



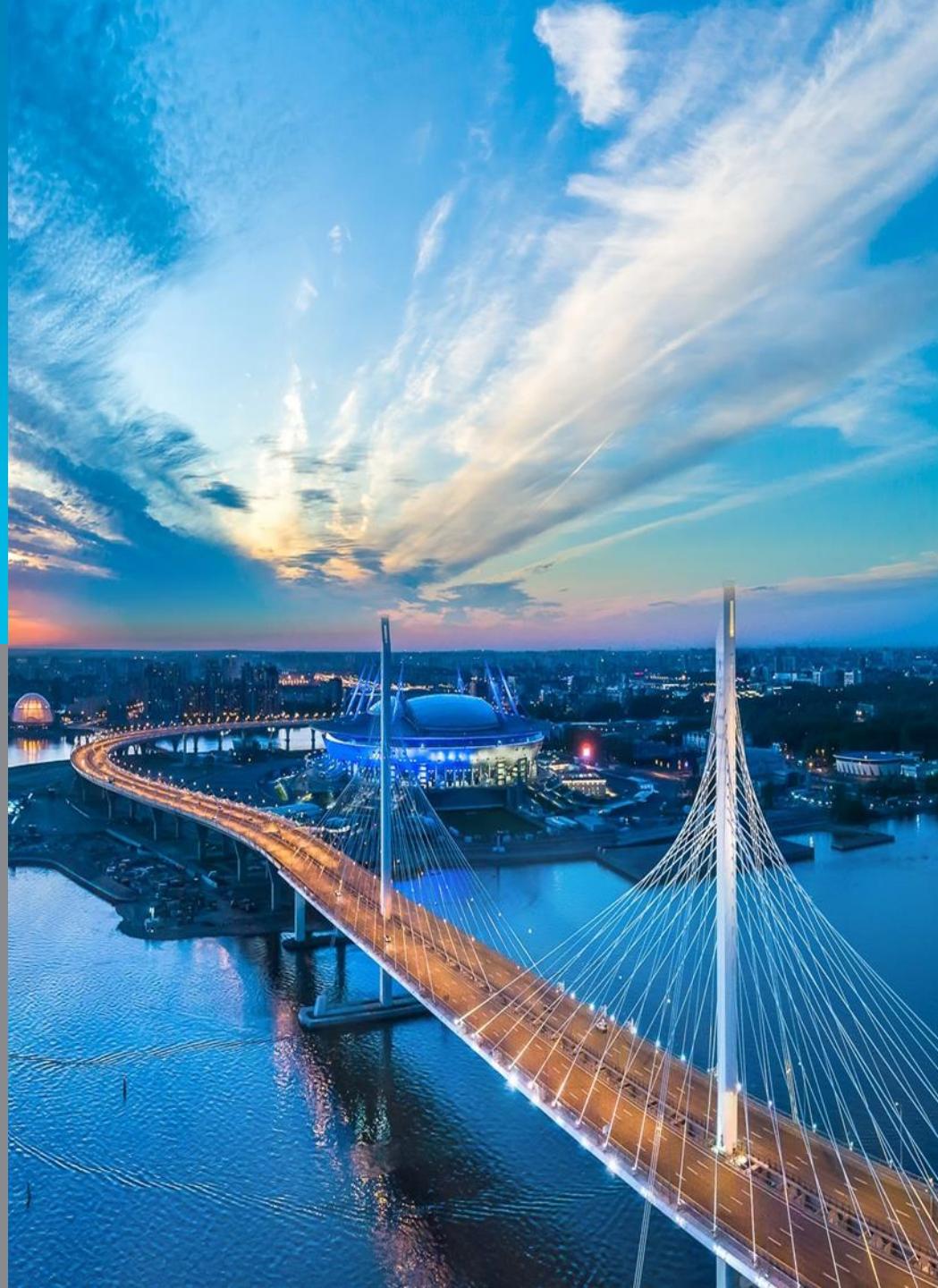
Банк России

## ОЦЕНКА ЭФФЕКТА ПЕРЕНОСА ВАЛЮТНОГО КУРСА НА ЦЕНЫ В УСЛОВИЯХ СТРУКТУРНЫХ СДВИГОВ

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## Общие замечания

- Последние годы наблюдается **высокая волатильность курса рубля**. Это повышает **актуальность** вопроса об **эффекте переноса**. Причем, повышенная волатильность делает более важными **нелинейные эффекты**.
- События **2022** года вызвали глубокие **структурные разрывы** в экономике РФ. Соответственно, эффект переноса так же мог претерпеть заметные изменения. Однако, длина рядов **после 2022** года не велика.
- **Курс является результирующим множеством** шоков (цена импорта, спрос на экспорт, цена нефти, движение капитала). **В зависимости от** того, какой из **шоков** вызвал изменение курса – **влияние на инфляцию будет различно**.
- Вопроса об **эффекте переносе курса**, это объединение в форме **усреднения** разных механизмов.



