Changes in the transmission of monetary policy: Evidence from a time-varying factor-augmented VAR[a]

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[a]The comments do not necessarily reflect the views of the OeNB

Contribution/conclusions of the paper

In terms of methodology

- factor augmented VAR
  - the factors are extracted from 592 time series
  - time-varying parameters in the FAVAR (transition) equation
  - stochastic volatility and time varying covariance in the FAVAR innovations
- convolution of several approaches
  - Bernanke, Boivin and Eliasz (2005, QJE)
    FAVAR approach
  - Cogley and Sargent (2002, NBER Macro Annuals)
    VAR with time-varying parameters and stochastic volatility
  - Primiceri (2005, RES)
    VAR with additionally time-varying covariances

→ non-stationary parameter time-variation

→ non-stationary covariance variation and integrated volatility

- impulse response functions
  - Koop, Pesaran and Potter (1996, JE)

  → fully Bayesian impulse responses, e.g. taking into account future time-varying processes?

$$
\begin{aligned}
\Delta_{t+k} &= E\left(Z_{t+k}|\Omega_{t+k}, \mu_{MP}\right) - E\left(Z_{t+k}|\Omega_{t+k}\right) \quad ? \\
\Delta_{t+k} &= E\left(Z_{t+k}|Z_t, \mu_{MP}\right) - E\left(Z_{t+k}|Z_t\right) \quad ? \\
E\left(Z_{t+k}|Z_t\right) &= \int Z_{t+k} \cdot \pi\left(Z_{t+k}|Z_t\right) dZ_{t+k} \\
\pi\left(Z_{t+k}|Z_t\right) &= \int \pi\left(Z_{t+k}, \vartheta^{t+k}|Z_t\right) d\vartheta^{t+k} \\
\pi\left(Z_{t+k}, \vartheta^{t+k}|Z_t\right) &= \pi\left(Z_{t+k}|\vartheta^{t+k}, Z_t\right) \pi\left(\vartheta^{t+k}|\vartheta_t, Z_t\right) \pi\left(\vartheta_t|Z_t\right)
\end{aligned}
$$

In reaction to a monetary policy tightening, over time

- aggregate impulse responses
  - reaction of real variables becomes less pronounced and less significant
  - reaction of prices becomes persistently stronger (no price puzzle)
- sectoral impulse responses (PCE prices and quantities)
  - share of components displaying a price puzzle decreases
  - quantities react less
  - heterogeneity in reactions decreases
  - nominal adjustment increasingly takes place by price changes (changes in price-setting mechanism?)

  $\longrightarrow$ time-variations are captured in the FAVAR equation

Comments: The model

For $i = 1, \ldots, N$ and $t = 1, \ldots, T$:

$$
\begin{aligned}
X_{it} &= \lambda_i F_t + \Psi_i R_t + e_{it} \\
& e_{it} \sim N\left(0, R_{ii}\right), \quad \pi\left(R_{ii}\right) \sim IG\left(5, 0.01\right) \\
& \text{posterior update} \quad \pi\left(R_{ii}|X\right) \sim IG\left(5+s, 0.01+T\right)
\end{aligned}
$$

large differences in idiosyncratic volatilities?

$\rightarrow$ but time series are standardized?

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& \quad\quad \pi(R_{ii}|X) \sim IG(5 + T, 0.01 + s) \\
& \quad\quad \text{large differences in idiosyncratic volatilities?} \\
& \quad\quad \rightarrow \text{but time series are standardized?}
\end{aligned}
$$

$$
\underset{N\times 1}{X_t} = \underset{(N\times J)(J\times 1)}{\Lambda F_t} + \underset{(N\times 1)(1\times 1)}{\Psi R_t} + \underset{(N\times 1)}{e_t}
$$

$$X_t = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ \lambda_{41} & \lambda_{42} & \lambda_{43} & \psi_4 \\ \vdots & & & \vdots \\ \lambda_{N1} & \lambda_{N2} & \lambda_{N3} & \psi_N \end{bmatrix} \begin{bmatrix} F_t \\ R_t \end{bmatrix} + e_t$$

$$\begin{bmatrix} F_t \\ R_t \end{bmatrix} = \Phi_t \begin{bmatrix} F_{t-1} \\ R_{t-1} \end{bmatrix} + \upsilon_t, \quad \upsilon_t \sim N\left(0, \Sigma_t\right)$$

- FAVAR? — dyn. factor model where R_t is driven by/drives factors
- identification — ordering is crucial when N large!
- neglected idiosyncratic dynamics

