Determining Exchange Rate Pass-through in Russia

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10th June 2021

Overview

- Price stability in an open economy depends on import prices $\Rightarrow$ local price level is subject to exchange rate fluctuations;
- In general, there is no one-to-one correspondence: producers along the distribution chain may adjust their markup to mitigate exchange rate shock;
- Russia has been exposed to numerous different macroeconomic shocks, especially oil price fluctuations $\Rightarrow$ it is crucial to estimate shock-dependent exchange rate pass-through.

Literature Review

Russian ERPT

- Only one work (Khotulev, 2020) estimates shock-dependent ERPT using DSGE;
- Values vary from paper to paper, ERPT is roughly 0.35–0.4 in LR.

Paper	Currency	Data	Infl. aggr.	Length	ERPT
Oomes et al., 2005	NEER	1996–2004	CPI	Short-run	0.4–0.5
Korhonen et al., 2006	USD	1999–2004	ULC[1]	Long-run	-0.42
Dobrynskaya et al., 2008	NEER	1995–2002	CPI	Long-run	0.35
Kataranova, 2010	USD	2000–2008	CPI	Short-run	0.06–0.2
Beckmann et al., 2013	USD	1999–2010	CPI	Long-run	-0.17
Ponomarev et al., 2016	NEER	2000–2012	CPI	Short-run	0.046
Faryna, 2016	USD	2000–2015	CPI Core	Long-run	0.1
Sinyakov et al., 2019	NEER	(2016–2017)	CPI	Long-run	0.35
Khotulev, 2020	NEER	2005–2019	CPI	Long-run	0.16

[1] Unit labour cost.

- Basic method — estimation of ARDL model:

$$INFL_t = \alpha_0 + \alpha_1 NEER_t + \alpha_2 NEER_{t-1} + \ldots + \epsilon_t \tag{1}$$

- Then, unconditional exchange rate pass-through (**ERPT**) value for horizon t is as follows:

$$ERPT_t = \sum_{i=1}^{N} \alpha_i \tag{2}$$

- Main drawback — ERPT value is shock-independent, not informative.

- Another option is to estimate VAR (either using frequentist or Bayesian approach) and calculate price-to-exchange rate ratio (PERR, as in Ortega et al. (2020)), for example:

$$Y_t = \mathbf{C} + \mathbf{B_1} Y_{t-1} + \ldots + u_t, \quad \mathbb{E}(uu') = \Sigma_u \tag{3}$$

$$Y_t = \left[\mathrm{CPI}_t, \mathrm{GDP}_t, \mathrm{IR}_t, \mathrm{ER}_t, \mathrm{OIL}_t\right]', \; u_t = \left[u_t^{\mathrm{CPI}}, \ldots, u_t^{\mathrm{OIL}}\right]'. \tag{4}$$

$$PERR_{h,shock} = \frac{\sum_{t=1}^{h} \mathrm{IRF}_{t,shock}^{\mathrm{CPI}}}{\sum_{t=1}^{h} \mathrm{IRF}_{t,shock}^{\mathrm{ER}}}, \tag{5}$$

- Reduced-form VAR does not capture structural shocks (Σ_u is not diagonal) $\Rightarrow$ need to use identification scheme.

ER = exchange rate, IR = interest rate, IRF = impulse response function.

- Full-form VAR:

$$A_0 Y_t = \tilde{\mathbf{C}} + \mathbf{A_1} Y_{t-1} + \ldots + \epsilon_t, \quad \mathbb{E}(\epsilon\epsilon') = \Sigma_\epsilon = \mathbb{I}_n. \tag{6}$$

$\epsilon_t = \left[\epsilon_t^{\mathrm{CPI}}, \ldots, \epsilon_t^{\mathrm{OIL}}\right]'$ is a vector of *structural* shocks at t, and model captures contemporaneous relations of variables.

- The most common way to get matrix of structural parameters — A_0 — is to use Cholesky decomposition of covariance matrix Σ_u:

$$\Sigma_u = (A_0)^{-1} \Sigma_\epsilon (A_0)^{-1'} = (A_0)^{-1} (A_0)^{-1'}. \tag{7}$$

- A huge drawback — this identification scheme is recursive (upper-/lower-triangular) $\Rightarrow$ rigid.

Methods

Zero and sign restrictions

- (Arias et al., 2014) propose to use agnostic suggestions about signs and zero values of IRF to identify shocks:
    1. Obtain n draws from posterior distributions of BVAR;
    2. For each draw generate m random matrices X_n and use QR decomposition to get orthonormal matrices Q such that $Q'Q = I_n$. Transform Q using an algorithm described in paper, if there are zero restrictions;
    3. For each matrix Q calculate $IRF_h \times Q$, where IRF_h is column-stacked IRF values calculated from corresponding draw, and check whether the result satisfies zero and sign restrictions.
- Suitable for under-identified and just-identified models;
- There should be less zero restrictions than an order of a particular shock.