## BVAR: inverse Wishart conjugated Normal

$$\mathbf{y}_t = \left( \sum_{i=1}^p A_i \mathbf{y}_{t-i} \right) + \mathbf{A}_0 \mathbf{z}_t + \boldsymbol{\varepsilon}_t = B \mathbf{x}_t + \boldsymbol{\varepsilon}_t$$

$$V(\boldsymbol{\varepsilon}_t) = \Omega \sim IW(S, n)$$

$$B \sim N(EB, VB \otimes \Omega)$$

$$VB_1 = ((VB_0)^{-1} + XX')^{-1}$$

$$EB_1 = (EB_0 (VB_0)^{-1} + YX')^{-1} VB_1$$

$$S_1 = S_0 + (EB_1 - EB_0)(VB_0)^{-1}(EB_1 - EB_0)' + (Y - EB_1 X)(Y - EB_1 X)'$$

$$n_1 = n_0 + T$$

$$ML = \left( \prod_{i=1}^{n_y} \frac{\gamma(n_1/2 + (1-i)/2)}{\gamma(n_0/2 + (1-i)/2)} \right) \frac{|S_0|^{n_0/2} |VB_1|^{n_y/2}}{|S_1|^{n_1/2} |VB_0|^{n_y/2} \pi^{Tn_y/2}}$$

$$P(\theta | Y, U) = P((\theta | Y) | U)$$



## BVAR-break: inverse Wishart conjugated Normal

- iWcN – распределение прайора и постериора.
- Разбить выборку на до и после. Первые пару периодов после – переходный период (не учитывать).
- Использовать постериор до, для формирования прайора после.

$$n_{0,1} = n_1 \psi_{dn}$$
$$S_{0,1} = \frac{\text{diag}(\sqrt{\psi_{ds}}) S_1 \text{diag}(\sqrt{\psi_{ds}})(n_{0,1} - n_y - 1)}{n_1 - n_y - 1}$$

$$EB_{0,1} = EB_1$$
$$VB_{0,1} = VB_1 + \text{diag}(\text{diag}(VB_1)\psi_{dv})$$

$$\text{ML}(Y_0, Y_1) = \text{ML}(Y_0)\text{ML}(Y_1 | Y_0)$$



## BVAR-nonlinear

$$y_t = \left( \sum_{i=1}^p A_i f(y_{t-i}) \right) + A_0 z_t + \varepsilon_t = B f(x_t) + \varepsilon_t$$

squared regressors

$$f_i(x) = \begin{cases} x & i=1 \\ x^2 & i=2 \end{cases}$$

$$vb_{i,j,l} = \begin{cases} \frac{\psi}{\{\Omega\}_{j,j} l^{\psi_p}} & i=1 \\ \frac{\psi \psi_n}{\{\Omega\}_{j,j} l^{\psi_p}} & i=2 \end{cases}$$

Quantile(0.2,0.8)

$$f_i(x) = \begin{cases} 0 & x \in (x_i; x_{i+1}] \\ x & x \notin (x_i; x_{i+1}] \end{cases}$$

$$vb_{i,j,l} = \frac{\psi (x_{i+1} - x_i)^{\psi_n}}{\{\Omega\}_{j,j} l^{\psi_p}}$$

Quantile2(0.2,0.8)

$$f_i(x) = \begin{cases} x & i = i_{\max} \\ 0 & x \in (x_i; x_{i+1}] \\ x & x \notin (x_i; x_{i+1}] \end{cases}$$

$$vb_{i,j,l} = \begin{cases} \frac{\psi}{\{\Omega\}_{j,j} l^{\psi_p}} & i = i_{\max} \\ \frac{\psi (x_{i+1} - x_i)^{\psi_n}}{\{\Omega\}_{j,j} l^{\psi_p}} & i \neq i_{\max} \end{cases}$$



## Exchange rate pass-through (ERPT) measures

Nonlinear IRF:

$$IRF(v, i, s, t, \theta) = \begin{pmatrix} E(x_v | \varepsilon_i \sim N(s\sigma(\varepsilon_i)s, \sigma(\varepsilon_i)); \theta) \\ -E(x_v | \varepsilon_i \sim N(0, \sigma(\varepsilon_i)); \theta) \end{pmatrix} / s$$

Unexplosive:

$$\forall v, i : abs(IRF(v, i, s=1, t=48, \theta)) < 0.3 \max_t (abs(IRF(v, i, s=1, t, \theta)))$$

ERPT:

Exchange rate come back problem

$$ERPT(shock, T, \theta) = \frac{\sum_{t=1}^T IRF(p, shock, t, \theta) / 12}{\sum_{t=1}^T IRF(ex, shock, t, \theta)}$$

Maximum exchange rate pass-through:

$$MERPT(shock, T, \theta) = \frac{\sum_{t=1}^T IRF(p, shock, t, \theta) / 12}{\max_{1 \leq s \leq T} \left( \sum_{t=1}^s IRF(ex, shock, t, \theta) \right)}$$



## Данные и ограничения

- 2013m1 - 2023m11
- Annualized log-growth CPI, RUONIA, log-growth proxy-GDP (services, construction, industrial production and retail trade based), minus log-growth rate of BIS effective exchange rate (nominal)
- Seasonal adjusted by TRAMO-SEATS

	Supply (productivity, cost) shock	Monetary policy shock	Demand shock	Exchange rate shock
Inflation	+ (25%)	-	+	+
Interest rate	+	+ (25%)	NA	NA
Output growth	-	-	+ (25%)	+
Exchange rate	+	-	NA	+ (25%)

