Monetary Policy Surprises in Russia*

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January, 2019

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Abstract

The current paper studies the monetary policy transmission in the Russian economy. The key question of this work is how monetary policy affects the macroeconomy through currency exchange rates. I construct a series of monetary policy surprises for the Russian economy using the high-frequency identification approach. Many papers use futures on the interest rates as monetary policy instruments; however, we do not have these futures in the Russian financial market. Therefore, I use different currency futures as monetary surprises because these futures are liquid, and they can reveal the market sentiment. I take the dates when the Board of Directors of the Central Bank of Russia made a decision on the key rate and looked at the changes in the currency exchange market in a tiny 30-minute window. Next, I construct a structural vector autoregression model to show the effect of these surprises on macroeconomic variables. In the identification process, I use an external instrument approach a-la Gertler and Karadi. Finally, I compare the results with other methods (Cholesky decomposition). I find that the tightening monetary policy significantly increases bonds rate; moreover, the effect on the inflation is not immediate, but it appears after a couple of months.

Keywords: Monetary Policy Transmission, External Instrument, High-Frequency Identification, Structural VAR, Currency Futures

JEL Codes: E31, E32, E43, E44, E52, E58

*I would like to thank Konstantin Styrin for helpful comments and suggestions. All errors are mine.

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‡Replication files you can find at https://github.com/avtishin/Monetary_policy_surprises

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Introduction

Since the 90s, the role of the interest rate has increased. Today many countries are using inflation targeting policy. To achieve the aims of monetary policy in the country, the Central Bank or the policymaker should understand the consequences of its actions.

Many countries have already used inflation targeting for a long time, for example, New Zealand adopted it in 1990 and a year after it was done by Canada. A good overview of the history of inflation targeting and the current principles of monetary policy is given in the recent book by Adrian et al. (2018). Inflation targeting policy means that the Central Bank is actively using its interest rate to keep inflation around the targeting level. For example, when the current (or expected) inflation is above the targeting level, the Central Bank wants to raise its interest rate and in this situation, the Central Bank would like to evaluate the effects of this monetary policy, i. e. to understand the future path of other economic indicators.

The Central Bank of Russia[1] have switched to floating exchange rate in the late 2014 and decided to keep inflation at 4% in the medium term. The role of the key rate increased significantly. This paper is written to evaluate the effects of the key rate changes by the Bank of Russia. In other words, to show the transmission mechanism in the Russian economy.

The motivation for this paper is the following. Firstly, the responses of financial and macroeconomic variables are of interest to the Central Bank since it allows for a more accurate understanding of the impact of monetary policy. Secondly, the major difference from other papers is that I will use the currency exchange rate as an indicator of monetary policy surprises. So, the transmission channel through currency can be an alternative way to identify the surprises and their effects on the macroeconomy. Finally, there is no similar research on Russian data.

The contribution of this paper is the following. Firstly, I construct a new series of monetary policy surprises for Russia. Secondly, I construct proxy SVAR a-la Gertler and Karadi (2015) and expand it to a small open economy.

The research question is how monetary policy decisions affect the future path of macroeconomic variables.

[1] On parameters of Bank of Russia exchange rate policy
https://www.cbr.ru/eng/press/PR/?file=10112014_122958eng_dkp2014-11-10T12_26_04.htm

In the process of writing this paper, I find different challenges. The Russian financial market does not have a very long history. On this very short time horizon, a lot of events happened: from the crisis of 2008 to changing monetary policy in 2014. Moreover, investors in the markets have their own beliefs about the credibility of the monetary policy of the Bank of Russia. They also have beliefs about the future path of monetary policy. Although nowadays, the Central Bank is trying to pursue a consistent monetary policy, however in the early 2000s investors could less believe in the consistency of monetary policy by the Central Bank, which could contribute to the monetary surprises.

For a long time, a classic way to identify monetary surprises was the difference between the realised key rate announced by the Central Bank and the consensus forecast of the experts. However, this approach does not take into account a lot of information which is available in the high-frequency financial markets.

In this paper, I study the monetary policy transmission using the high-frequency identification strategy. In section 2 I present the high-frequency identification approach, which is based on the idea of identification monetary policy shocks using the intra-day data.

In section 3 I present the econometrics framework. It is based on the estimation of structural VARs in which I isolate the structural innovation of the variable of interest using the instrumental variables approach. As instruments, I take monetary policy surprises which I identify using HFI.

Firstly, I replicate the baseline model from Gertler and Karadi (2015) paper. As instruments, I use the so-called GSS set of instruments (introduced by Gürkaynak et al. (2005)), and I use daily surprises. Moreover, I test new instruments based on S&P 500 and different currency futures. I find that the impulse responses of 1-year government bond yield and excess bond premium are moving in the supposed direction: when the FOMC raises its interest rate then 1-year bond yield and excess bond premium grow, but CPI shows puzzles. Moreover, daily monetary surprises have much larger confidence intervals and noticeably smaller relevance of instruments. A more detailed discussion can be found in section 4.

Secondly, the more important part of this paper is dedicated to evaluating the monetary policy of the Central Bank of Russia. For Russia, I estimate a baseline model (closed economy model) and a small open economy model. As external instruments, I use currencies spot, futures and forwards exchange rates with different maturity dates. These results are different from the ones in the USA.

I find that the 1-year government bond rate shows the same dynamic. However, it is not the case for CPI and excess bond premium. These variables show counter-intuitive dynamics. When the Bank of Russia raises the key rate, CPI is growing and only a few months later begins to decline. EBP falls immediately. These results are described in detail in section 5.

1 Literature review

The number of papers has already used the high-identification strategy in the process of evaluating monetary policy surprises. This approach is firstly used in the paper by Kuttner (2001), where the authors used the current-month (spot) federal funds futures contract (FF1) to measure the monetary policy surprises around the FOMC meeting day. They find that for anticipated federal funds rate changes there is a very small response, while for unanticipated the response is high and statistically significant.

Another famous paper by Romer and Romer (2004) used a narrative approach to monetary policy surprises together with "Greenbook" forecasts to construct surprises which are independent of the future information. They show the significant responses of inflation and unemployment.

One more interesting paper is written by Gürkaynak et al. (2005), the key difference from previous is that they use a set of instruments in the process of shock identification. They use the current month's Federal funds futures (FF1), the three month ahead Federal funds futures (FF4), and the six months, nine months and a year ahead futures on three month Eurodollar deposits (ED2, ED3, ED4) on the days of FOMC decision announcement. They find that monetary policy statements and monetary policy actions have a different effect on the financial market. Many authors continue to develop this approach, for example, Swanson (2017) study effect of forward guidance and large-scale asset purchases during 2009-2015. Moreover, economists do not study monetary policy surprises only for the USA or Europe. For example, Pescatori (2018) examine monetary policy communications by the Central Bank of Chile. They also find that forward guidance is an effective tool in monetary policy and tightening monetary policy leads to a decline in the economy, which coincides with other papers.

The most famous (and recent) paper about HFI is written by Gertler and Karadi (2015). In their paper authors use three month ahead Federal funds rate futures. These futures include market expectations about the future path of the target rate. They show consistent responses in output and inflation for SVAR models. Moreover, they show that forward guidance is an important tool in modern monetary policy. The similar work was done for the UK by Cesa-Bianchi et al. (2016). They adopt this framework to a small open economy model. They construct monetary policy surprises for the UK. They find that a rise of the interest rate leads to reductions in economic activity and an appreciation of the nominal exchange rate.

Many people try to work with economic forecasts and market expectations. Nakamura and Steinsson (2018) build a model in which the FED could affect markets beliefs not only about the future path of monetary policy but also about other macroeconomic variables. The forward guidance becomes a very important tool of monetary policy. Justiniano et al. (2012) show that forward guidance helps the FED to commit to keeping interest rates at zero levels for a longer time. Moreover, Cieslak and Schrimpf (2018) show that non-monetary news also plays a very important role in the Central Banks communications. They show that financial markets react to this non-monetary news from the Central Banks.

Finally, measuring monetary policy shocks is developing now. Zhang (2018) finds that the previous measure of monetary policy surprises has a positive correlation with the Blue Chip forecast of inflation and negative correlation with Blue Chip unemployment forecasts. This correlation is counter-intuitive because when the FOMC raises the Federal funds' rates they are signalling to the market that the inflation is above the stationary level and the unemployment is below. She proposes a new measure of monetary policy surprises, which has the correct correlation with these indicators.

2 High-frequency identification

This paper is based on two important issues: high-frequency identification and structural vector autoregression. In this section, I discuss the process of HFI, and in the next section, I discuss the SVAR framework.

I construct monetary policy surprises using the intra-day and daily data. The high-frequency approach is a kind of identification when I look at the changes in small intervals similar to Gertler and Karadi (2015). I define monetary policy surprises as:

$$s_m = \frac{p_{m+20} - p_{m-10}}{p_{m-10}}, \quad (1)$$

$$s_d = \frac{p_d - p_{d-1}}{p_{d-1}}, \quad (2)$$

where $s_{m/d}$ is a measured surprise, the subscript d refers to the daily data, m refers to the intra-day data, $p_{m/d}$ is a price for the asset in the day d or in the minute m. So, in other words, using the intra-day data, I identify the monetary policy surprise as the asset return in a 30-minute window: 10 minutes before the monetary policy event and 20 minutes after this event. Some authors, for example, Ferrari et al. (2016), average prices in this interval, but I will not do it. Using the daily data I identify surprises as the daily asset return at the end of the event's day to the previous day.

These monetary policy surprises should show the unanticipated changes in the markets as described in Cesa-Bianchi et al. (2016), namely:

$$s_t = \epsilon_t^{mp} + \nu_t, \quad (3)$$

$$\mathbb{E}[\nu_t | \epsilon_t^{mp}] = 0, \quad (4)$$

where ϵ_t^{mp} is the true monetary policy surprise and ν_t is a noise.

These equations mean that when I construct a monetary policy surprise I measure a surprise with some random error, which is independent from the true monetary policy shock. Therefore, there are two very important assumptions (Cesa-Bianchi et al. (2016)) in this the process of identification:

1. $\mathbb{E}[\nu_t | x] = 0$ – the background noise is independent of a state of macroeconomy (x) for any t.

2. $\text{Var}[\nu_y] \simeq 0$ – the probability of this shock is very small (MIT shock).

Unfortunately, this paper does not include any formal test of these assumptions (for example, a test of overidentifying restrictions). However, there is an economic intuition to use these assumptions. Starting with the first one, the intuition is that high-frequency identification helps to isolate the monetary policy shock from all others, i. e. in the tiny 30-minute window, the only news on the markets is about the monetary policy decision. This logic works less on the daily data because in the business day a lot of news comes to the markets. Nevertheless, if we look at the relevance of different financial news, monetary policy news will always be very important. For example, in Thomson Reuters Eikon, news about monetary policy decisions is marked as highly important news. Therefore, I can assume that if I measure a daily surprise, I still measure monetary policy surprise but, probably, with higher noise level compared to the intra-day data.

Let us turn to the second assumption. It is about the likelihood of shock. I assume that when I measure the monetary policy shock, the probability of other shocks is very small. The choice of small windows is also very helpful in this situation. When I look at the even in a 30-minute window, it is less possible that another event will occur. It is less true for daily data, but it is still possible to use this assumption.

3 Econometrics framework review

In this section, I describe the econometric framework, which I use to show the transmission mechanism. In this section, I will follow the Cesa-Bianchi et al. (2016) and Kilian (2011). I estimate the Structural Vector Autoregression model using external instruments to isolate monetary policy innovations. This approach is quite common in modern economic literature.

So, this identification strategy implies that I obtain the estimated residuals from the reduced form VAR, then I use the IV approach to estimate the matrix of coefficients of structural form innovations and, finally, compute impulse response functions. For longer horizons, I can iterate $\mathcal{IRF}$s. The more detailed process is described below.

Let's consider the following structural VAR model (it is possible to add a constant, trend, exogenous variables, more lags.):

$$AY_t = BY_{t-1} + C\epsilon_t, \tag{5}$$

$$A^{-1}AY_t = A^{-1}BY_{t-1} + A^{-1}C\epsilon_t, \tag{6}$$

$$Y_t = DY_{t-1} + F\epsilon_t, \tag{7}$$

$$Y_t = DY_{t-1} + u_t, \tag{8}$$

where Y_t is $(m \times 1)$ the vector of endogenous variables, D is $(m \times m)$ the matrix of reduced form coefficients, u_t is $(m \times 1)$ the reduced form error term. The aim is to find the matrix F, note that the matrix A can be a unit. Moreover, we know that $\Sigma_\epsilon = I$, $\Sigma_u \neq I$. Note that, the equation 7 (or 8) is called the reduced form VAR.

Further, let's divide the Y_t variables into the variable of interest, for example, p_t and the rest variables X_t:

$$Y_t = \begin{bmatrix} p_t \\ X_t \end{bmatrix} = \begin{bmatrix} d_{11} & D_{12} \\ D_{21} & D_{22} \end{bmatrix} \begin{pmatrix} p_{t-1} \\ X_{t-1} \end{pmatrix} + \begin{bmatrix} f_{11} & F_{12} \\ F_{21} & F_{22} \end{bmatrix} \begin{pmatrix} \epsilon_t^p \\ \epsilon_t^X \end{pmatrix}, \tag{9}$$

where d_{11} and f_{11} are scalars, D_{12} and F_{12} are $(1 \times m-1)$ vectors, D_{21} and F_{21} are $(m-1 \times 1)$ vectors, D_{22} and F_{22} are $(m-1 \times m-1)$ vectors, ϵ_t^p is the structural innovation which associated to the variable of interest and ϵ_t^X are the structural innovations of other variables.

Now we can easily find the impulse response functions, as derivative with respect to the vector ϵ_t^p and then iterate to find $\mathcal{IRF}$ for n-step.

$$\begin{bmatrix} \mathcal{IRF}_0^p \\ \mathcal{IRF}_0^X \end{bmatrix} = \begin{bmatrix} f_{11} \\ F_{21} \end{bmatrix} \Rightarrow \tag{10}$$

$$\begin{bmatrix} \mathcal{IRF}_0^p \\ \mathcal{IRF}_0^X \end{bmatrix} = \begin{bmatrix} 1 \\ \frac{F_{21}}{f_{11}} \end{bmatrix} \Rightarrow \tag{11}$$

$$\begin{bmatrix} \mathcal{IRF}_n^p \\ \mathcal{IRF}_n^X \end{bmatrix} = D^{n-1} \begin{bmatrix} \mathcal{IRF}_{n-1}^p \\ \mathcal{IRF}_{n-1}^X \end{bmatrix}, \text{ for } n = 2, \ldots, N. \tag{12}$$

The interesting fact is that to find the $\mathcal{IRF}$s for one variable ϵ_t^p, I do not need to estimate all coefficients in F, but I need only the first column.

To find $\mathcal{IRF}$s I need to obtain f_{11}, F_{21} and D. It should be divided into the estimation of the matrix D and the estimation of f_{11}, F_{21}. To estimate D I just estimate reduced form VAR and find the matrix of estimated coefficients $\hat{D}$. However, there is a more sophisticated way to estimate f_{11}, F_{21}. I use the external instruments approach here.

Let's assume that I have an instrument Z_t $(z \times 1)$, $z \leq m$. The instrument's number of observations z could be less than the number of observations m, even in this case, we can find f_{11}, F_{21}.