- Quarterly data from 2005Q2–2020Q4;
- All variables, except for interest rate, are in growth rates;
- Two CPI aggregates: full and core (excl. fuel, fruits and vegetables, community transport services, utilities etc.).

Variable	Description	Source
Oil price	Brent oil price nominated in US dollars, quarterly average, QoQ.	Bloomberg
Interest rate	MIACR 31–180 days, quarterly average.	CBR
Exchange rate	Nominal effective exchange rate (NEER) of ruble, Ruble appreciation = NEER decline, QoQ, Central Bank of Russia methodology.	CBR
Output	Russian real GDP (2015Q1 = 100), seasonally adjusted by institution, QoQ.	FRED
Price level	Consumer price index and core consumer price index, QoQ, seasonally adjusted (X13-SEATS), Rosstat methodology.	Rosstat

- Two 1-lag BVAR specifications: full and core CPI for price level variable. Order is chosen based on SIC criterion. Normal inverse-Wishart prior is used;
- 500 draws from posterior distribution, 1000 random *Q* matrices for each draw.

Variable	Demand shock	Supply shock	Monetary shock	Exchange rate shock	Global persistent shock
CPI/Core	+	–	–	+	?
Real GDP	+	+	–	?	?
Interest rate	+	?	+	+	?
NEER	–	?	–	+	–
Oil price	0	0	0	0	+

Table: + (-) describe values ≥ 0 (≤ 0) of variable's contemporaneous and next quarter response to a particular shock. 0 indicates no contemporaneous reaction.

- All PERR are higher for core composition;
- Exchange rate shock pass-through is the highest for both specifications;
- Global shock is low for full CPI and huge for core composition;
- Supply shocks are comparable for both specifications;
- Except for supply shock, pass-through is faster for core CPI.

Horizion	Short-run (1Q)		Long-run (4Q)	
Shock	PERR (CPI)	PERR (Core)	PERR (CPI)	PERR (Core)
Global persistent shock	0.070	0.344	0.158	0.427
Monetary shock	0.044	0.110	0.281	0.448
Exchange rate shock	0.146	0.197	0.403	0.565
Supply shock	-0.239	-0.124	-0.356	-0.391
Demand shock	-0.037	-0.295	-0.133	-0.354

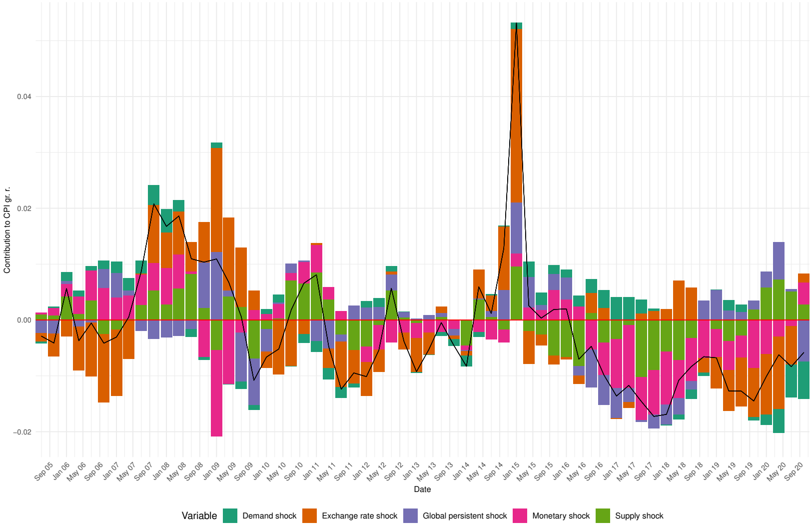

Figure: Hist. decomp. of demeaned CPI gr. r. time series.

Conclusion

- Result is comparable to (Khotulev, 2020) for monetary and global shocks;
- PERR values are higher for Russia comparing to Euro area;
- Exchange rate pass-through is higher and faster to core CPI;
- Exogenous exchange rate shock leads to the highest pass-through;
- COVID-19 crisis has been driven mainly by global persistent and demand shocks.