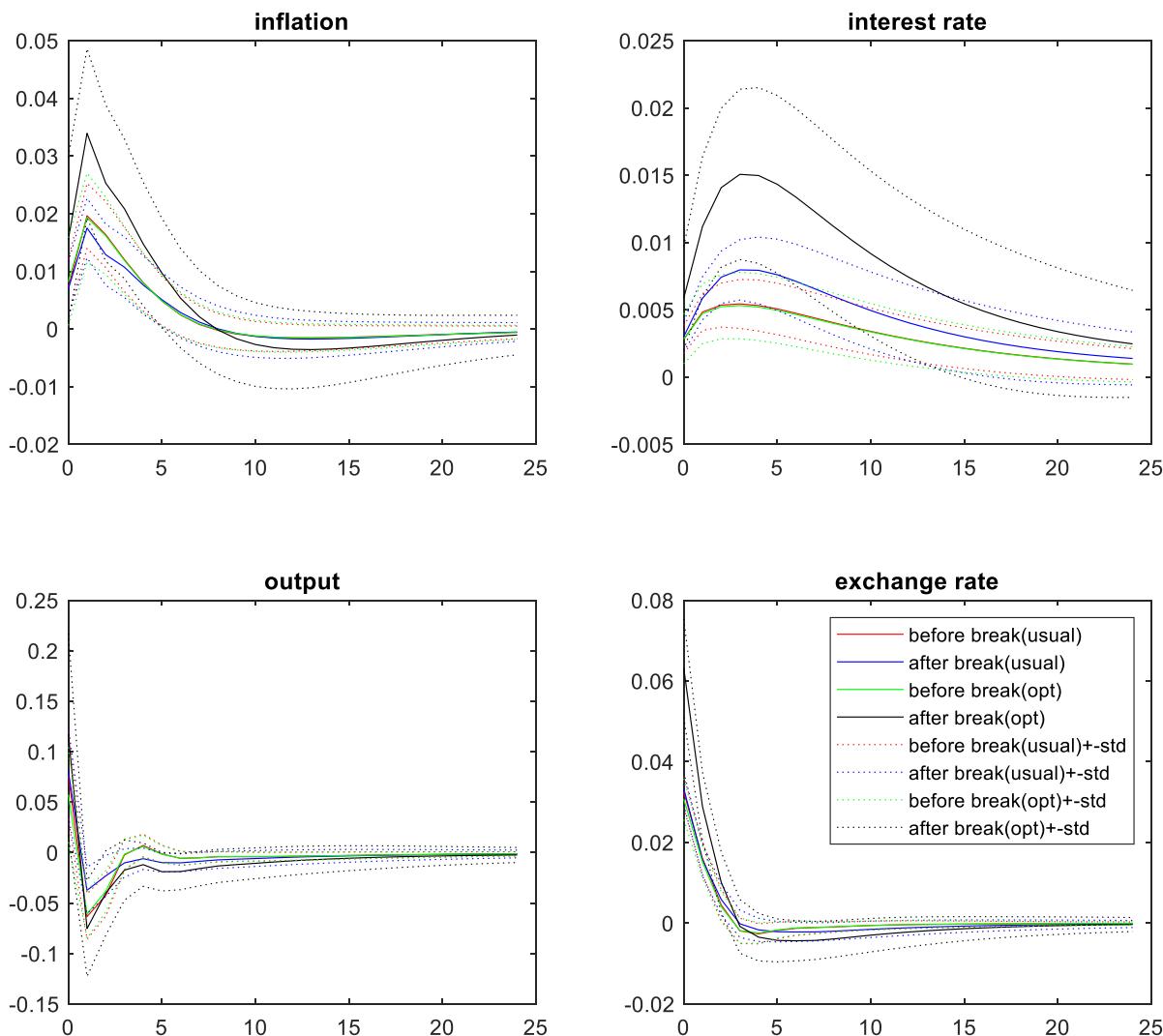


## Выбор модели

Lags number	Line	squared regressors	quantile	quantile2	Line, break 2014M10	squared regressors, break 2014M10	quantile, break 2014M10	quantile2, break 2014M10
1	871.0	872.4	<b>864.2</b>	871.2	<b>751.5</b>	<b>763.6</b>	<b>754.2</b>	<b>751.5</b>
2	<b>872.8</b>	<b>874.5</b>	862.9	<b>872.2</b>	749.3	759.4	747.8	745.5
3	867.8	868.1	857.2	864.4	742.7	750.3	741.8	736.6
4	865.3	864.3	854.1	860.5	738.1	743.3	735.8	729.0
5	861.5	859.7	854.6	857.8	733.8	737.6	737.1	725.9
6	858.6	855.4	851.6	854.8	730.2	732.4	733.7	722.3
7	856.7	852.0	848.9	853.2	727.8	728.2	729.5	719.3
8	855.9	851.5	846.6	852.0	726.1	726.4	731.4	718.4
9	853.8	848.8	842.5	850.6	723.8	723.1	727.4	716.3
10	851.8	846.7	841.9	849.0	721.6	720.2	725.8	714.3
11	850.3	844.7	841.3	847.8	720.0	718.3	723.7	712.7
12	849.1	842.8	840.9	846.6	718.9	716.2	723.4	711.9