A good instrument should satisfy two conditions. Firstly, It should be correlated with the variable which I instrument (ϵ_t^p). Secondly, It should be uncorrelated with all other shocks (ϵ_t^X).

$$\mathbb{E}[\epsilon_t^p Z_t] \neq 0 \tag{13}$$

$$\mathbb{E}[\epsilon_t^X Z_t] = 0. \tag{14}$$

However, I do not observe the structural ϵ_t, I can only estimate $\hat{u}_t$. Nevertheless, I know that $D\epsilon_t = u_t$, therefore, u_t is a kind of measure of true ϵ_t, then I can use 2SLS of u_t^X on u_t^p using instruments Z_t:

$$u_t^p = \beta Z_t + \mu_t, \tag{15}$$

to obtain the estimated values $\hat{u}_t^p$, then regress u_t^x on $\hat{u}_t^p$ to find the $\hat{\frac{F_{21}}{f_{11}}}$:

$$u_t^X = \frac{F_{21}}{f_{11}} \hat{u}_t^p + \eta_t. \tag{16}$$

Finally, when I estimate $\hat{\frac{F_{21}}{f_{11}}}$ and $\hat{D}$, I can easily obtain $\mathcal{IRF}$s as shown in the equations 11 and 12.

4 Monetary policy surprises in the USA

In this section, I discuss the replication work of the famous paper by Gertler and Karadi (2015). The main purpose of this section is to show that the instruments used by GK, namely, Federal funds futures (FF1, FF4), Eurodollar deposit futures (ED2, ED3, ED4), is working not only when we measure the intra-day surprises but also when we measure the daily surprises. The second purpose is to offer new instruments and to check their validity, namely, I check the euro-dollar futures (EC1, EC2, EC3) and 10-year treasury notes futures (TY1, TY2).

The key point in this research is to use futures data because investors include expectations of some future events in the prices of futures. Therefore, the change for futures today can capture the changes in investors' sentiments. Moreover, the USA futures market is very rich about different futures, for example, the Chicago Mercantile Exchange (CME) gives the following statistics about the average daily volume, see the table 1[2]. We see that these futures are very liquid. GK have already used the most suitable instruments like futures on Federal funds. The price on these futures includes the current (and expectations about the future) rate of Federal funds. However, there are still a lot of futures which can indirectly show the effects of changing the Federal funds rate.

One of the aims of this excise is to find new possible instruments, which can be used in a similar

[2] https://www.cmegroup.com/market-data/volume-open-interest/exchange-volume.html

Contract	Exchange	Daily Volume, contracts
Eurodollars	CME	2,185,510
10-Year Treasury Note	CBOT	1,546,969
5-Year Treasury Note	CBOT	955,641
U.S. Treasury Bond	CBOT	315,616
30 Day Federal funds	CBOT	164,054

Table 1: Leading interest rate futures

analysis for Russia. The main possible candidates for it: currency instruments (futures on currency and FX) and stock market index instruments (S&P 500 and futures on S&P 500). In further analysis, I show the results for both groups of these instruments. Moreover, I also use much more futures, but I do not include all of them in the paper because they do not improve the results, some of them you can find in the appendix.

4.1 Data

Monetary policy events. The term event refers to the date when the Federal Open Market Committee meeting takes place. I collect the dates of publication FOMC's decision report and the dates of publication minutes from their meeting from March 1938. Unfortunately, I do not have access to the intra-day data; therefore, the following analysis will be based on the daily data.

Instruments. In my analysis I use the following instruments, taking from Quandl database, Quandl (2018). Note that, further the low case names always refer to original GK series and upper-case names refer to the daily monetary policy surprises built by me.

Moreover, I use macroeconomic data. Most of these data were taken from FRED-MD and FRED-QD: Monthly and Quarterly Databases for Macroeconomic Research, McCracken and Ng (2016), expect an excess bond premium. The excess bond premium was taken from the paper by Gilchrist and Zakrajšek (2012) and continued until August 2016 by Gilchrist himself.

To build a VAR model on monthly data I need to obtain monthly surprises. Firstly, I find daily surprises based on either the intra-day data or on the daily data as described in section 2. Secondly, I combine data into monthly, if I have more than one event in one month, I sum these surprises up. If

I do not have monetary policy events in the current month, I give this month zero. In other words, I calculate the 30-minutes returns of the asset, and then I combine into monthly series. The same process I make for daily data. I take the closing price of the day of the FOMC meeting and compare with the same closing price yesterday; finally, I aggregate it to monthly series in the same way as above.

To be more visual I draw some of these surprises on graphs. For example, on the figure 1 you can see the original Gertler and Karadi surprises (up to 2012:6 – intra-day data) and continued by me until 2016:6 (daily data). On this figure, the low case names refer to original GK series and upper-case names refer to the daily series. We see that surprises computed on the daily data are more volatile. It can be a sign that these surprises capture not only monetary policy event's surprises but also some other news that comes to the markets during one day.

On figure 2 you can see some new instruments, namely, TY2 (10-year T-note futures) and ES2 (S&P 500 e-mini futures). Both computed on the daily data. The interesting thing here is that these two instruments are even more volatile, especially ES2 is highly volatile. The possible reason could be that ES futures refer to S&P 500 index which underlying assets are shares of the 500 largest companies; therefore, these futures include the investors' expectations about all these companies. In contrast, the underlying asset for Federal funds futures is the Federal funds rate; hence, these futures reflect changes in investors' expectations mainly about the Federal funds.

On figure 3 you can see monetary policy surprises which are currency-related. Here we can see that

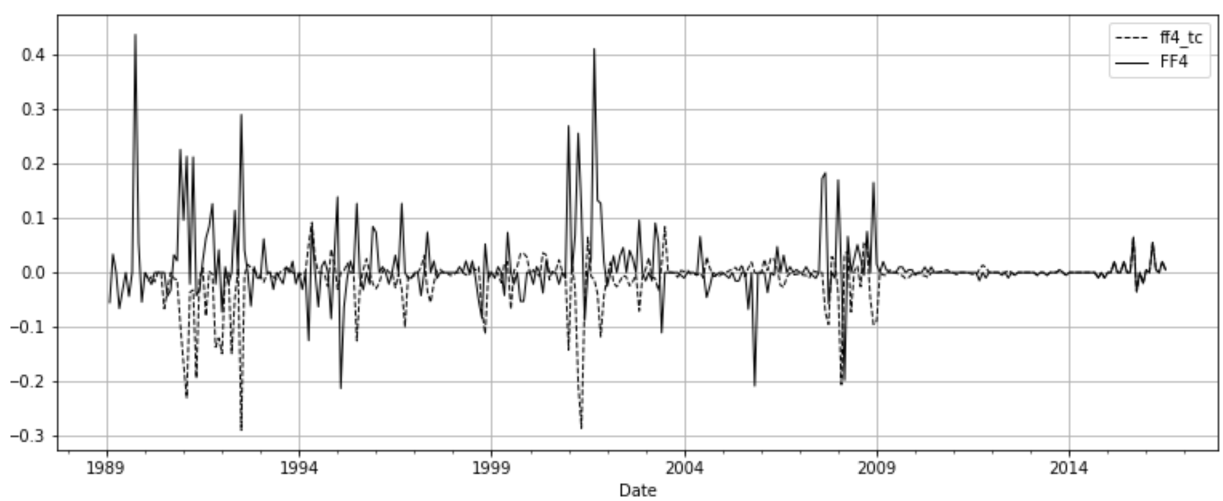


Figure 1: Original GK instruments both the intra-day and the daily surprises

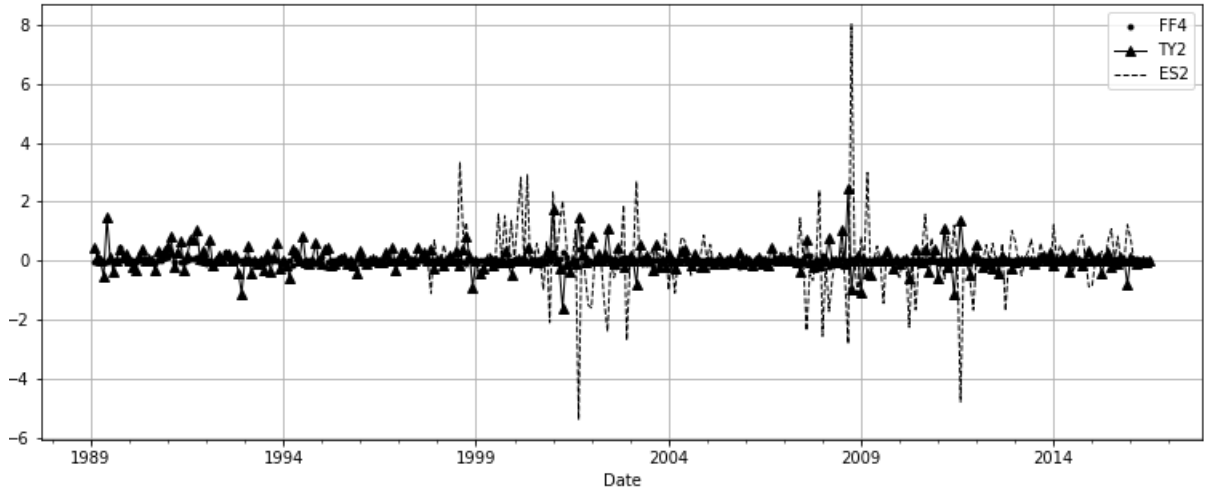


Figure 2: New instruments: TY2 and ES2

currencies are even more volatile than TY2 and ES2. We still have a large pick at the end of 2008, which represent the latest crisis. However, the USD/PND FX are highly volatile from 1989 to 1994 and from 1999 to 2004. I think that this volatility comes from the origins of these instruments. Currencies are very sensitive to completely different news. It can be some political news in the same of the day FOMC meeting; it can be other economic news about some companies on the same day and etc.

Now let us turn to the VAR analysis. In the next section, I replicate the original GK impulse response functions based on the intra-day data (from 1979 until 2012:6 and the daily data until 2016:6). Also, I show $\mathcal{IRF}$s based on the daily data on new instruments.

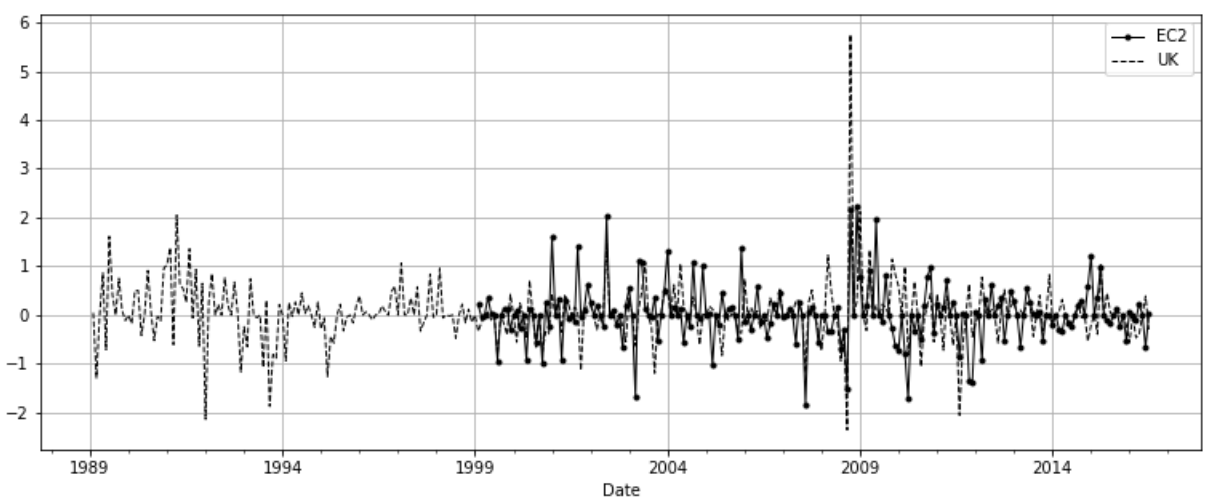


Figure 3: New instruments: EC2 and UK FX

4.2 Results

In this section, I show the obtained results. Mostly, they are very similar to the GK paper using their instruments.

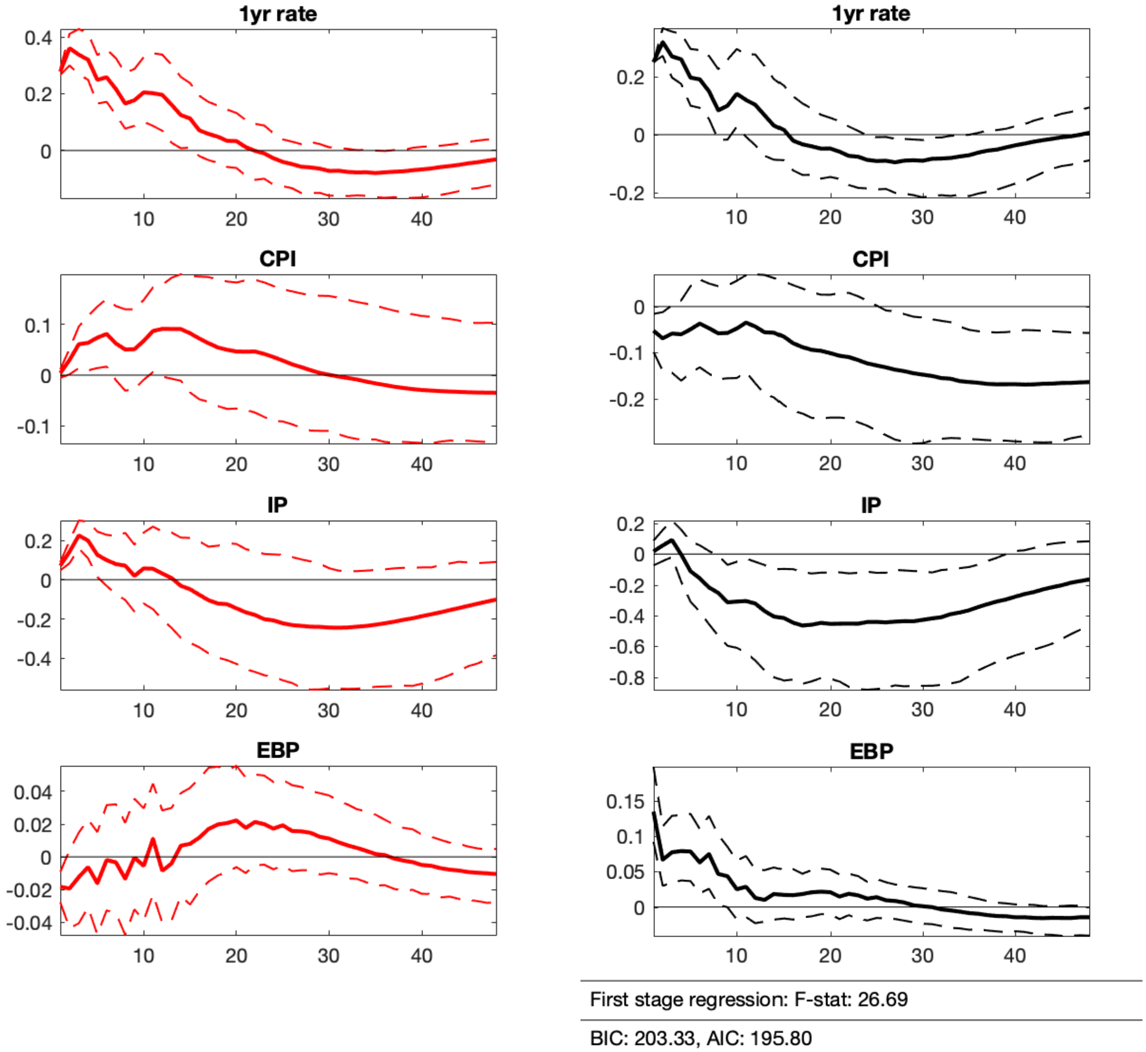
All these VARs models were estimated at the same time interval from 1979:7 to 2016:7. I do not drop periods of different crises. All VARs include 12 lags plus a constant. $\mathcal{IRF}$s show the effect of the tightening monetary policy; in other words, $\mathcal{IRF}$s show the effect of 25 bps interest rate increase. I always use only one instrument, which always specified in the figures' title. The dash-line represents 95% bootstrapped confidence intervals using the wild bootstrap approach. I do not use any exogenous variables. To estimate VARs I use Matlab software with VAR toolbox by Cesa-Bianchi, Ambrogio (2015). For each VAR I report the value of F statistics from the first step and the values of information criteria. According to Stock and Yogo (2002) for a good instrument F statistics from the first step should be greater than 10. For information criteria, there is also a simple rule: the lower the value the better. However, we can compare models with the same y variables.