Comments: Time-varying processes

$$
\begin{aligned}
vec\left(\Phi_t'\right) &= vec\left(\Phi_{t-1}'\right) + \eta_t \\
\theta_t &= \theta_{t-1} + \eta_t, \quad \eta_t \sim N\left(0, Q\right) \\
&\quad \pi\left(Q\right) \sim IW\left(var\left(\hat{\theta}^{\text{OLS}}\right) \cdot 10^{-4} \cdot T_0, T_0\right) \rightarrow \text{is } Q \text{ diagonal?} \\
&\quad \theta_0 \sim N\left(\hat{\theta}^{\text{OLS}}, V\right),\ V = diag\left(var\left(\hat{\theta}^{\text{OLS}}\right)\right)
\end{aligned}
$$

- stationarity restrictions on Φ_t?
- $vec\left(\Phi_t'\right) = \theta_0 + \sum_{j=0}^{t} \eta_{t-j} \rightarrow cov\left(vec\left(\Phi_t'\right)\right)$ is non-stationary, the precision of the distribution decreases

$$\Sigma_t = A_t H_t A_t', \quad A_t = \begin{bmatrix} 1 & \cdots & 0 \\ & \ddots & \\ \alpha_{ij,t} & & 1 \end{bmatrix}, \; H_t = \begin{bmatrix} h_{1t}^2 & & 0 \\ & \ddots & \\ 0 & \cdots & h_{J+1,t}^2 \end{bmatrix}$$

$$uvec\left(A_t'\right) = uvec\left(A_{t-1}'\right) + \tau_t$$

$$\alpha_t = \alpha_{t-1} + \tau_t, \quad \tau_t \sim N\left(0, S\right), \; S = \begin{bmatrix} S_2 & & 0 \\ & \ddots & \\ 0 & & S_{J+1} \end{bmatrix}$$

$$\underset{(i-1)\times(i-1)}{\pi\left(S_i\right)} \sim IW\left(diag \underbrace{\left(\hat{a}_{i\cdot}^{\mathrm{OLS}}\right)}_{\text{may be negative?}} \cdot 10^{-3}, \underbrace{i}_{\text{why not } T_0?}\right)$$

Primiceri (2005): $IW\left(V\left(\hat{a}_{i\cdot}^{\mathrm{OLS}}\right) \cdot 10^{-2} \cdot i, i\right)$

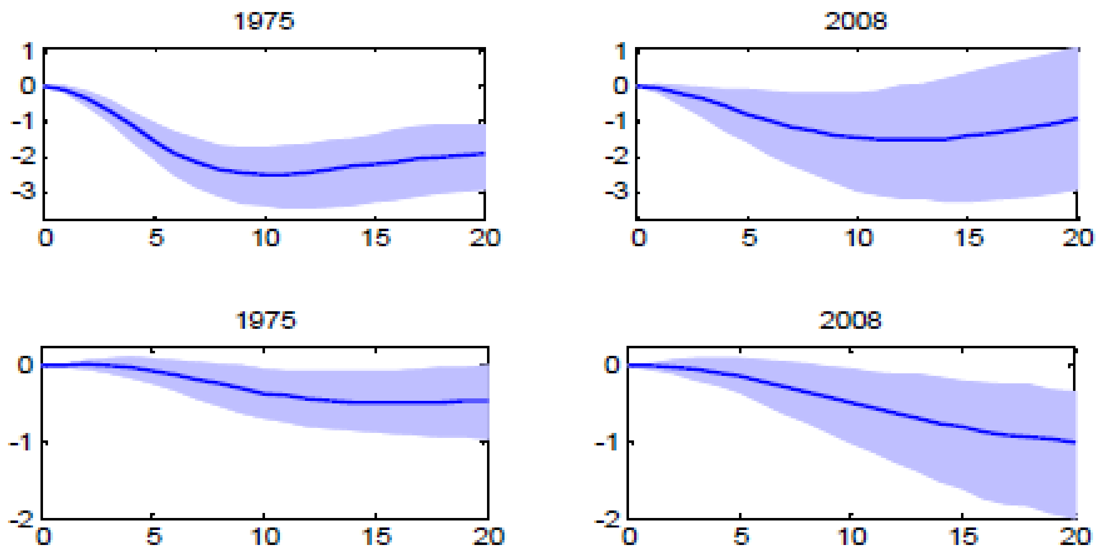
$A_0 \sim N\left(\hat{a}^{\mathrm{OLS}}, V\left(\hat{a}^{\mathrm{OLS}}\right)\right)$

$$\ln h_{it}^2 = \ln h_{i,t-1}^2 + \varepsilon_{it}, \quad \varepsilon_{it} \sim N\left(0, \sigma_i^2\right)$$

$$\pi\left(\sigma_i^2\right) \sim IG\left(\frac{10^{-4}}{2}, \frac{1}{2}\right)$$

$$\ln h_{i0} \sim N\left(\ln\left(\hat{\sigma}_i^{\mathrm{OLS}}\right), 10\right) \rightarrow \text{in the paper } 10 \cdot I_{J+1}$$

- Positive definiteness of Σ_t?
- $\pi\left(\Sigma_t | \cdot\right)$ depends on quadratic form of integrated processes $\rightarrow$ non-stationary, precision is decreasing in t.