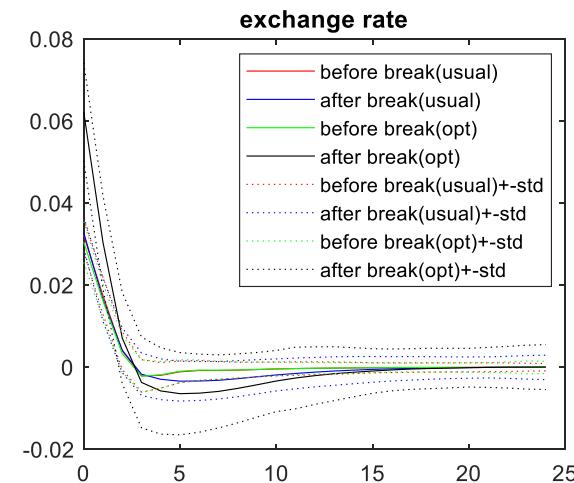
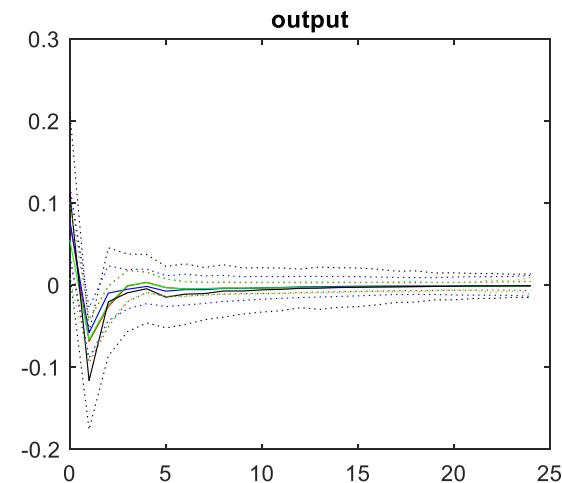
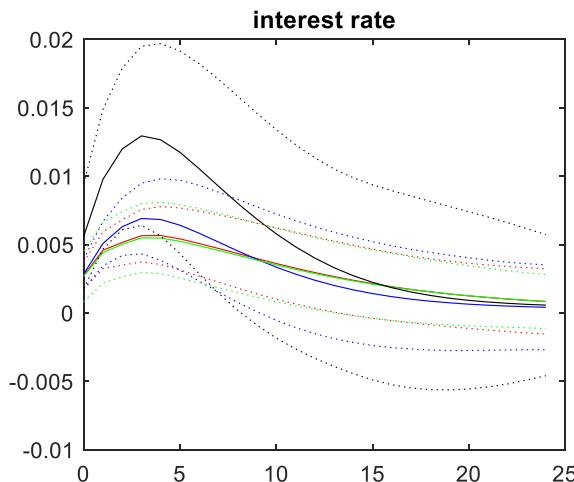
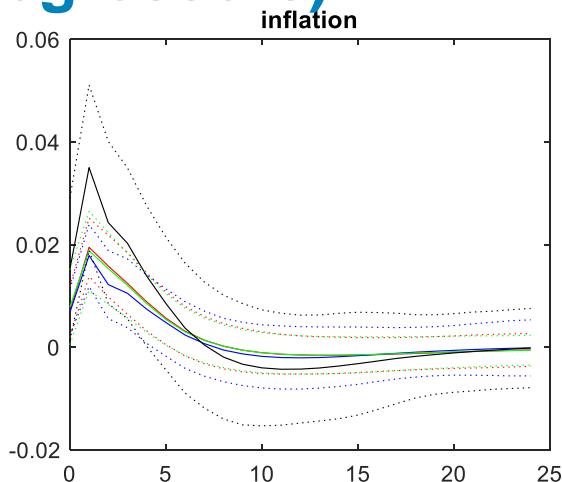
## IRF (line)

Initial draws: 4000  
Before sign restriction  
check keeps: 2141  
Final check:  
Usual before 2141  
Usual after 2141  
Opt before 1301  
Opt after 1281

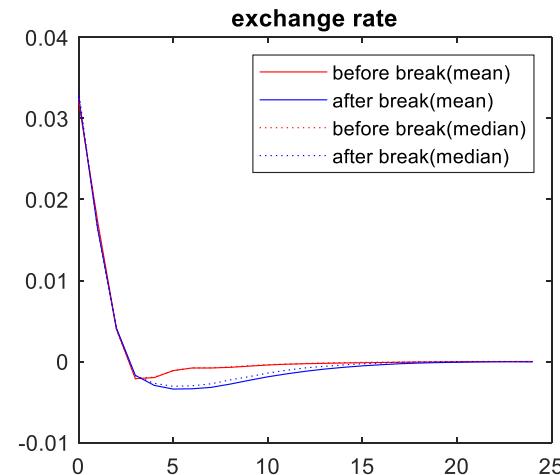
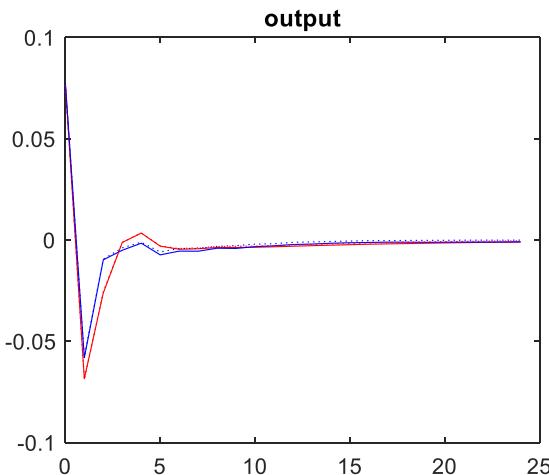
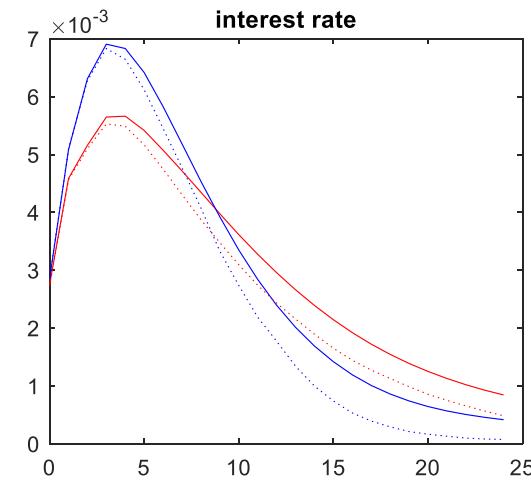
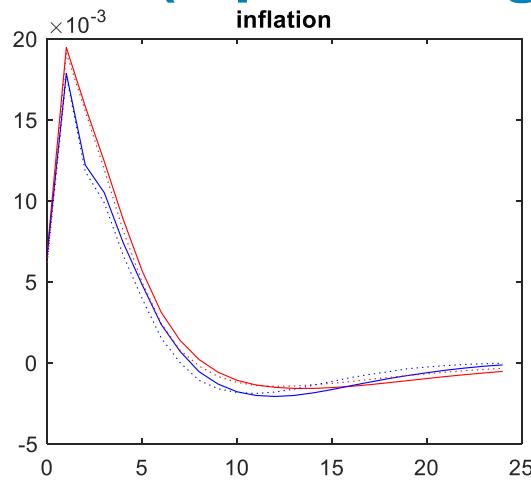


