymbol{u}'_{ea}, \boldsymbol{u}'_{ru}\right)'$$

- The **GVAR** model

$$\boldsymbol{x}_t = \underbrace{\boldsymbol{F}\boldsymbol{x}_{t-1}}_{\boldsymbol{F}=\boldsymbol{G}^{-1}\boldsymbol{H}} + \underbrace{\tilde{\boldsymbol{u}}_t}_{\boldsymbol{G}^{-1}\boldsymbol{u}_t}$$