Let us discuss the results in details. In the context of the USA, I discuss only baseline model with four variables: the one-year government bond rate, the log of a consumer price index, the log of industrial production, and the excess bond premium.

On the figure 4 you can see the replication of the GK $\mathcal{IRF}$s, on the left figure 4a you can see a standard Cholesky decomposition. On the right figure 4b you can see the external instruments identification. In this case, I use the GK ff4 (three-month ahead Federal funds futures). The other instruments do not improve the results or show even worse results. Note that in the case of external instruments F statistics from the first step is 26.69 which above 10.

Both types of identification show that tightening monetary policy leads to 0.25%-0.3% increase in government bond rate. Industrial production shows a slight increase in the beginning and later decrease. Note that, this decline in IP is statistically significant in the case of external instruments. The consumer price index shows a small decline in both types of identification, but it is insignificant. Finally, the excess bond premium increases by 0.1% in the case of external instruments, but for the Cholesky identification, it is insignificant.

The important difference between these kinds of identifications is that in the Cholesky case, the order



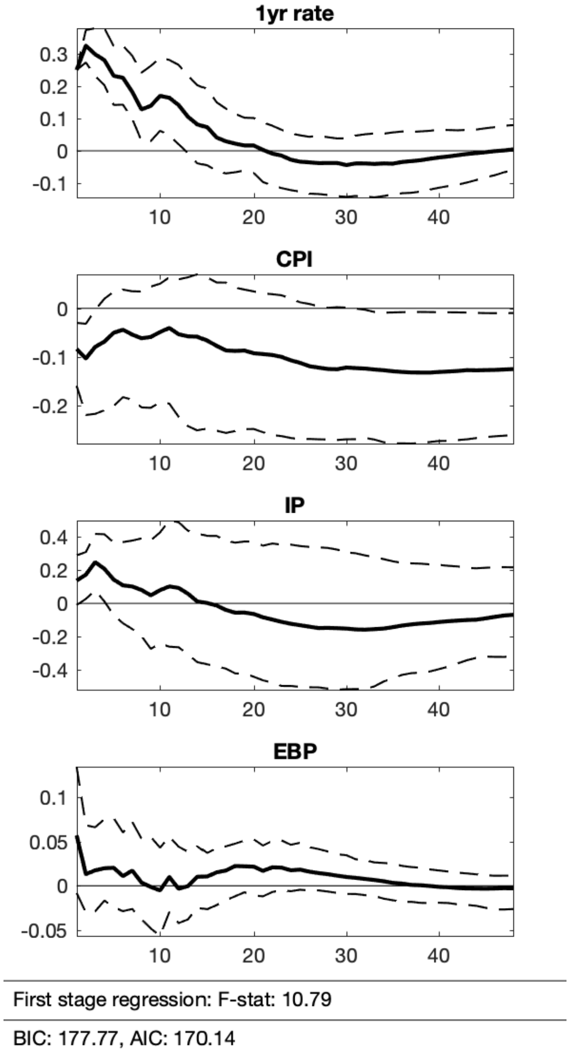
(a) Cholesky decomposition (b) GK external instruments, ff4

Figure 4: Replication of GK

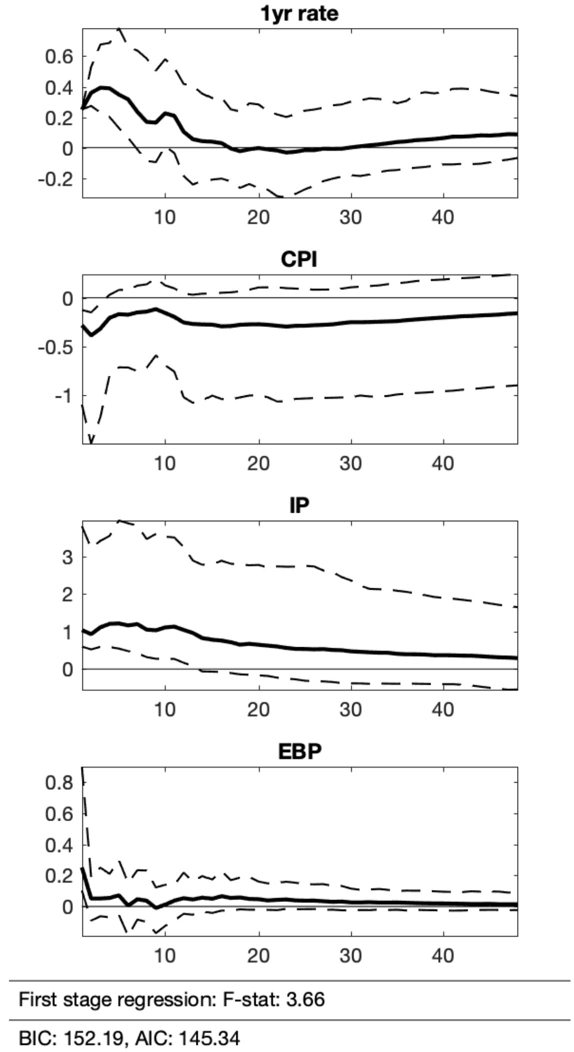
of variables: 1-year government bond rate, CPI, IP, EBP is very important. If we change this order, the results could also change. However, it is not the case when we use external instruments approach. In that case, we identify a pure monetary policy shock.

As Gertler and Karadi write these types of identifications display “puzzles”, we know that the Central Bank (the FOMC) decides to raise its interest rate in a case when, for example, the CPI is above the targeting level. Therefore, we expect to see that after this decision the CPI goes down, from figure 4 we see that falling, but it is not statistically significant.

Now let us turn to the next figures. Here I reestimate the same VAR using new instruments on



(a) Daily FF4 surprises

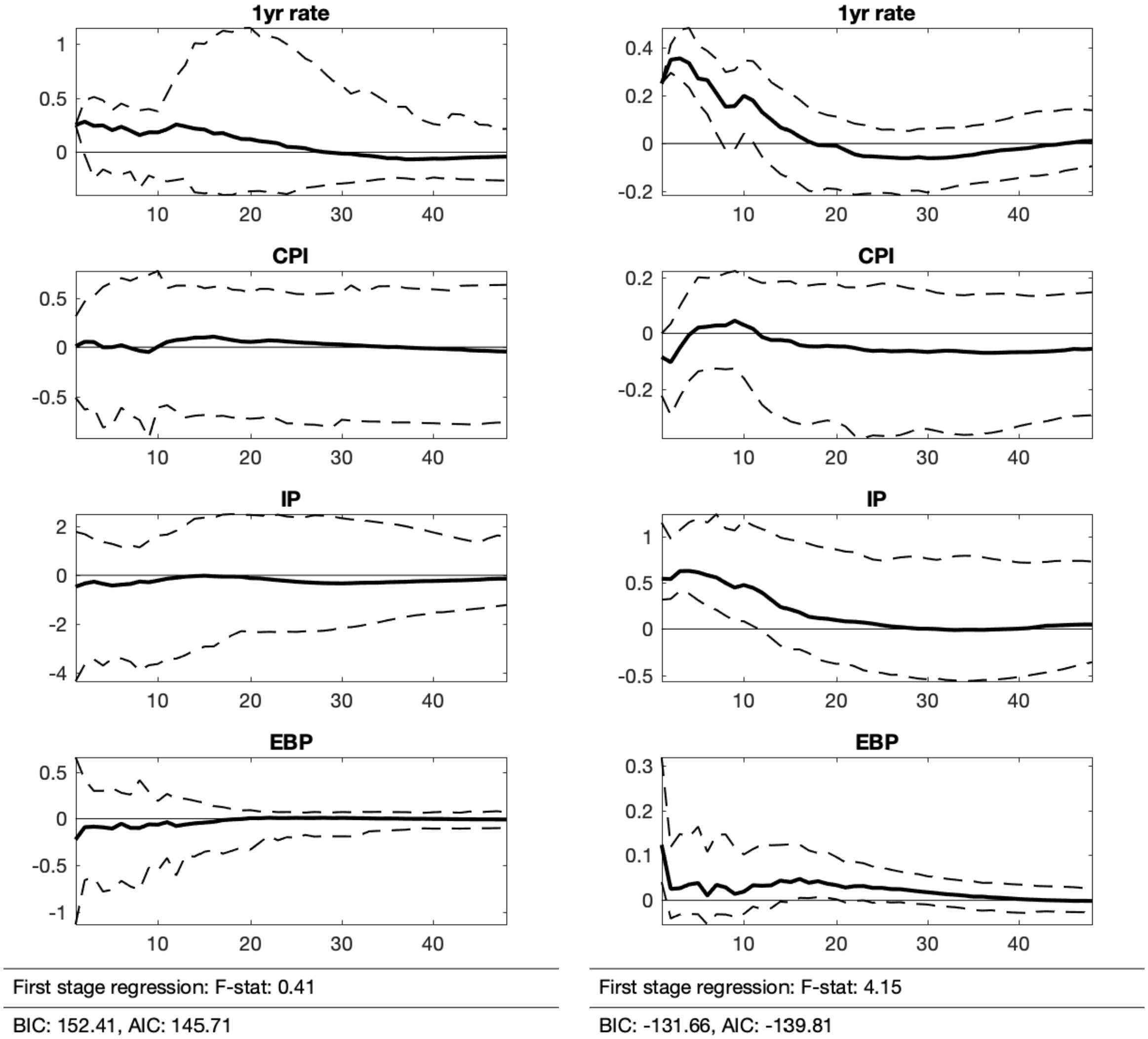


(b) Daily ES2 surprises

Figure 5: Daily surprises

the daily data. I show only a few of them, namely, FF4 (three month ahead Federal funds futures), ES2 (three months ahead E-mini S&P 500 futures), EC2 (one month ahead Euro FX futures), UK FX (USD/PND spot exchange rate). The rest figures you can see in the appendix.

From the figure 5 you can see the $\mathcal{IRF}$s for FF4 (on the left side of 5a) and ES2 (on the left side of 5b). These results are now worse. For example, we can compare $\mathcal{IRF}$s from the figure 4b and from 5a. I use in both cases the same instrument: FF4. However, the results are very different. We have a huge decline in the F statistics, now it is only 10.79, and it is on the margin. The movement of variables has also changed. Now we have mostly insignificant results for CPI, IP and EBP. The only variable that



(a) Daily EC2 surprises

(b) UK FX

Figure 6: Daily surprises

has saved the significance is the 1-year government bond rate. The situation is even worse when I use ES2 as an external instrument. Only 1-year government bond rate has saved the significance. The F statistics is only 3.66, which do not allow us to consider it as a good instrument.

The same situation is shown on the figure 6, on the left figure 6a you can see the $\mathcal{IRF}$s of EC2, on the right 6b you can see the $\mathcal{IRF}$s of UK FX. Both of these instruments also show signs that they are weak instruments. Both have very small F statistics. EC2 does not show any responses, although UK FX shows some results, they are not convincing.

Let us sum up these results. I present a part of $\mathcal{IRF}$s for the USA. I show that the monetary policy surprises which are computed on the daily data give worse results. No other futures cannot improve them; therefore, I can not be sure that currency futures will work for other countries.

4.3 Robustness exercise

In this section, I present one robustness exercise. When we try to identify the monetary policy surprise, we are linked to one date, the date when the FOMC makes the decision about the federal funds rate. We believe that in that 30-minute window (or in the whole day, when I use the daily data) there is no other events and the $\mathcal{IRF}$s show the transmission mechanism of monetary policy.

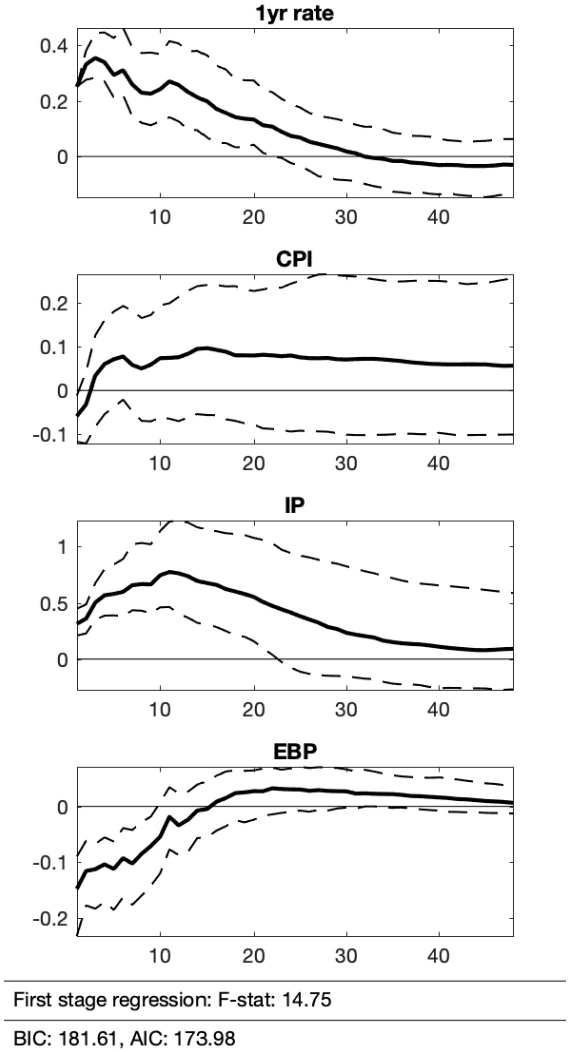
In this robustness exercise, I look at the "surprises" which occurred a day before the FOMC meeting and a day after. If we identify the right day, then there should be no responses on other days. Moreover, in this exercise I use daily data, i. e. daily returns yesterday and tomorrow compared to the day of the monetary policy decision.

On the figure 7 you can see the $\mathcal{IRF}$s for FF4 instrument. On the left figure 7a you can see the $\mathcal{IRF}$s for one day before the FOMC meeting, on the right figure 7b you can see the $\mathcal{IRF}$s for one day after the FOMC meeting.