## IRF (squared regressors)

Initial draws: 4000  
Before sign restriction  
check keeps: 2830  
Final check:  
Usual before 2487  
Usual after 2269  
Opt before 1543  
Opt after 1371

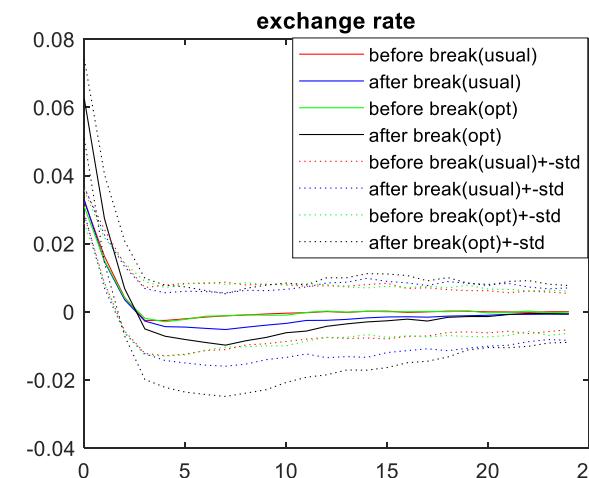
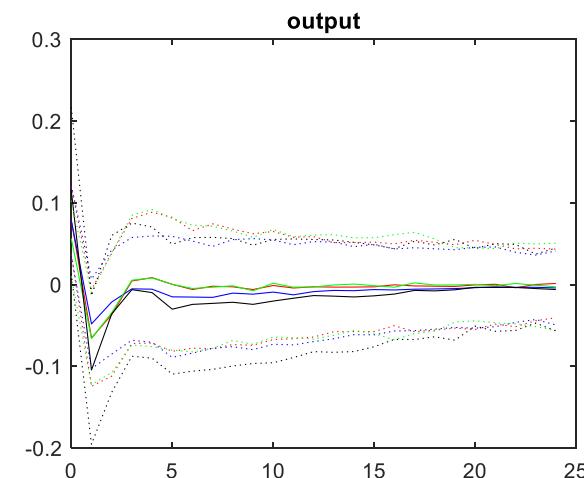
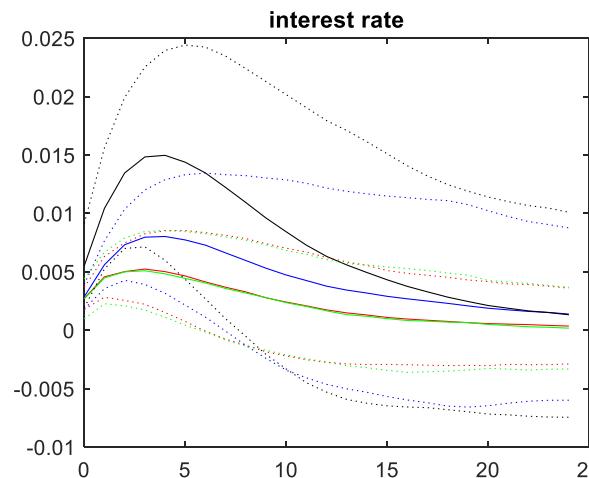
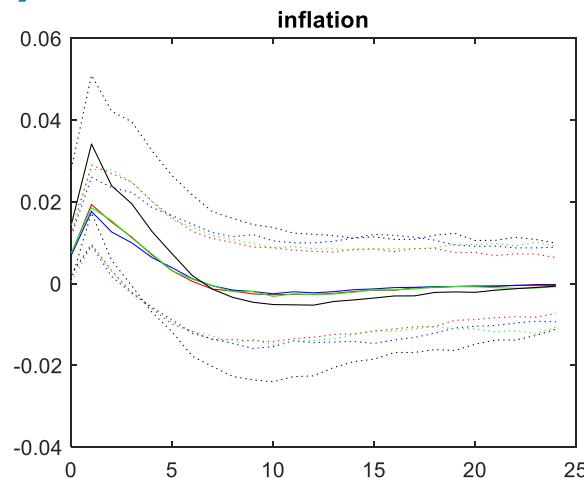