Q&A

- Software discussion
- How Q matrix is constructed with zero restrictions?
- Bayesian model specification
- Full CPI IRFs, Core CPI IRFs
- Core CPI HD

1. Matlab — `ZeroSignVAR`:
   - No long-run IRFs;
   - Bug with hist. dec. figures — some colors are erroneously identical.
2. R — `BVAR`:
   - No long-run IRFs;
   - Only contemporaneous restrictions;
   - No historical decomposition.
3. Eviews — `arw`:
   - No long-run IRFs;
   - Rigid restrictions.
4. R — `ZerosignR` — my implementation, which implements long-run IRF restrictions. *Under development*.

Return to Q&A

Annex

Zero restrictions on Q matrix

Data: Z = zero restrictions matrix, n = number of zero restrictions, Z_j = j-th shock zero restrictions, $1 \leq j \leq n$, z_j = number of zero restrictions for shock j such that $z_j \leq n - j$.

$R_j(A_0, A_+) = \begin{bmatrix} Z_j \times IRF(A_0, A_+) \\ Q'_{j-1} \end{bmatrix}$. $Q_j = [q_1, \ldots, q_j]'$, q_j = j-th column of Q, $Q_0 = q_0 \equiv \emptyset$.

for $j = 1 \ldots n$ **do**

  $N_{j-1} = \text{Null}(R_j)$;

  $x_j \sim \mathbb{N}_n(0, 1)$;

  $q_j = N_{j-1} \frac{N'_{j-1} x_j}{\|N'_{j-1}\|}$;

end

- Zero restrictions are held by construction.

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1. Prior

Return to Q&A

1. *Why didn't I estimate unconditional ERPT?*
   - Shock-dependent ERPT (PERR) is not studied well for Russia;
   - Unconditional ERPT requires discussion about specification of model and choice of data — a whole separate dissertation would have been written;
2. *Why didn't I split time series to periods before/after adoption of floating regime?*
   - 24 quarterly observations after Bank of Russia's decision to adopt floating regime — few for estimation of VAR, even using Bayesian approach.

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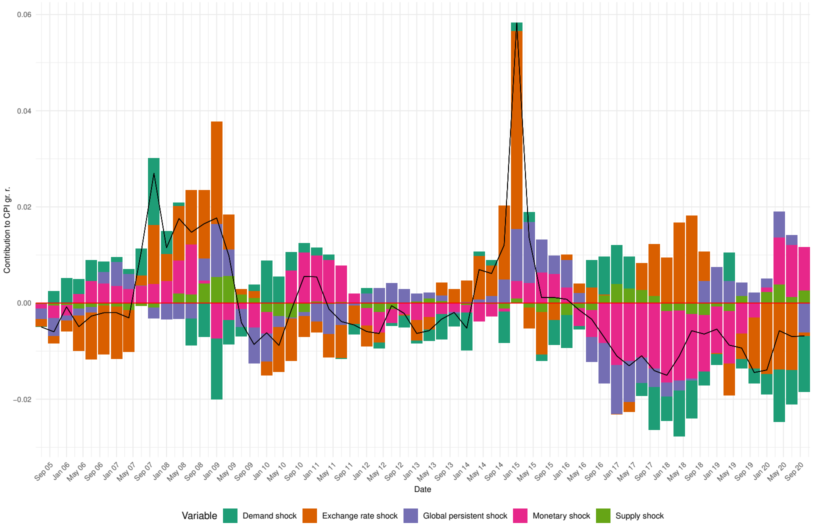

Figure: Hist. decomp. of demeaned NEER gr. r. time series, core CPI.

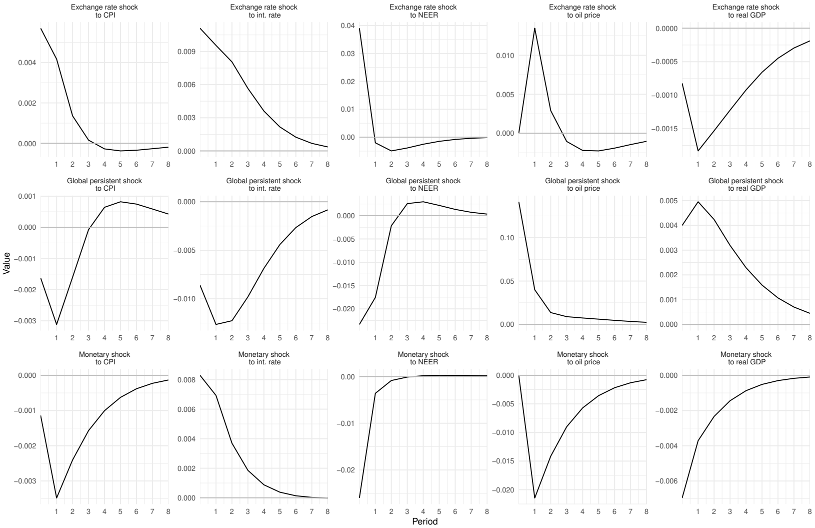

Figure: Impulse response functions of full model, CTM (1).