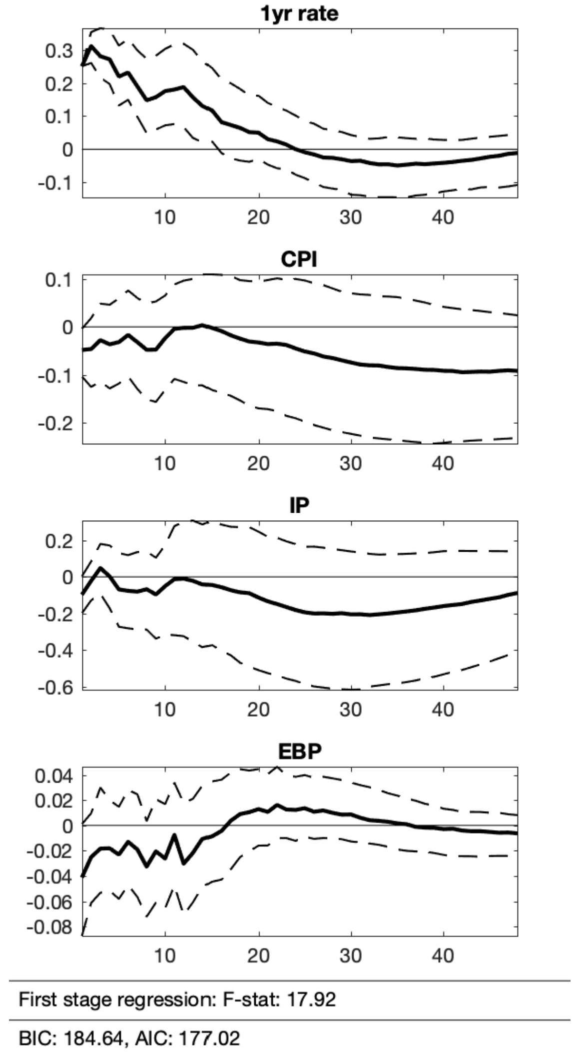
Note, that F statistics are above 10 for both models. However, It is clear that there is no transmission for one day after. Most responses are insignificant. That could mean that in the day on the FOMC meeting the market has changed their expectations about the future and the changes of FF4 the next day does not show any effects. In other words, the prices for the next day have already included the effects of FOMC decision.

Nevertheless, I have significant responses for the FF4 one day before the FOMC meeting. We have a significant increase in industrial production, 1-year government bond rate and a significant decrease in excess bond premium. Some of these responses are counter-intuitive. For example, we expect a rise in ebp as a response to the tightening monetary policy, and we also expect a drop in IP and a decline in CPI. However, the given results do now show it. In the appendix, you can find other figures which show the same pictures.

This phenomenon clearly shows that in $\mathcal{IRF}$s in the day on the FOMC meeting are unique, and the result obviously depends on the chosen day. Moreover, these $\mathcal{IRF}$s also show that the day before the



(a) FF4 1 day before



(b) FF4 1 day after

Figure 7: Robustness checks

market has no expectations about the future decision. In the opposite case, we would have the "right" $\mathcal{IRF}$s a day before the FOMC meeting.

In this small exercise, I show the uniqueness of impulse responses in the day of monetary policy decision. The impulse responses for one day before and one day after do not coincide with $\mathcal{IRF}$s on the day of the meeting. In other words, monetary policy surprises which identified in one day after and one day before do not match each other. It means that the policy decision gives distinctive shocks on macroeconomic variables.

4.4 Discussions

The bottom line of this section about the USA is the following. Gertler and Karadi show that the external instruments approach works better than the Cholesky decomposition. They also show that their instruments based on the intra-day data have a high level of validity; in other words, all their instruments have high F statistics from the first step. The same results are obtained in the process of replication their paper.

However, I could not get the same results on the daily data. For daily surprises, I use the daily returns of the selected instruments. Even for the instruments proposed by Gertler and Karadi the results are worse. I have much less F statistics, if for the intra-day data I have F statistics above 25, for the daily data the maximum F statistics is only 10. The problem could be that taking the whole day surprises I do not capture the change in the asset due to the monetary policy surprise. Since I look at the daily change I take the closing day price, the price of the last trade and I compare with the same price yesterday. This price does not include only news about changes in monetary policy but also include other news which comes to the market during the last 24 hours.

Moreover, I also show that there is no instrument better (or at least as good as) than those which Gertler and Karadi are using. I try instruments that are related to currencies, indexes and even commodities. None of them shows good results. The reason is simple, Gertler and Karadi have taken the best instruments, instruments that are related to interest rate directly. Although other instruments should also respond to changes in monetary policy, capture this on the daily data is very difficult.

Finally, I show that these impulse responses are being created precisely by monetary policy event and not some others. I present some robustness checks which confirm the identification procedure. In the next section, I present the same analysis for Russia.

5 Monetary policy surprises in Russia

In this section, I discuss a similar analysis for Russia. The financial market in Russia is very different from the USA. We do not have any instruments on the interest rate. Therefore, I need to measure monetary policy surprises through other existing instruments.

The most liquid futures on the Russian financial market are the currency futures and the stock market index futures. For futures, I use both daily and intra-day data. The amounts of trades for one day you can see in the table 2[3]. The second important source of instruments is also linked to currency: FX and forward exchange rates, since these derivatives mostly trade on OTC markets, I use daily data for them.

Contract	Volume of trades, contracts	Number of trades
Futures	**3 511 249**	**664 391**
RTS-3.19	244 430	108 540
MIX-3.19	19 597	11 902
Si-3.19	1 270 586	251 340
Eu-3.19	71 033	20 062

Table 2: Amounts of trades of futures

The important difference between FX rate and futures (forwards) is that in the price of futures could be included the investors' expectations about future events; however, FX rate is a spot price for today.

In this paper, I construct monetary policy surprises for Russia based on both spot and futures (forwards) rates. The construction of these surprises is the same as described in section 2. I measure 30-minute returns (or one-day returns) in the day of a monetary policy decision, then I aggregate it to monthly surprise, if I have more than one surprise in one month, I sum them up. If I do not have a surprise in a month, I give this month zero. For example, figure 8 shows the obtained surprises using 1) USD/RUB spot price (black line), 2) USD/RUB 3 month ahead futures (dash line). All three are calculated on the daily data.

We see a huge pick at the end of 2014. It was the day when the Board of Directors of the Central Banks of Russia decided to raise the key rate to 17%. Is was on December 16, 2014. The volatility of USD/RUB futures is higher than FX rates. Also, for some dates, the obtained shock has the opposite direction as compared to FX rates.

One can argue that the decisions of the Central Bank of Russia are very predictable. Especially for one day before the meeting and even more so for 10 minutes. If that statement is true, then, prices should adjust at the moment when the market understands the future policy decision. In other words,

[3] https://www.moex.com/en/derivatives/

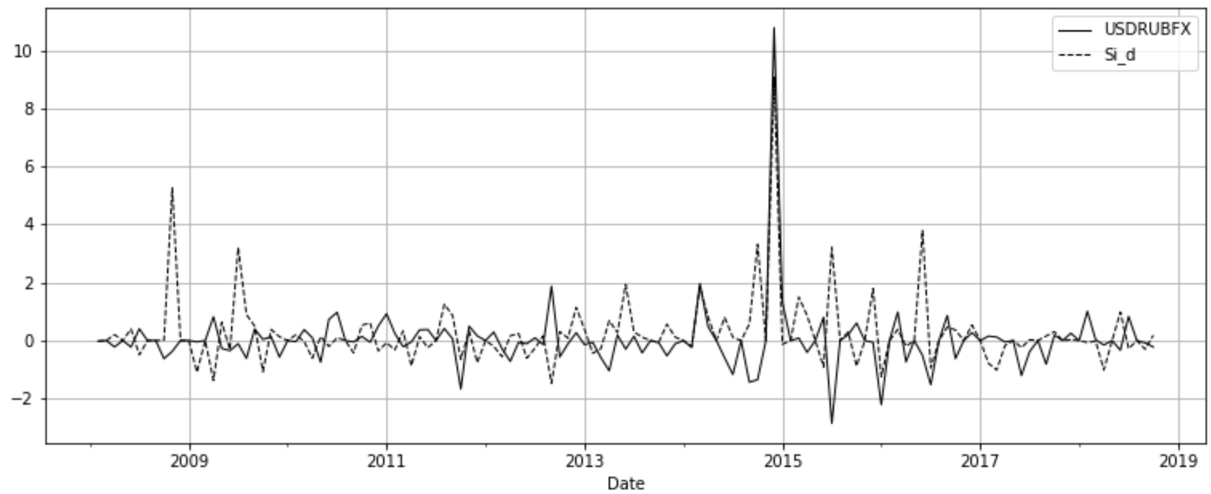


Figure 8: Monetary policy surprises for Russia

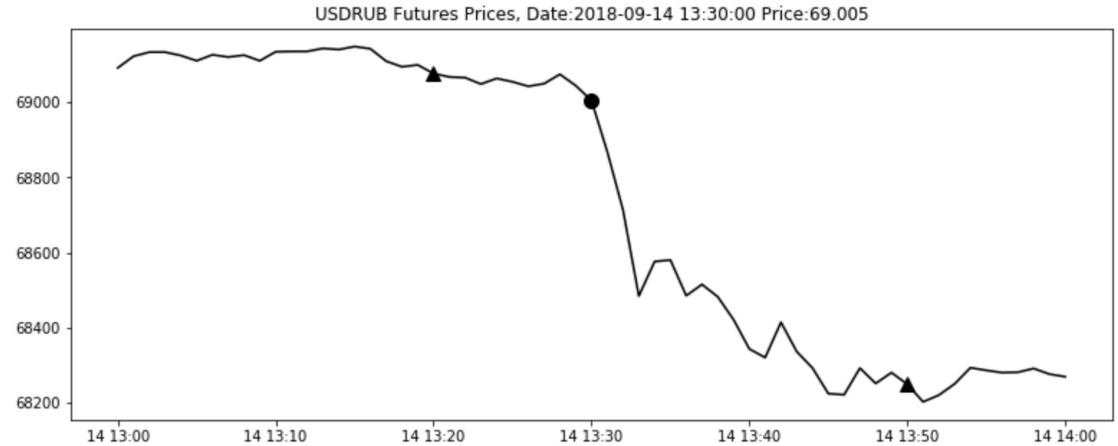
the price should noticeably change before the meeting, and in the day or minutes around the meeting, we should see no changes. On figure 9 you can see some selected dates of meetings of the Board of Directors. I show the prices for three month ahead USD/RUB futures. In these figures, the round point indicates the time of publication the decision about the kay rate. The left triangle point indicates the price 10 minutes before the report publication, and the right triangle point indicates the price 20 minutes after the decision publication. For both figures, we see a drop in prices either right at the time of publication or a couple of minutes later. That can tell us that there is some reaction to the key rate changes in the Russian financial market. The rest figures you can see in the appendix.

In the next sections, I describe the available data I have in more detail. Describe monetary policy events and show $\mathcal{IRF}$s for Russia.

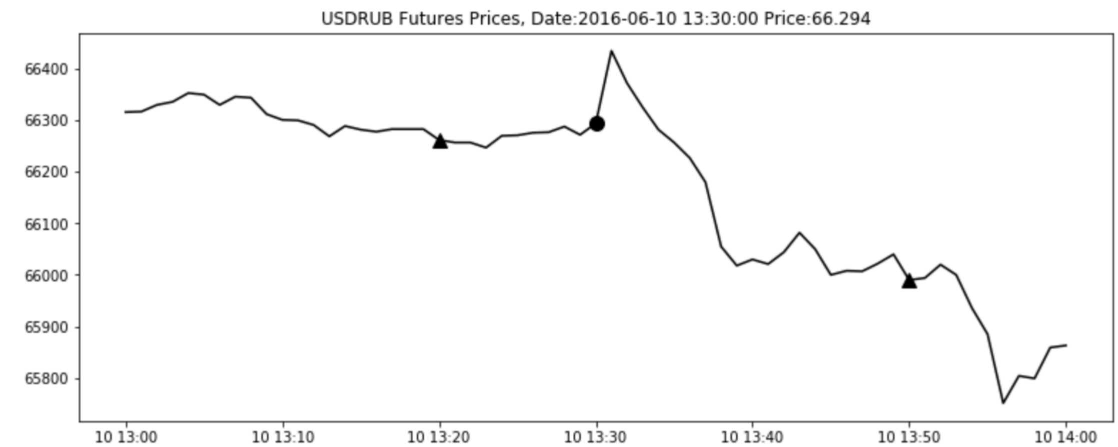
5.1 Data

I estimate the VARs model and choose the period from 2002:12 to 2018:10. The starting point is chosen due to the earliest data availability. These time series include several important events: two crises in 2008 and 2014 and the change of Bank of Russia exchange rate policy. I discuss these issues later.

Monetary policy events I obtain the dates of the Board of Directors of the Central Bank of Russia meeting from 2008 to 2018 from the official site (Central bank of Russia, 2018). The monetary policy of the Bank of Russia needs a detail discussion.



(a) Surprise at 2018-09-14, raise by 0.25%, new rate is 7.5%



(b) Surprise at 2016-06-10, cut by 0.5%, new rate is 10.5%

Figure 9: Minutes surprises

The Bank of Russia does not have a long history[4]; however, it has passed through several stages of modern monetary policy formation. From 1999 to 2014 years, the Bank of Russia used the managed floating exchange rate regime. It was necessary to smooth unexpected shocks on the Russian economy. Over time, the exchange currency band widened, and in August 2014 it was nine rubbles. From November 10 2014, the Bank of Russia decided to switch its exchange rate policy to a fully flexible exchange rate.

As for monetary policy events, the Bank of Russia post only press releases about monetary policy decisions and later on the same day they post monetary policy report. From 2014 the Bank of Russia posts the decision in the 13:30. This tradition is new for the Bank of Russia because before 2014 the publication of monetary policy decisions was chaotic, and for early years was not systematic. It can be

[4] The History of the Bank of Russia FX policy
http://cbr.ru/eng/DKP/exchange_rate/fx_policy_hist/

a possible source of the problem in a further paper.

Instruments. I use Thomson Reuters Datastream (Datastream, 2018) to obtain FX and forwards rates, I use the intra-day data from Finam (Finam, 2018) to find futures prices for monetary policy surprises. I also use data from Moscow exchange for monthly VARs (Moscow Exchange, 2018). The detailed list you can find in the appendix.

Since the Russian financial market is much smaller than the US one and we do not have derivatives on the interest rate. I try to recover monetary policy surprises from the currency markets, namely, USD/RUB spot rate, forward rate and futures. Additionally, I use index-linked instruments, namely, MOEX and RTS futures. I choose these instruments because of their liquidity.

Moreover, I use macroeconomics data from Thomson Reuters Datastream (Datastream, 2018) and Russian statistical agency (Federal State Statistics Service, 2018) for key macroeconomic variables and from IMF (International Monetary Fund, 2017) for the world economic indicators like oil prices. The detailed list you can find in the appendix.

The important difference in macroeconomics data is that as the excess bond premium I take a spread between the clean price of government bonds and corporate bonds. The clean price is the price of the bond minus accrued interest. In the original paper by Gilchrist and Zakrajšek (2012), the authors clean this spread from default premia. This "cleaning" is not an obvious exercise and, unfortunately, out of this work; therefore, I use "excess bond premium" with default premia.