## IRF mean vs median(squared regressors, conventional)

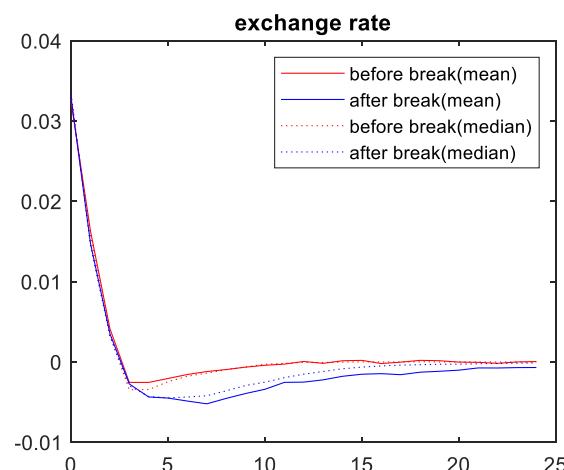
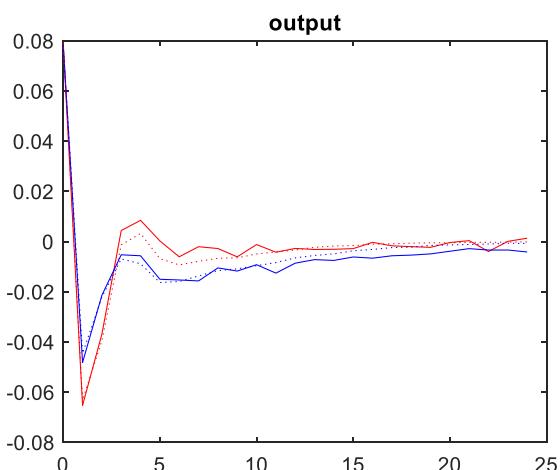
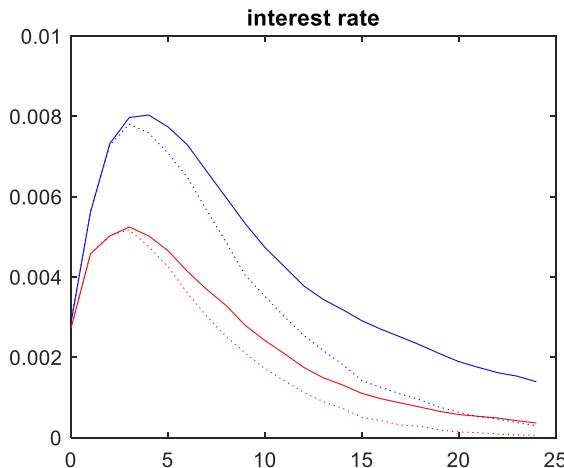
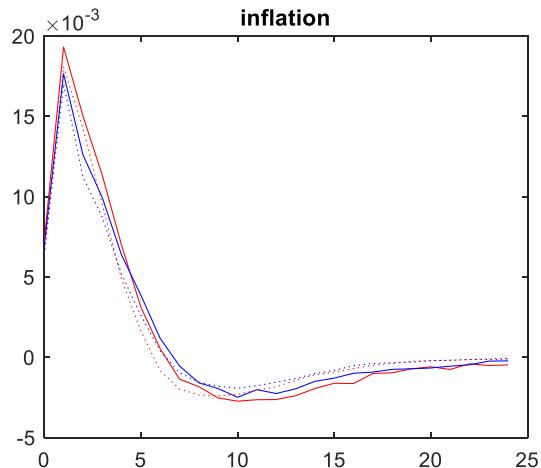


## IRF (quantile2)

Initial draws: 25000  
Before sign restriction check keeps: 1682  
Final check:  
Usual before 1489  
Usual after 1368  
Opt before 902  
Opt after 818



## IRF mean vs median(quantile2, conventional)





## Некоторые показатели ERPT (линейная модель)

	3	6	12	24	48
<b>mean MERPT, opt, before</b>	7.20%	11.09%	10.90%	8.54%	7.95%
<b>mean MERPT, opt, after</b>	6.02%	9.48%	9.21%	6.72%	6.32%
<b>mean ERPT, opt, before</b>	7.55%	14.23%	18.03%	15.35%	11.97%
<b>mean ERPT, opt, after</b>	6.42%	14.52%	5.42%	38.19%	48.91%
<b>median ERPT, opt, before</b>	6.62%	12.00%	13.25%	10.07%	8.73%
<b>median ERPT, opt, after</b>	5.61%	9.86%	10.43%	5.66%	4.29%
<b>ERPT based on mean IRF, opt, before</b>	7.27%	12.92%	14.47%	12.13%	11.31%
<b>ERPT based on mean IRF, opt, after</b>	6.09%	10.67%	13.80%	12.43%	12.41%
<b>ERPT based on median IRF, opt, before</b>	6.79%	12.49%	13.21%	10.41%	9.45%
<b>ERPT based on median IRF, opt, after</b>	5.70%	10.08%	11.88%	9.50%	8.59%
<b>mean MERPT, usual, before</b>	6.57%	10.24%	10.04%	7.89%	7.33%
<b>mean MERPT, usual, after</b>	5.40%	8.67%	8.56%	6.34%	5.98%
<b>mean ERPT, usual, before</b>	6.82%	12.48%	14.72%	12.66%	10.30%
<b>mean ERPT, usual, after</b>	5.76%	10.73%	9.93%	1.60%	-6.45%
<b>median ERPT, usual, before</b>	6.62%	11.94%	12.73%	10.23%	9.20%
<b>median ERPT, usual, after</b>	5.44%	9.54%	10.97%	6.60%	4.65%
<b>ERPT based on mean IRF, usual, before</b>	6.77%	12.14%	13.48%	11.24%	10.50%
<b>ERPT based on mean IRF, usual, after</b>	5.67%	9.94%	12.74%	11.53%	11.56%
<b>ERPT based on median IRF, usual, before</b>	6.59%	11.90%	12.57%	10.37%	9.42%
<b>ERPT based on median IRF, usual, after</b>	5.48%	9.64%	11.72%	9.75%	8.81%