- Origin of time-varying volatility is of no interest
  $\rightarrow$ you may directly sample Σ_t

$$\pi\left(\Sigma_t\right) \sim IW\left(cov\left(\hat{v}^{\mathrm{OLS}}\right) \cdot T_0 \cdot \kappa_\Sigma, T_0\right)$$

- Alternative time-varying specification:
  Giordani and Kohn (2008, JBES)

$$\theta_t = \theta_{t-1} + \eta_t, \quad \eta_t \sim N\left(0, I_t \cdot Q\right)$$

$$I_t = \begin{cases} 1 \text{ with prob. } p \\ 0 \text{ with prob. } 1-p \end{cases}$$

Comments: Interpretation of results

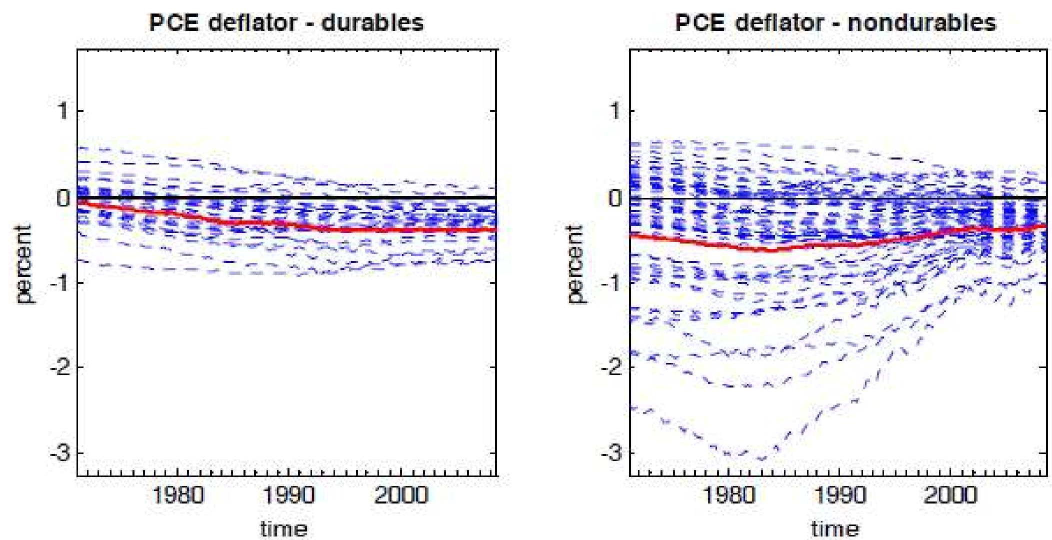
The changes in responses to monetary policy and the decrease in heterogeneity of price responses are driven by:

$$\begin{bmatrix} F_t \\ R_t \end{bmatrix} = \Phi_t \begin{bmatrix} F_{t-1} \\ R_{t-1} \end{bmatrix} + \upsilon_t, \ \upsilon_t \sim N\left(0, \Sigma_t\right)$$

- changing interest rate persistence, i.e. last line in Φ_t
- decreasing effect of interest rates on factors, i.e. last column in Φ_t
- interpretation: changes in sectoral price reactions not only due to changes in price setting decisions
  $\rightarrow$ due to everything that influences data dynamics and hence influences factor dynamics.

Heterogeneous price responses (in levels)?

- persistency over forecast horizon and over time



  - lies in the statistical model (non-dynamic, constant factor loadings and interest rate effect)!
    modelling heterogeneous price stickiness:

$$X_{it} = \lambda_i(L)F_t + \Psi_i(L)R_t + e_{it}$$

- important for monetary policy?
  - for evaluating/forecasting policy stance — yes
    $\rightarrow$ price components have to be weighted, however!
  - for policy setting — no (it's the aggregate that matters)
    if at all relative price changes matter: in terms of heterogeneity in price stickiness

To conclude

To remember

- real responses have become less pronounced and less persistent
- aggregate price responses have become more pronounced and more persistent
- nominal adjustment occurs increasingly by changing prices rather than quantities

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Issues raised

- origin of decreased price response heterogeneity?
- heterogeneity persistence as statistical artifact?