Finally, the choice of variables for the small open economy framework is also not an easy task. This choice is based on the paper by Cesa-Bianchi et al. (2016) and add new variables like oil prices.

5.2 Results

To identify monetary policy shocks I still use the external instruments approach by Gertler and Karadi (2015). The same as in the USA case with the external instruments I try to isolate the variation of the structural innovation of the variable of interest in the VAR model.

Russia is a very different country from the USA. Russia is a small open economy, which makes adjustments to the estimation of the VARs models. Therefore, I estimate the baseline model, the same as Gertler and Karadi (2015) and the open economy model using the ideas from Cesa-Bianchi et al. (2016) and add Russia specific variables like oil prices.

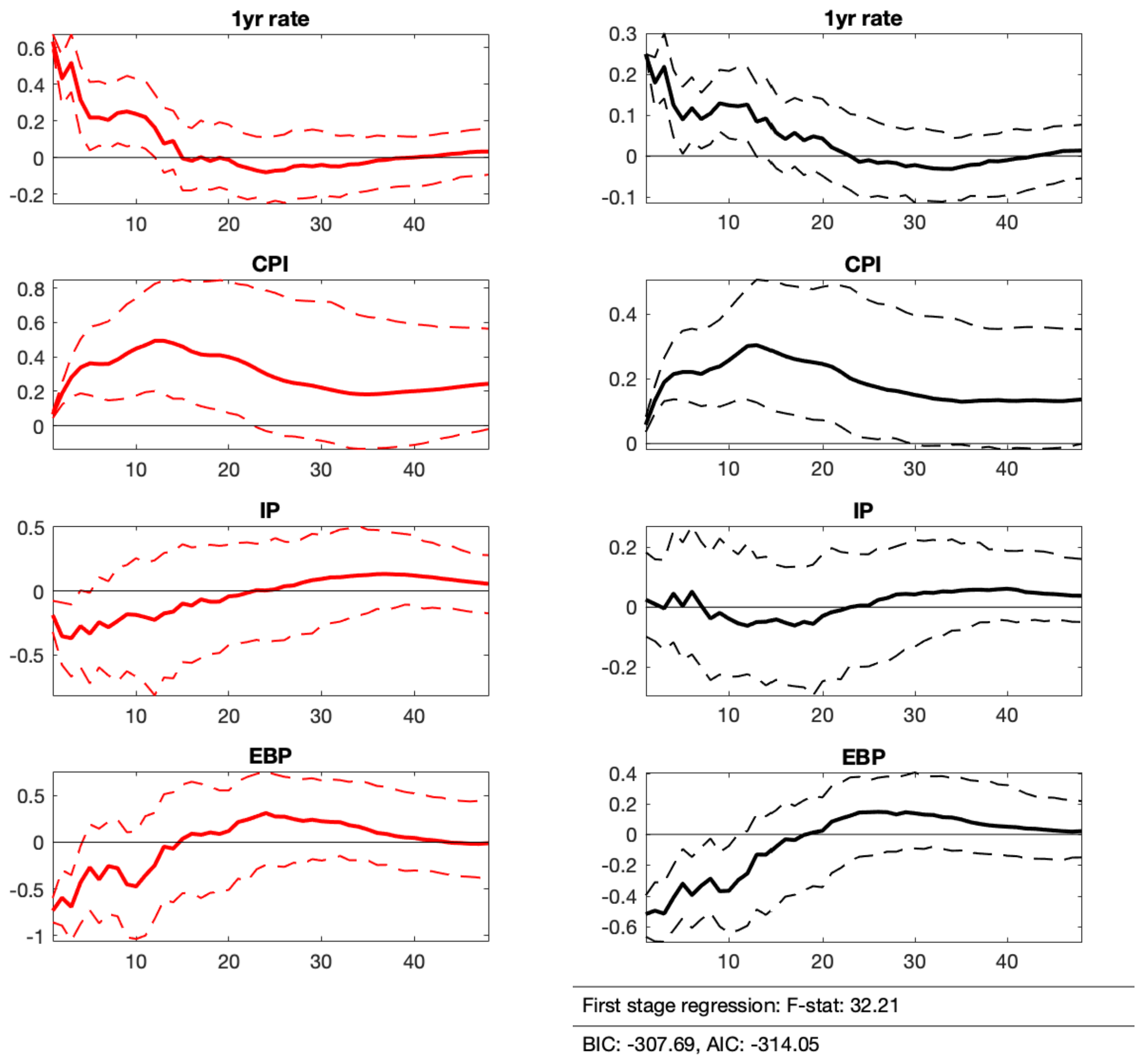
All these VARs models were estimated at the same time interval from 2002:12 to 2018:10. I do not drop periods of different crises, like 2008 or 2014. Baseline VARs always include 12 lags plus constant, and it could help to capture not an instant effect of transition mechanism, for example, the reaction of the CPI to changes in monetary policy can occur only after six months. Open economy specifications include 2 or 8 lags, which written in the headline of the corresponding figure. This lag reduction is due to the "short" time series that I have for the Russian economy, for example, if I have four variables and 12 lags I estimate about 52 coefficients. When I go to the open economy model, the number of coefficients grows rapidly; therefore, I need to reduce the number of lags.

All $\mathcal{IRF}$s show the effect of the tightening monetary policy; in other words, $\mathcal{IRF}$s show the effect of 25 bps interest rate increase. I always use only one instrument, which always specified in figure title. The dash-line represents 95% bootstrapped confidence intervals using the wild bootstrap approach.

To estimate VARs I use Matlab software with VAR toolbox by Cesa-Bianchi, Ambrogio (2015). For each VAR I report the value of F statistics from the first step and the values of information criteria. According to Stock and Yogo (2002) for a good instrument F statistics from the first step should be greater than 10. For information criteria, there is also a simple rule: the lower the value the better. However, we can compare models with the same set of y variables.

In the baseline model, I use the 1-year government bond rate, the log of the consumer price index (index, 2010=100), the log of industrial production (index, 2010=100), and the excess bond premium. I do not use any exogenous variables. For open economy, I add (in different specifications) real and nominal effective exchange rates, export and import, trade balance as the difference between export and import, oil prices and RVI as the index for the volatility of the financial market. In some specification, I add oil prices and volatility index as exogenous variables. Moreover, I use some of these series in levels, which can raise questions about stationarity, Stock and Watson (2016) write that in this case I just obtain cumulative $\mathcal{IRF}$s.

Closed economy. Let us discuss the results of the baseline model in detail. On the figure 10 you can see Cholesky decomposition (10a) and the external instrument identification approach (10b), to be precise, the spot USD/RUB rate is used as an instrument.

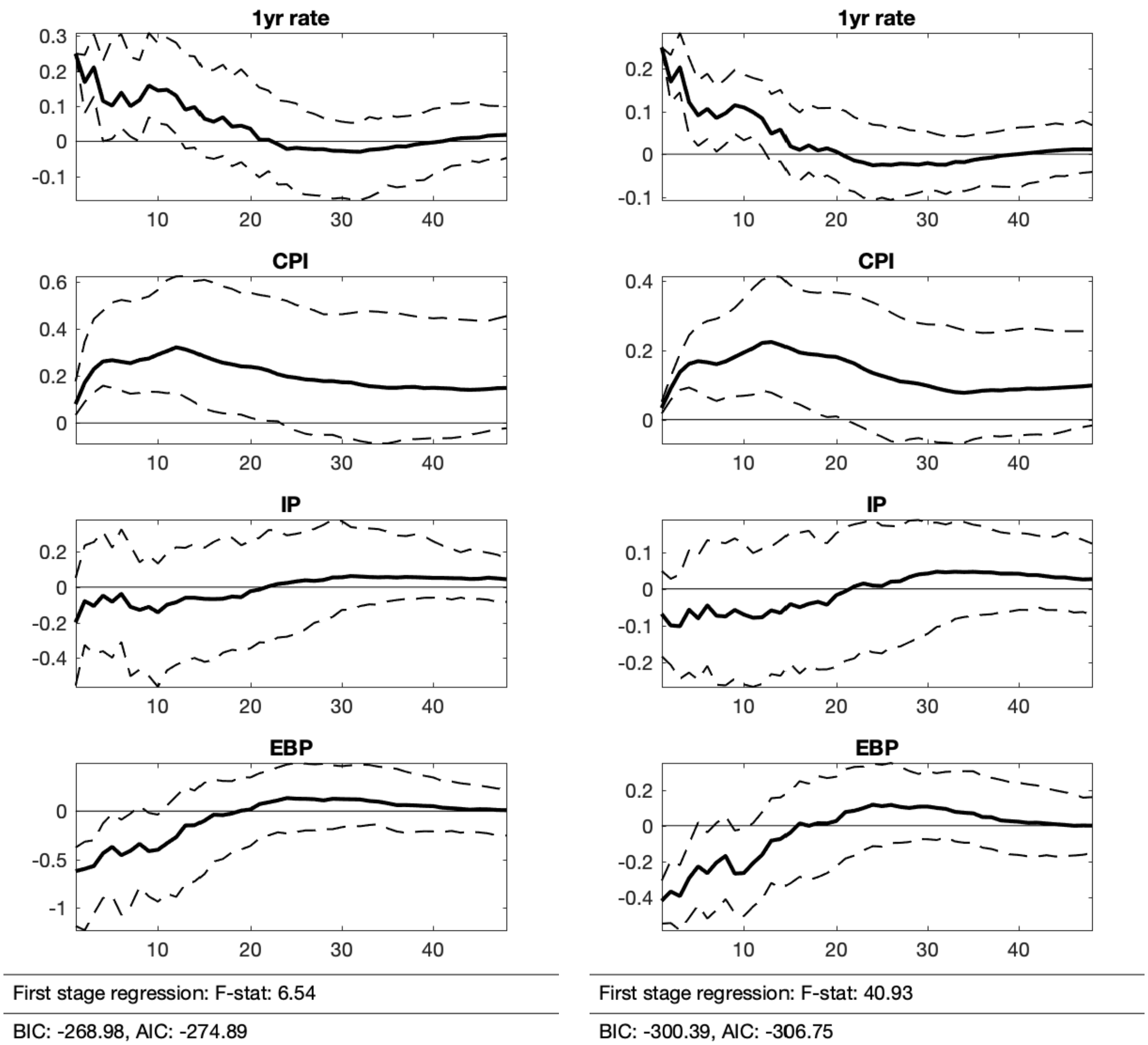


(a) Cholesky decomposition (b) USD/RUB FX

Figure 10: Baseline model, Cholesky and USD/RUB FX

In contrast to the USA, both types of identification show practically the same results. We see a strong and statistically significant increase in 1-year government bond rate. CPI shows the inverse U-shape statistically significant form response, i. e. in the beginning, it increases, then it falls. Excess bond premium falls, and it is statistically significant. IP is insignificant. The F statistics from the first step is 32, which is very high.

However, these results are counter-intuitive. The movements of macroeconomic variables do not coincide with the theory. For example, if the inflation is above the targeting level, then the Central Bank raise the key rate. Therefore, we expect to see that inflation falls. However, it raises for approximately a year after a shock.



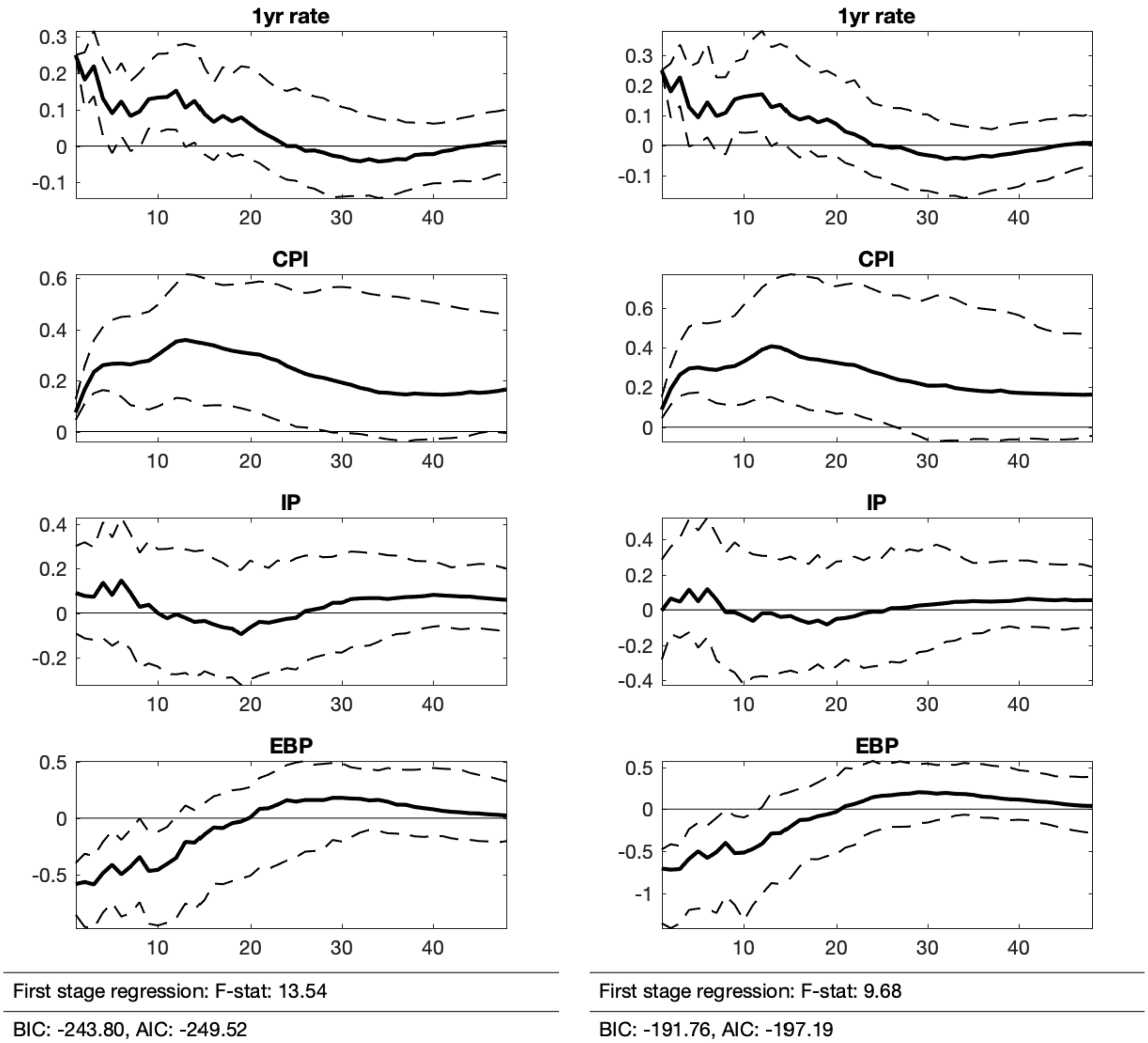
(a) Munite surprises

(b) Daily surprises

Figure 11: Baseline model, USD/RUB 3 month futures, minute and daily data

The problem can be in the fact that I use daily FX rates. These rates are forming in the OTC market; therefore, it is not possible to use minutes data. However, even if I use USD/RUB 3 month ahead futures as the external instruments, the results do not change much. On the figure 11 you can see the $\mathcal{IRF}$s computed using the intra-day data (11a) and using daily data (11b).