## Некоторые показатели ERPT (squared regressors)

	3	6	12	24	48
<b>mean MERPT, opt, before</b>	6.65%	10.53%	10.49%	8.19%	7.71%
<b>mean MERPT, opt, after</b>	5.92%	9.11%	8.15%	6.15%	6.40%
<b>mean ERPT, opt, before</b>	7.21%	14.25%	20.17%	4.28%	41.03%
<b>mean ERPT, opt, after</b>	6.71%	11.42%	12.22%	3.33%	16.78%
<b>median ERPT, opt, before</b>	6.35%	11.68%	12.40%	9.13%	8.15%
<b>median ERPT, opt, after</b>	5.80%	9.88%	7.04%	3.61%	3.15%
<b>ERPT based on mean IRF, opt, before</b>	7.00%	12.60%	13.93%	11.47%	10.74%
<b>ERPT based on mean IRF, opt, after</b>	6.22%	11.65%	15.99%	13.98%	14.52%
<b>ERPT based on median IRF, opt, before</b>	6.56%	12.16%	12.61%	9.80%	8.75%
<b>ERPT based on median IRF, opt, after</b>	5.92%	11.02%	11.65%	8.45%	8.45%
<b>mean MERPT, usual, before</b>	6.14%	9.88%	9.83%	7.57%	7.19%
<b>mean MERPT, usual, after</b>	5.34%	8.49%	7.86%	5.82%	5.96%
<b>mean ERPT, usual, before</b>	6.61%	12.27%	14.63%	9.81%	45.39%
<b>mean ERPT, usual, after</b>	5.90%	13.90%	13.89%	-12.61%	0.61%
<b>median ERPT, usual, before</b>	6.32%	11.58%	12.44%	9.39%	8.67%
<b>median ERPT, usual, after</b>	5.51%	10.06%	8.66%	4.09%	3.43%
<b>ERPT based on mean IRF, usual, before</b>	6.57%	11.92%	13.21%	10.80%	10.30%
<b>ERPT based on mean IRF, usual, after</b>	5.75%	10.94%	15.67%	14.07%	14.70%
<b>ERPT based on median IRF, usual, before</b>	6.44%	11.88%	12.65%	9.77%	9.05%
<b>ERPT based on median IRF, usual, after</b>	5.63%	10.50%	13.71%	9.67%	9.39%



## Некоторые показатели ERPT (quantile2)

	3	6	12	24	48
<b>mean MERPT, opt, before</b>	5.58%	7.89%	6.06%	3.48%	2.98%
<b>mean MERPT, opt, after</b>	5.80%	8.64%	7.07%	4.86%	4.62%
<b>mean ERPT, opt, before</b>	3.96%	-160.93%	21.31%	4.45%	10.81%
<b>mean ERPT, opt, after</b>	6.86%	15.54%	16.80%	7.56%	21.08%
<b>median ERPT, opt, before</b>	6.51%	10.99%	7.98%	5.80%	5.23%
<b>median ERPT, opt, after</b>	5.86%	10.10%	3.73%	-0.01%	-0.32%
<b>ERPT based on mean IRF, opt, before</b>	6.91%	12.22%	12.00%	8.10%	7.53%
<b>ERPT based on mean IRF, opt, after</b>	6.25%	12.22%	26.38%	96.00%	-380.77%
<b>ERPT based on median IRF, opt, before</b>	6.66%	11.88%	9.76%	6.38%	5.40%
<b>ERPT based on median IRF, opt, after</b>	5.76%	11.50%	17.13%	12.85%	12.01%
<b>mean MERPT, usual, before</b>	5.23%	7.47%	5.54%	3.43%	3.10%
<b>mean MERPT, usual, after</b>	5.27%	7.93%	6.63%	5.11%	4.67%
<b>mean ERPT, usual, before</b>	6.71%	17.56%	13.96%	4.39%	31.63%
<b>mean ERPT, usual, after</b>	2.44%	3.50%	-9.19%	-6.19%	-12.20%
<b>median ERPT, usual, before</b>	6.37%	10.64%	8.10%	5.52%	5.36%
<b>median ERPT, usual, after</b>	5.77%	9.95%	3.68%	-0.42%	-1.47%
<b>ERPT based on mean IRF, usual, before</b>	6.56%	11.49%	10.72%	7.56%	6.96%
<b>ERPT based on mean IRF, usual, after</b>	6.05%	12.07%	27.43%	-209.28%	-29.96%
<b>ERPT based on median IRF, usual, before</b>	6.43%	11.38%	9.31%	5.90%	5.50%
<b>ERPT based on median IRF, usual, after</b>	5.78%	11.46%	18.50%	21.90%	23.21%



## Некоторые показатели ERPT

	Magnitude	-5 std shock			5 std shock		
		3	12	48	3	12	48
squared regressors	Period						
	mean MERPT, opt, before	6.21%	10.40%	7.10%	6.84%	10.24%	7.75%
	mean MERPT, opt, after	4.70%	8.29%	5.83%	6.14%	7.60%	6.54%
	MERPT based on mean IRF, opt, before	6.66%	11.84%	8.29%	7.12%	11.16%	8.57%
	MERPT based on mean IRF, opt, after	5.20%	9.85%	7.28%	6.47%	8.39%	7.32%
	mean MERPT, usual, before	5.78%	9.91%	6.62%	6.35%	9.58%	7.10%
	mean MERPT, usual, after	4.90%	8.17%	5.70%	5.55%	7.76%	6.38%
	MERPT based on mean IRF, usual, before	6.29%	11.39%	7.82%	6.71%	10.58%	7.94%
	MERPT based on mean IRF, usual, after	5.37%	9.47%	7.13%	5.93%	8.72%	7.33%
	mean MERPT, opt, before	6.58%	8.23%	5.56%	5.39%	4.36%	1.56%
quantile2	mean MERPT, opt, after	6.20%	8.63%	6.51%	5.26%	4.24%	1.06%
	MERPT based on mean IRF, opt, before	7.28%	9.75%	7.01%	5.84%	5.50%	2.53%
	MERPT based on mean IRF, opt, after	6.36%	9.30%	7.06%	5.34%	4.79%	1.24%
	mean MERPT, usual, before	6.35%	8.13%	5.71%	5.08%	4.63%	1.93%
	mean MERPT, usual, after	5.74%	7.80%	5.57%	5.11%	4.93%	2.23%
	MERPT based on mean IRF, usual, before	7.07%	9.66%	7.14%	5.64%	5.84%	2.92%
	MERPT based on mean IRF, usual, after	6.14%	8.66%	6.04%	5.45%	5.68%	2.58%