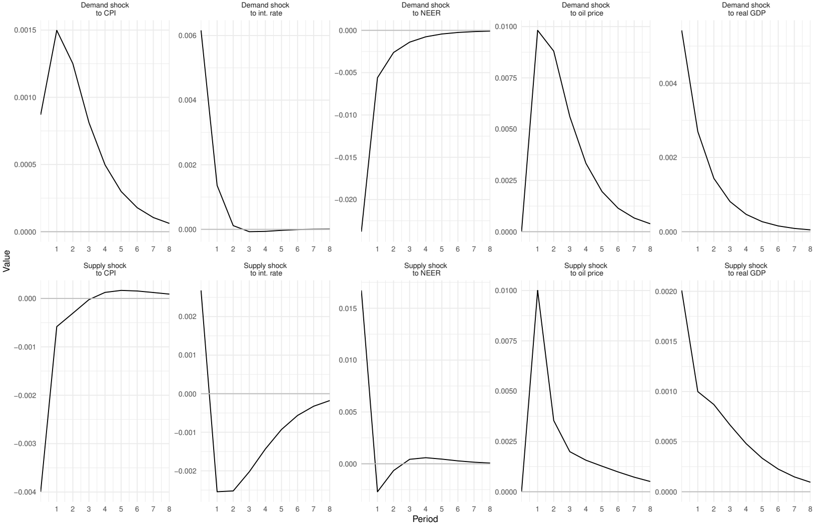

Figure: Impulse response functions of full model, CTM (2).

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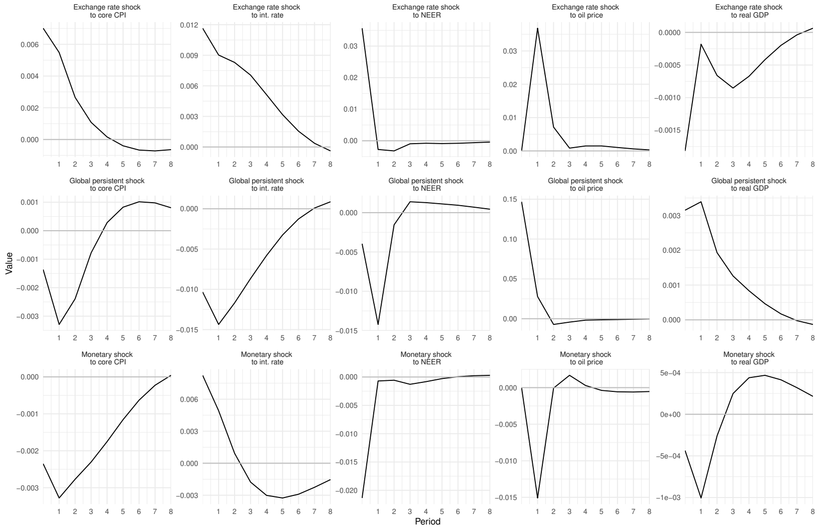

Figure: Impulse response functions of core model, CTM (1).

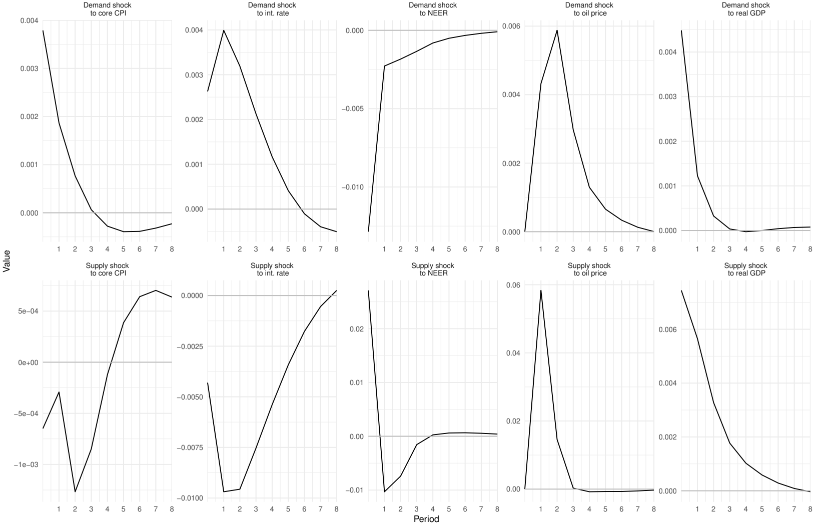

Figure: Impulse response functions of core model, CTM (2).

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