The results are quite unexpected. Intra-day data do not improve the results. For intra-day data, F statistics is only 6.54, which indicates it as a weak instrument. Moreover, these results are very sensitive to the window choice. For example, if I take the 20-minute window (10 minutes before and 10 minutes after the meeting), the results are even worse. Furthermore, the large window size I take, the better results I obtain. For example, on the daily window F statistic is more than 40. Moreover, the $\mathcal{IRF}$s show the same movement as in the previous case.



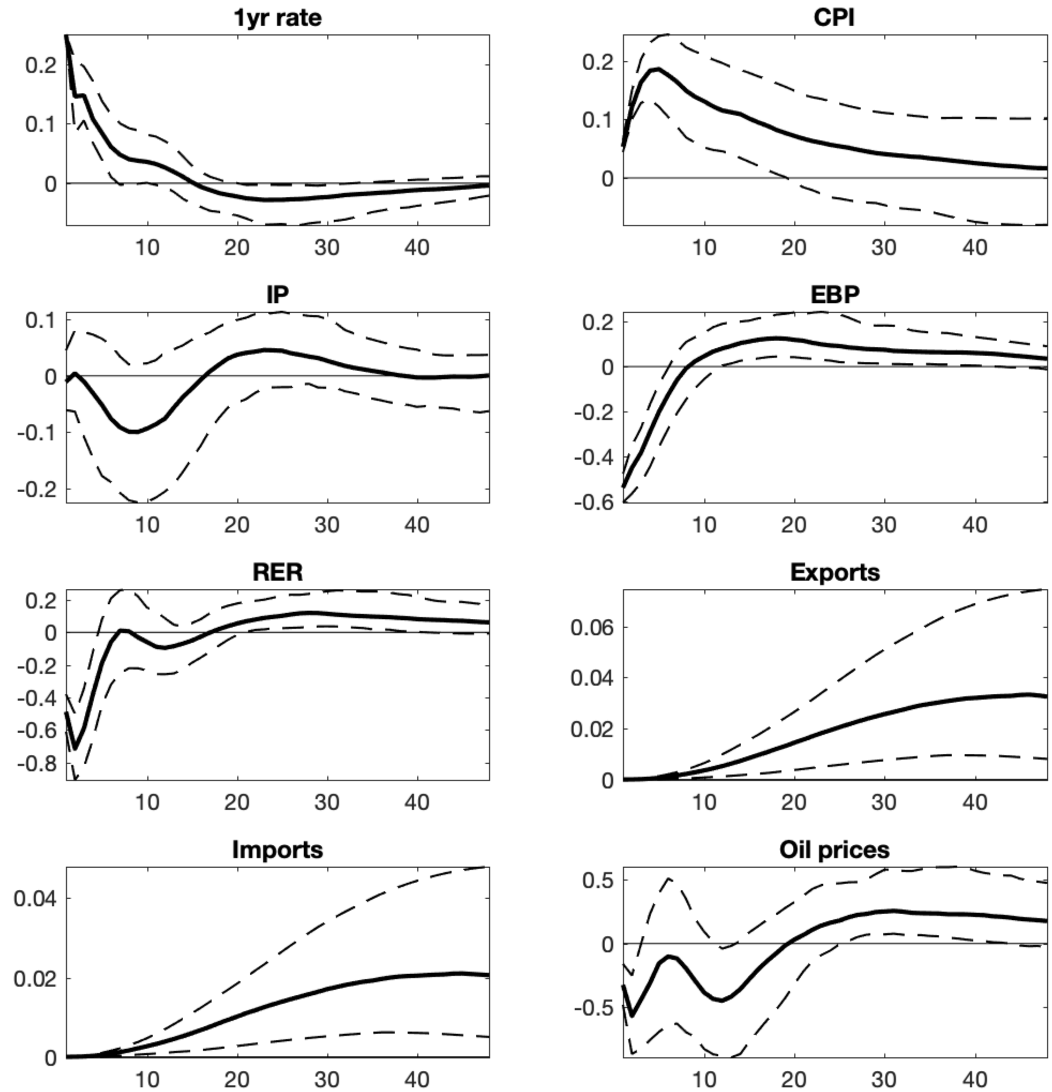
(a) USD/RUB 3 month Forward

(b) EUR/RUB 3 month futures

Figure 12: Baseline model, forwards and futures

Finally, let us compare the futures and forwards as instruments. On the figure 12 you can see the $\mathcal{IRF}$s for USD/RUB 3 month forwards (12a) and EUR/RUB 3 month futures (12b). As in both previous cases, we see the same movements. CPI is significant growing and then declining. EBP statistically significant drops. 1-year government bond rate increases. F statistics is around 10 and much smaller than for USD/RUB FX and futures rates.

The rest instruments do not show any better results, and you can see their $\mathcal{IRF}$s in the appendix.



First stage regression: F-stat: 35.63

BIC: -350.11, AIC: -356.48

Figure 13: Open economy model, USD/RUB FX, 2 lags

Open economy. Now, let us turn to the small open economy framework. In this section, I estimate different specifications; all of them show more or less the same results. Below I show the most interesting examples.

As new open economy variables, I add to the model real and nominal effective exchange rates (index, 2010=100), export and import (index, 2010=100), and their difference as a trade balance. I use oil prices (spot price) and the Russian volatility index (RVI) in some specifications as exogenous variables. Note that RVI index is a new instrument on the Russian financial market. It was only introduced in 2013 before it there was RTSVX index. RTSVX is the RTS volatility index; it was calculated from 2006 to 2013. In this paper, I combine both indexes in one to obtain more long time series. Further, I will call this "artificial" index as RVI for simplicity. All these series are on a monthly basis, seasonally and inflation adjusted if needed.

On figure 13 you can see the results where I use RVI as exogenous and oil prices as endogenous variables. I use here only two lags. This figure clearly shows the problem of "short" time series. We see that confidence intervals for two lags VAR is considerably smaller. There is another side of the coin if the connection between variables occurs more than in two months, we do not catch it.

Nevertheless, the $\mathcal{IRF}$s are very similar to the closed economy case. The government bond rates increases and statistically significant. CPI increases and then declines and also statistically significant. EBP and RER both statistically significant decline. Export and import start to grow only after ten months. Oil prices do not show any significant results. F statistics from the first step is still very high.

On figure 14 you can see the results for RVI and oil prices as exogenous. We see that at least two variables have changed their responses. Now industrial production show sinusoidal-monotonous character, i. e. it combines periods of growth and decline, but IP is insignificant. The figure for CPI has also changed. For the baseline specification, I have the inverse U-shape curve. It was a concave function (after the pick). In this case, this function becomes convex (after the pick). Furthermore, the decline in CPI happens much earlier than in the baseline model. This effect can support the idea that the reaction of CPI to tightening monetary policy occurs only after a few months. Moreover, we see that the real effective exchange rate is falling down in the moment of the interest rate decision. In other words, the exchange rate depreciates. Trade balance does not show any responses in the approximately first ten months and then start to grow.

The open economy framework slightly improves the results from the closed economy. For example, the responses of CPI could be explained from the economic point of view. For example, when the Central Bank raises the key rate the effect is not contemporaneous, but the inflation starts to decline in a few

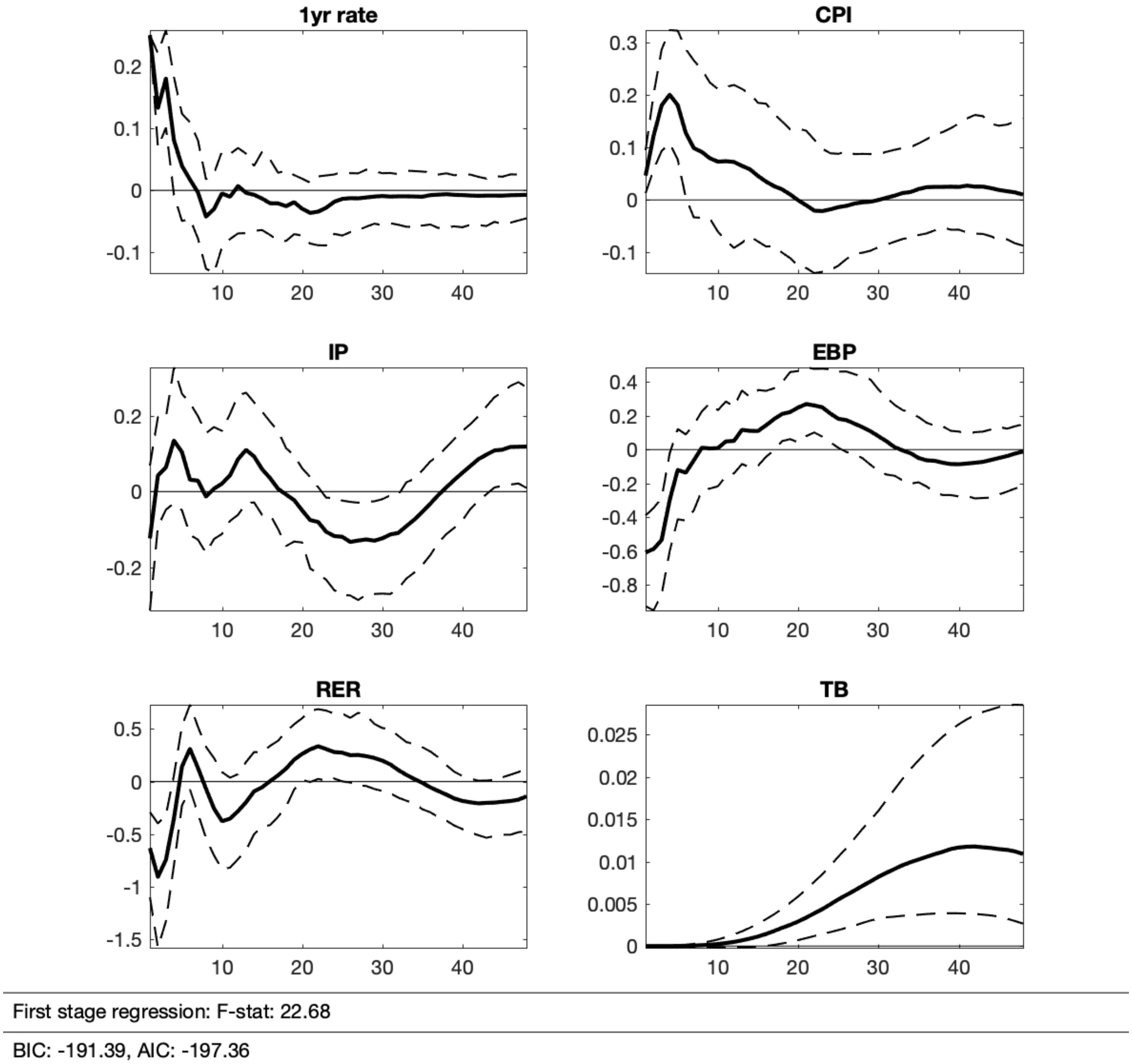


Figure 14: Open economy model, Open economy model, USD/RUB FX, 8 lags, oil prices and RVI as exogenous

months later. This is what the graphs show. Inflation is growing for a few months after the shock and then starts to fall.

However, many problems are still here. For example, the wrong response of the excess bond premium. The problem with ebp could be licked with the wrong calculation method. Gilchrist and Zakrajšek (2012) remove the default premia from their excess bond premium. In my case, ebp still, has default premia. It can be one source of inconsistency.

5.3 Robustness exercise

In this section, I perform two robustness checks. The first one is more important. The Central Bank of Russia only recently began to target inflation, to be precise at the end of 2014 The Central Bank of Russia switched to inflation targeting monetary policy, set a floating exchange rate and choice a medium-term inflation target of 4%.

Restricted sample. In this exercise, I restrict my sample by the summer of 2014 (the last period is 2014:6). This period divides two very different monetary policy regimes. If the results are robust to it, then it is a good sign.

On the figure 15 you can see Cholesky decomposition (15a) and USD/RUB stop exchange rate (15b). Now the results are completely different from the full sample. We do not have any significant results. $\mathcal{IRF}$s are zero practically everywhere. Moreover, the results are the same with other instruments.

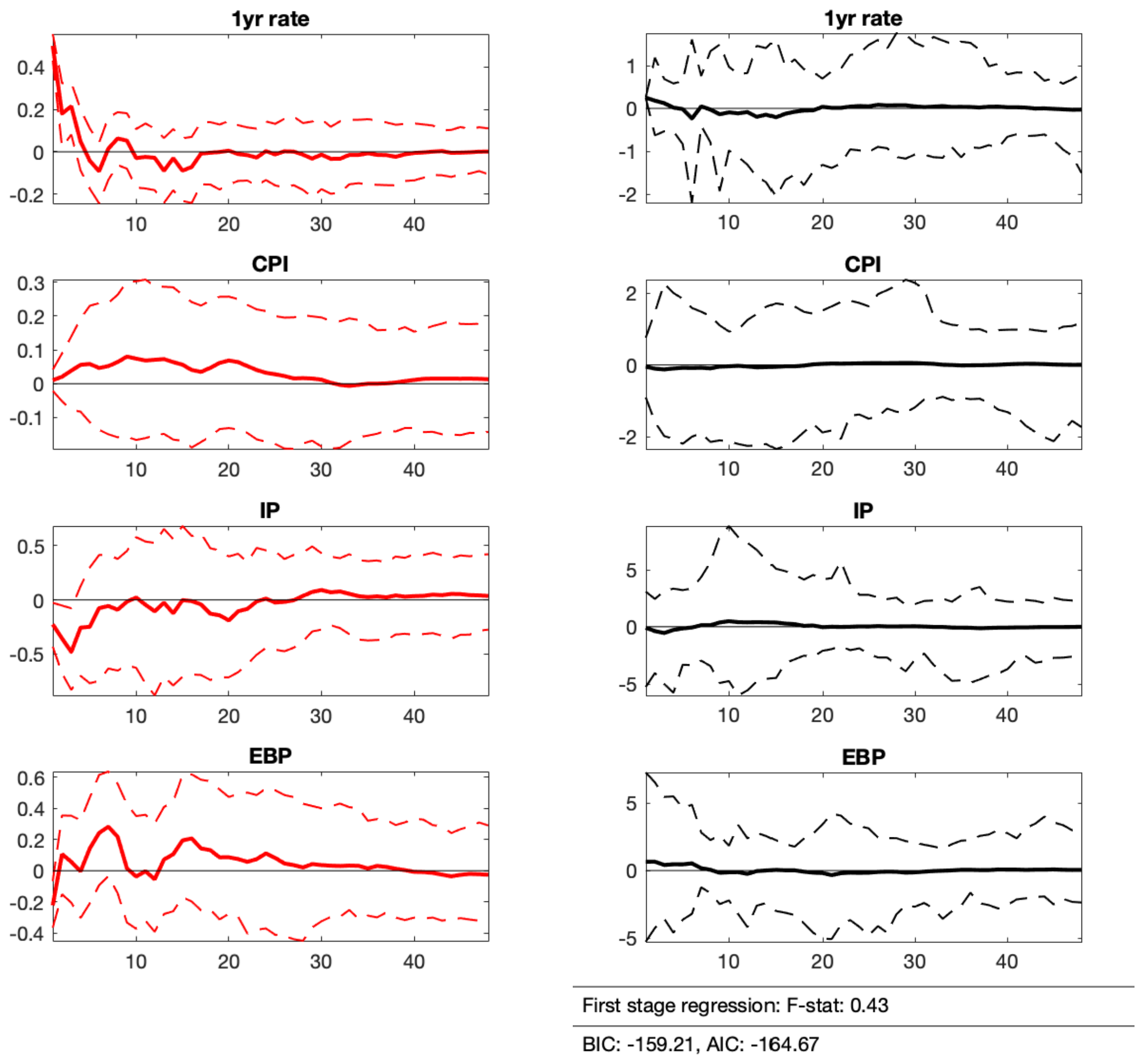
Possible explanation here is that before 2014 we have the managed floating exchange rate. Although the corridor expanded over time[5], the key rate itself did not play a significant role in monetary policy. Moreover, the key rate was introduced only in September 2013 before this key rate the Central Bank used the refinancing rate, which played a less important role in monetary policy.