## Заключение

- Предложен **метод** расчетов для **BVAR** моделей **со структурными разрывами**, а так же обобщение для **нелинейных** зависимостей.
- Продемонстрировано, что **теоретические проблемы** связанные с распространенной мерой **ERPT реализуются** в российских данных. Эффект возврата курса (паритет покупательной способности) даже при малой вероятности, делает такую меру нестабильной. Предложена **альтернативная мера**, не обладающая такими недостатками.
- **Эффект переноса** на инфляцию после структурного разрыва **снизился 1%-2%** по почти всем рассмотренным мерам эффекта переноса.
- Показатели **эффекта переноса**, для шока обменного курса, **близки для линейных и нелинейных** моделей.
- **Асимметрия и нелинейные** эффекты шоков обменного курса, при учете **косвенного** воздействия оказываются **существенно меньше**, чем в рамках предшествующих работ.



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## Robustness check: pure approach

Lags number	Line	squared regressors	quantile	quantile2	Line, presample 36	squared regressors, presample 36	quantile, presample 36	quantile2, presample 36
1	736.6	691.2	577.7	573.4	881.4	884.7	877.2	879.9
2	659.8	565.1	359.6	352.1	882.9	885.7	873.7	880.3
3	564.7	423.1	156.4	147.0	874.8	875.5	866.7	869.7
4	477.5	287.1	0.3	-21.6	871.0	869.4	862.5	864.5
5	389.6	161.5	-102.5	-136.7	865.1	862.8	862.3	860.8
6	304.2	41.2	-161.2	-204.0	860.9	856.4	857.6	856.6
7	221.1	-51.9	-210.8	-249.5	857.4	850.6	853.6	853.6
8	141.2	-129.3	-202.5	-202.1	855.3	848.7	850.9	851.5
9	66.9	-178.7	-163.4	-80.9	851.9	844.3	845.0	848.7
10	2.5	-216.0	-28.3	-27.5	849.0	841.0	844.7	846.6
11	-56.6	-245.0	47.5	5.6	846.4	837.8	843.8	845.0
12	-85.9	-255.5	92.3	23.1	844.8	835.1	842.4	843.4



## Robustness check: pure approach

		3	6	12	24	48
line, presample 0	mean MERPT, opt, before	6.66%	10.49%	9.91%	7.21%	6.47%
	mean MERPT, opt, after	5.37%	8.98%	8.95%	5.69%	4.79%
	mean MERPT, usual, before	6.21%	9.91%	9.32%	6.58%	5.83%
	mean MERPT, usual, after	4.86%	8.23%	8.13%	4.88%	4.06%
	mean MERPT, opt, before	5.99%	10.65%	11.49%	8.05%	7.02%
	mean MERPT, opt, after	5.39%	8.58%	7.85%	6.07%	6.16%
	mean MERPT, usual, before	5.53%	9.95%	10.80%	7.70%	6.95%
	mean MERPT, usual, after	4.72%	7.76%	7.19%	5.37%	5.41%
line, presample 36	mean MERPT, opt, before	6.23%	10.24%	11.25%	8.88%	7.69%
	mean MERPT, opt, after	5.57%	9.39%	9.94%	7.53%	6.99%
	mean MERPT, usual, before	5.86%	9.85%	10.90%	8.60%	7.40%
	mean MERPT, usual, after	5.16%	8.97%	9.58%	7.29%	6.80%
squared regressors, presample 36	mean MERPT, opt, before	6.73%	8.84%	9.25%	8.34%	8.45%
	mean MERPT, opt, after	5.88%	7.16%	5.74%	5.72%	5.75%
	mean MERPT, usual, before	6.06%	8.11%	8.08%	7.17%	7.28%
	mean MERPT, usual, after	5.55%	7.37%	6.35%	6.87%	7.34%



## Robustness check: period

Lags number	Line, period -24	squared regressors, period -24	quantile, period -24	quantile2, period -24	Line, period -36	squared regressors, period -36	quantile, period -36	quantile2, period -36
1	732.0	733.8	<b>721.8</b>	<b>735.9</b>	621.1	623.1	609.4	623.3
2	<b>735.9</b>	<b>735.5</b>	720.7	734.3	<b>624.0</b>	<b>623.6</b>	615.6	<b>625.7</b>
3	733.2	731.6	718.7	730.1	620.9	619.3	<b>617.5</b>	623.3
4	732.0	729.4	716.4	728.5	619.6	617.1	615.0	622.7
5	727.7	724.2	719.0	724.7	615.8	612.3	609.6	616.6
6	725.5	720.5	717.3	723.9	614.1	609.3	608.9	615.0
7	725.3	718.8	716.8	725.3	614.6	608.3	610.3	616.1
8	724.9	718.8	715.6	723.5	614.5	608.3	608.5	615.6
9	723.7	717.0	712.7	720.2	613.6	606.9	606.4	614.4
10	722.0	715.2	710.6	717.6	612.1	605.1	605.6	611.4
11	720.3	712.9	710.8	716.2	610.7	603.2	603.3	609.4
12	719.2	711.3	711.8	716.1	609.7	601.6	600.3	607.8



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