Change the date. The second exercise is about the identification of the day of the monetary policy event. The same as in the section 4.3. I reestimate the baseline model but instead of the day t, the day when the meeting took place, I choose $t-1$ and $t+1$ days. In this example to capture the changes in investors' expectations, I use USD/RUB 3 month ahead futures.

On the figure 16 you can see the results, on the left figure (16a) you can see the $\mathcal{IRF}$s for one day after the meeting and on the right figure (16b) you can see the $\mathcal{IRF}$s for one day before the meeting.

The interesting this here is that after the decision we do not see any responses. However, one day before the meeting, the $\mathcal{IRF}$s are very similar to the $\mathcal{IRF}$s, for example, on figure 11. The movements of all macroeconomic indicators coincide with the movements in the day of the Board of Directors meeting. F statistics is also very high.

[5] Parameters of the Bank of Russia FX policy mechanism
`https://www.cbr.ru/eng/hd_base/valintbr/sp_fxpm_new/`



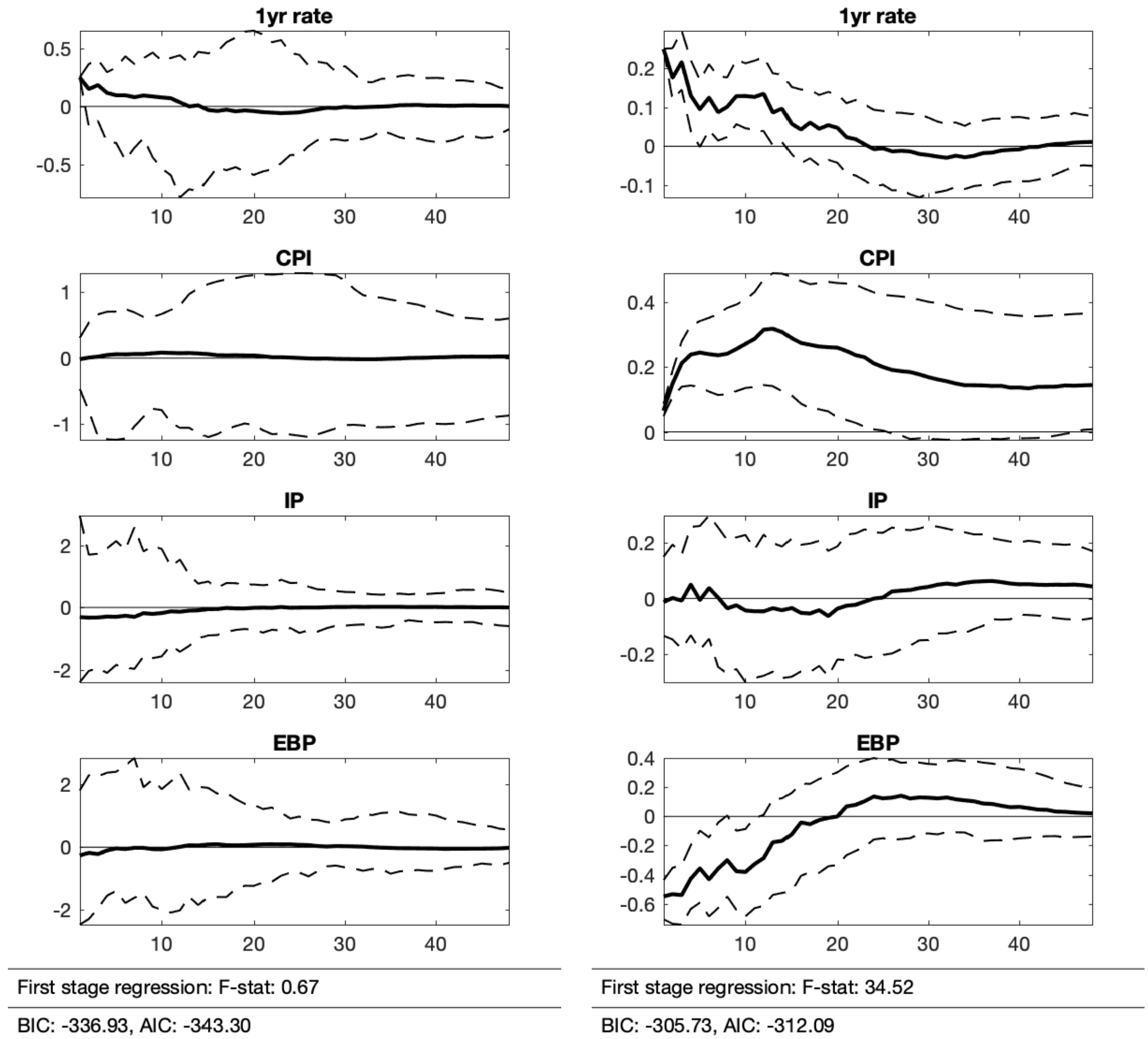
(a) Cholesky decomposition

(b) USD/RUB FX

Figure 15: Restricted sample, Cholesky and USD/RUB FX

One of the possible explanations is the following. Either in the day of meeting the monetary policy surprise is too small and insignificant for the market participants, or the opposite the market participants understand the future decision and change their expectations about future prices. In other words, I can not distinguish surprises on the day t and $t-1$ because they have very similar $\mathcal{IRF}$s. This brings new questions about the effects of monetary policy decisions on the financial market. The rest $\mathcal{IRF}$s you can see in the appendix.

Unfortunately, these robustness exercises do not inspire confidence in the obtained results. In my opinion, the question about transmission mechanism under the managed floating exchange rate regime



(a) 1 day after

(b) 1 day before

Figure 16: Robustness check, USD/RUB 3 month futures

is debatable, and it requires further study. The second date falsification exercise also does not show robustness. We have almost the same responses for two different dates.

5.4 Discussions

The bottom line of this section about Russia is the following. Firstly, I collect the dates of publication of monetary policy decisions by the Bank of Russia from 2008 to 2018. Secondly, I construct a new series of monetary surprises for Russia. Finally, I estimate SVAR models on Russian data.

I find that similar to the US, 1-year government bond rate increases in response to the tightening monetary policy. CPI shows the inverse U-shape curve. The form of this curve is questionable. Excess bond premium contradicts the theory and falls.

I expand this framework to the small open economy and find that the results coincide with the baseline specification. Tightening monetary policy increases the trade balance and decreases the exchange rate.

These models do not show robust results. The monetary policy under the managed floating exchange rate regime does show any significant results. Also, the falsification of the date of the decision only brings new questions.

Nevertheless, I think that this analysis about Russia is successful, although we have no robustness in the results, we still learn something new about the transmission mechanism in Russia. Finally, I cannot put an end to this study because all these issues require further study.

Conclusion

This paper shows the impact of monetary policy surprises on two markets: the USA and Russia. In both cases, I use external instruments approach, which allows obtaining exogenous monetary policy shocks on the intra-day data and on the daily data.

For the USA I confirm the results by Gertler and Karadi (2015). I find that the intra-day data better show the transmission mechanism for the USA economy. I have a statistically significant increase in 1-year government bond rate and excess bond premium. However, CPI shows some puzzles and do not decline as the theory predicts. Moreover, daily data show worse results. The reason for this is the following. During the whole day, a lot of new news comes to the markets. The investors take into account all of them and the information about the changes in the investors' expectations about monetary policy is lost. Finally, I provide one robustness check and find that monetary policy surprise that identified in the day of the FOMC meeting is unique; no other day gives the same surprises.

For Russia, the results are weaker. Instead of interest rate instruments which are not available for Russia, I use different currencies instruments. I find that the 1-year government bond rate increase in response to tightening monetary policy. Excess bond premium decreases, which contradict economic theory (however, there could be problems with the measurement of ebp). CPI shows the inverse U-shape curve. This response of CPI could be due to a non-immediate response to the tightening monetary policy. Moreover, in the case of a small open economy, the results stay the same.

Finally, the results do not survive robustness tests. If I restrict my sample to 2014:6 then the $\mathcal{IRF}$s do not show any responses. It can be due to a different type of monetary policy in which the interest rate plays a less important role.

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A. USA

A.1 Data list

The names of the variables coincide with names in working files for simplicity.

Intra-day and daily data:

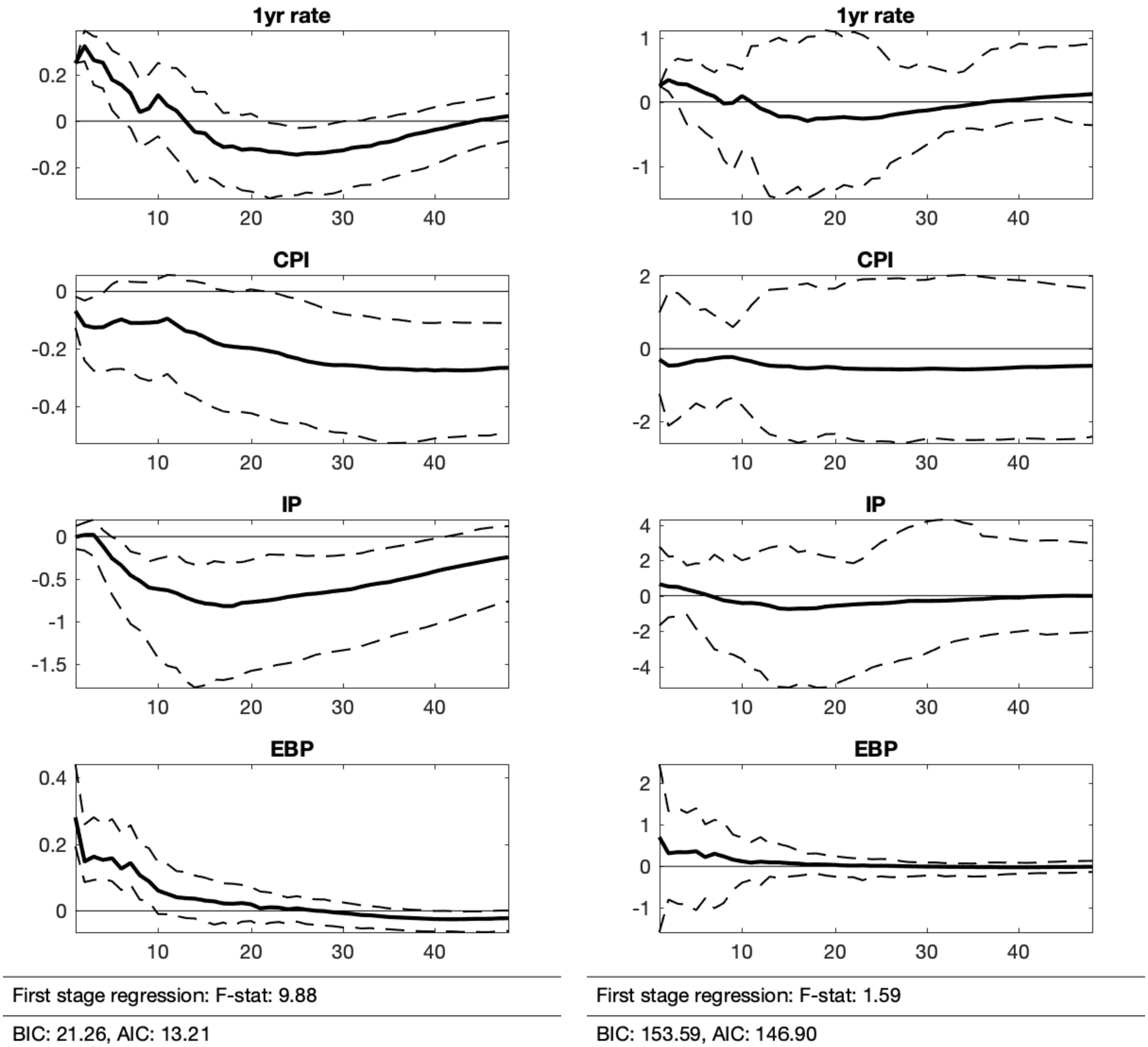
1. GK instruments (intra-day data):
   (a) ed2, ed3, ed4 – Eurodollar Futures, Continuous Contract #1 (six month ahead, ED1), #2 (nine month ahead, ED2), #3 (year month ahead, ED3);
   (b) mp1 (ff1), ff4 – 30 Day Federal funds Futures, Continuous Contract #1 (current month, ff1), #4 (3 month ahead, ff4);
2. Interest rate instruments (daily data):
   (a) ED2, ED3, ED4 – the same as above;
   (b) FF1, FF2, FF4 – the same as above plus Continuous Contract #2 (1 month ahead, FF2);
   (c) TY1, TY2 – 10 Yr Note Futures, Continuous Contract #1 (current month, TY1), #2 (3 month ahead, TY2);
   (d) FV2 – 5 Yr Note Futures, Continuous Contract #2 (3 month ahead, FV2);
   (e) US2 – U.S. Treasury Bond Futures, Continuous Contract #2 (3 month ahead, US2);
3. Currency:
   (a) EC1, EC2 – Euro FX Futures, Continuous Contract #1 (current month, EC1), #2 (1 month ahead, EC2);
   (b) EU – Spot Exchange Rate - Euro, USD/EUR Business day;
   (c) UK – United Kingdom – Spot Exchange Rate, USD$/POUND, Business day;
   (d) JY2 – Japanese Yen Futures, Continuous Contract #2 (1 month ahead, JY2);
   (e) DX1 – US Dollar Index Futures, Continuous Contract #1 (current month, DX1);
4. Index:
   (a) ES1, ES2, ES3 – E-mini S&P 500 Futures, Continuous Contract #1 (current month, ES1), #2 (3 month ahead month, ES2), #3 (6 month ahead, ES3);
   (b) SP2 – S&P 500 Futures, Continuous Contract #2 (6 month ahead, SP2);
   (c) YM1 – E-mini Dow ($5) Futures, Continuous Contract #1 (current month, YM1);
5. Additional instruments:
   (a) CL1 – Crude Oil Futures, Continuous Contract #1 (current month, CL10);
   (b) GC2 – Gold Futures, Continuous Contract #2 (1 month ahead, GC2);

Monthly data:

1. logcpi – logarithm of Consumer Price Index for All Urban Consumers: All Items (Index 1982-84=100);
2. logip – logarithm of Industrial Production Index (Index 2012=100);
3. gs1 – 1-Year Treasury Constant Maturity Rate (Percent);
4. ebp – Excess bond premium: spread between governments bonds and corporate bonds.

A.2 Other instruments $\mathcal{IRF}$s

1. Figure 17 represents $\mathcal{IRF}$s for surprises identified from Eurodollar deposits and EUR/USD FX rates;
2. Figure 18 represents $\mathcal{IRF}$s for robustness exercise using 3 month ahead Federal funds futures.

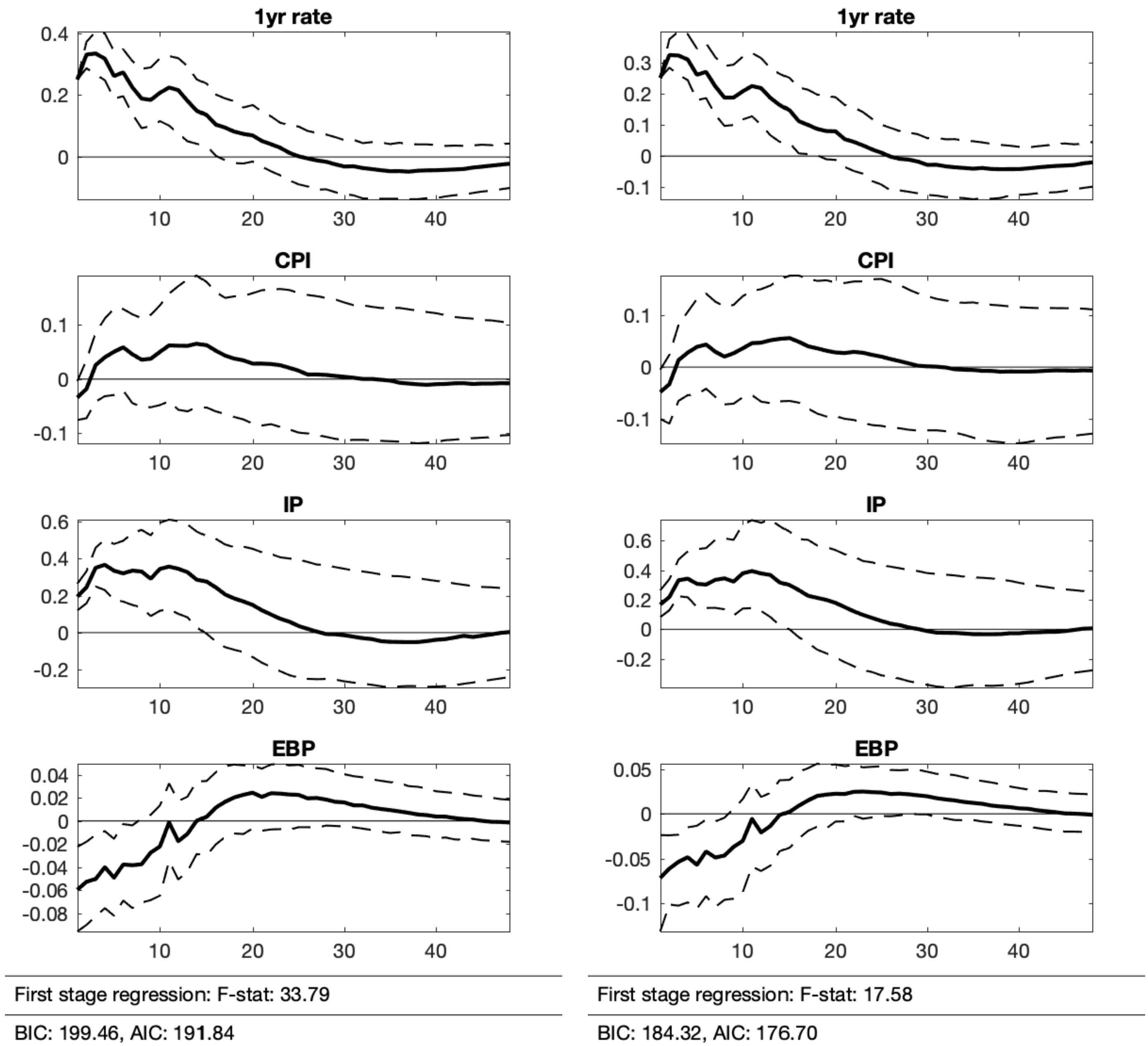


(a) ED2

(b) EUR/USD FX rate

Figure 17: Eurodollar Futures and EUR/USD FX rate

A.3 Other robustness checks



(a) 2 days after

(b) 2 days before

Figure 18: Robustness test, FF4

B. Russia

B.1 Data list

The names of the variables coincide with names in working files for simplicity.

Intra-day:

1. Eu_m – Euro/RUB Futures, Continuous Contract #2 (3 month ahead);
2. Si_m – USD/RUB Futures, Continuous Contract #2 (3 month ahead);
3. MIX_m – MOEX Futures, Continuous Contract #2 (3 month ahead);
4. RTS_m – RTS Futures, Continuous Contract #2 (3 month ahead);

Daily data:

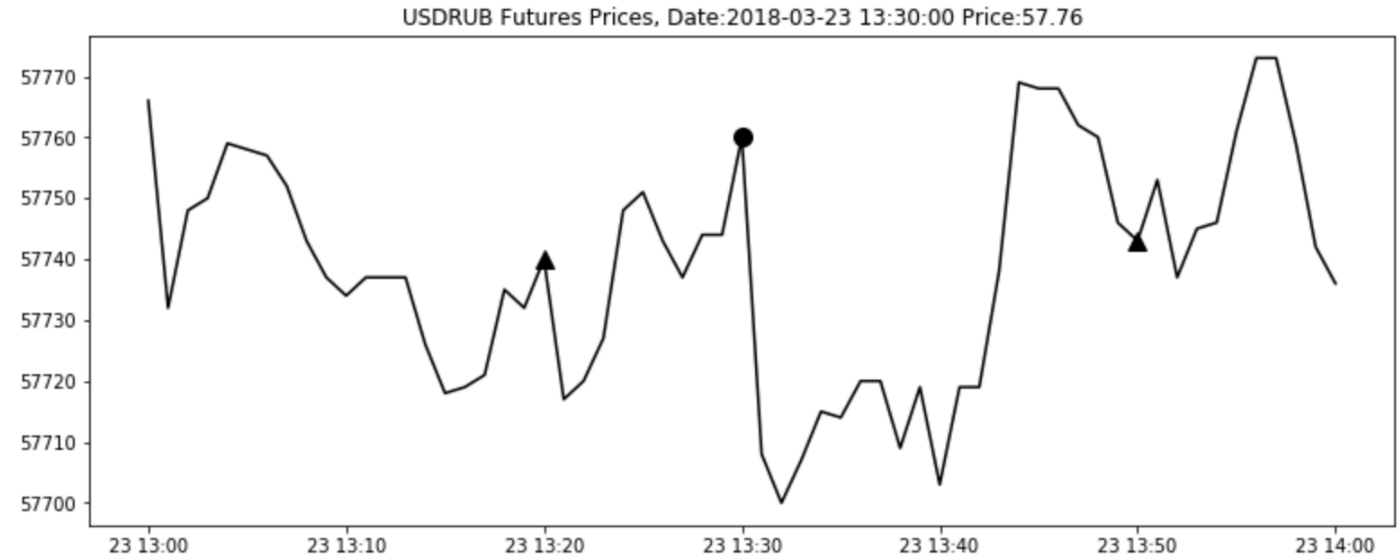
1. EURRUB1M – Euro/Russian Rouble 1 Month FX Forward Swap;
2. EURRUB3M – Euro/Russian Rouble 3 Month FX Forward Swap;
3. EURRUBFX – Euro/Russian Rouble FX Cross Rate;
4. EURRUBONOR – Euro/Russian Rouble Overnight FX Forward Outright;
5. USDRUB1M – US Dollar/Russian Rouble 1 Month FX Forward Swap;
6. USDRUB3M – US Dollar/Russian Rouble 3 Month FX Forward Swap;
7. USDRUB1MNDFOR – US Dollar/Russian Rouble 1 Month FX Non-Deliverable Outright;
8. USDRUB3MNDFOR – US Dollar/Russian Rouble 3 Month FX Non-Deliverable Outright;
9. USDRUBFX – US Dollar/Russian Rouble FX Spot Rate;
10. USDRUBONOR – US Dollar/Russian Rouble Overnight FX Forward Outright;
11. IMOEX – MOEX Russia Index;
12. IRTS – RTS Index;
13. MCX10 – MICEX 10 Index;
14. RTSSTD – RTS Standard Index;
15. Si_d – USD/RUB Futures, Continuous Contract #2;
16. Si_s1_d – USD/RUB Futures, Continuous Contract #2, 1 day before the meeting;
17. Si_s2_d – USD/RUB Futures, Continuous Contract #2, 2 days before the meeting;
18. Si_b1_d – USD/RUB Futures, Continuous Contract #2, 1 day after the meeting;
19. Si_b2_d – USD/RUB Futures, Continuous Contract #2, 2 days after the meeting;

Monthly:

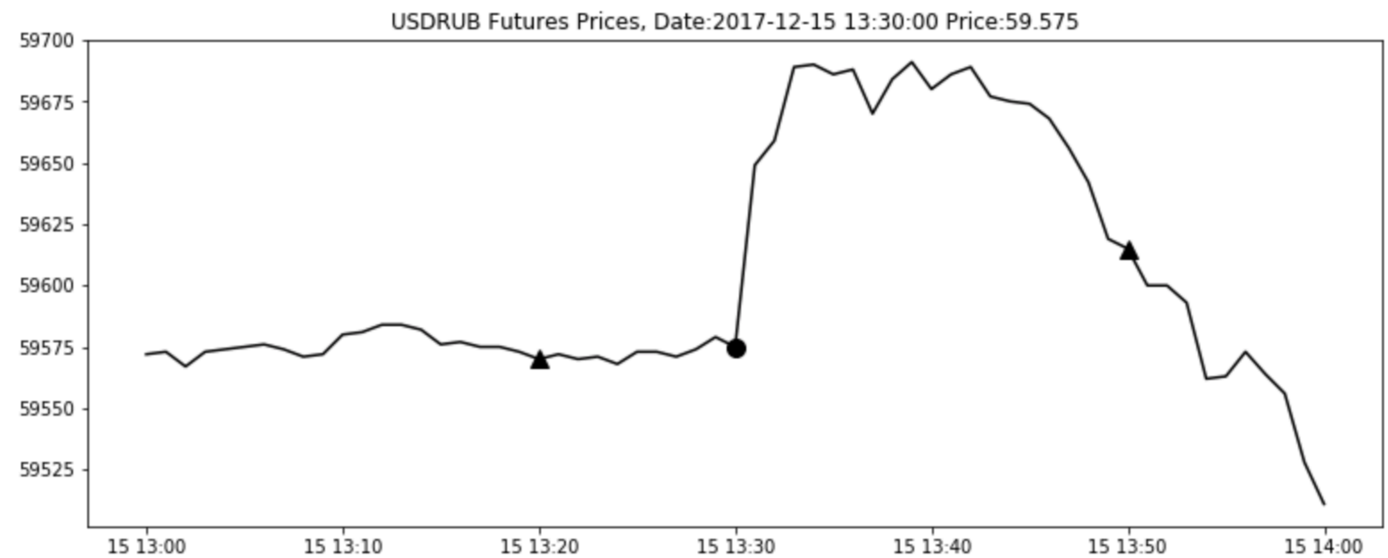
1. ebp – Spread between Russian Government Bond Index and Moscow Exchange Corporate Bond index;
2. GB1Y – 1-year government bond rate;
3. CPI – Russia CPI, Standardized, SA, Index, 2010=100;
4. IP – Russia Industrial Production Index, Standardized, SA, Index, 2010=100;
5. POILAPSP_p – Crude Oil (petroleum), simple average of three spot prices; Dated Brent, West Texas Intermediate, and the Dubai Fateh;
6. RVI – Russian Volatility Index (from 2006-01 to 2016-12 – RTSVX – RTS Volatility Index);
7. NER – Russia BIS, Nominal Broad Effective Exchange Rate Index, 2010=100;
8. RER – Russia BIS, Real Broad Effective Exchange Rate Index, 2010=100;
9. Imports_tr – Russia Imports, free on board, USD, Index, 2010=100, SA;
10. Exports_tr – Russia Exports, free on board, USD, Index, 2010=100, SA;
11. TB – Export minus Import, SA.

B.2 Other instruments $\mathcal{IRF}$s

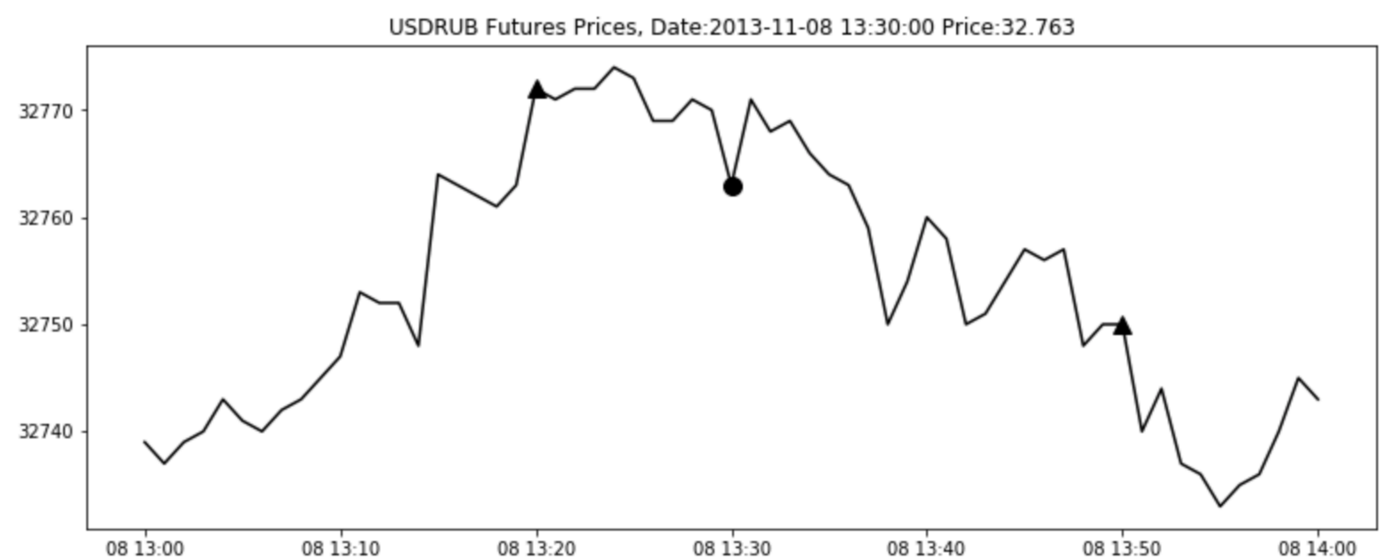
1. Figure 19 represents intra-day data for the time of decision publication;
2. Figure 21 represents $\mathcal{IRF}$s for open economy, surprises identified from USD/RUB spot rate, 2 lags;
3. Figure 22 represents $\mathcal{IRF}$s for robustness exercise using USD/RUB futures, test for the day of meeting;
4. Figure 23 represents $\mathcal{IRF}$s for robustness exercise using USD/RUB futures, restricted sample test.



(a) Surprise at 2018-03-23, cut by 0.25%, new rate is 7.25%

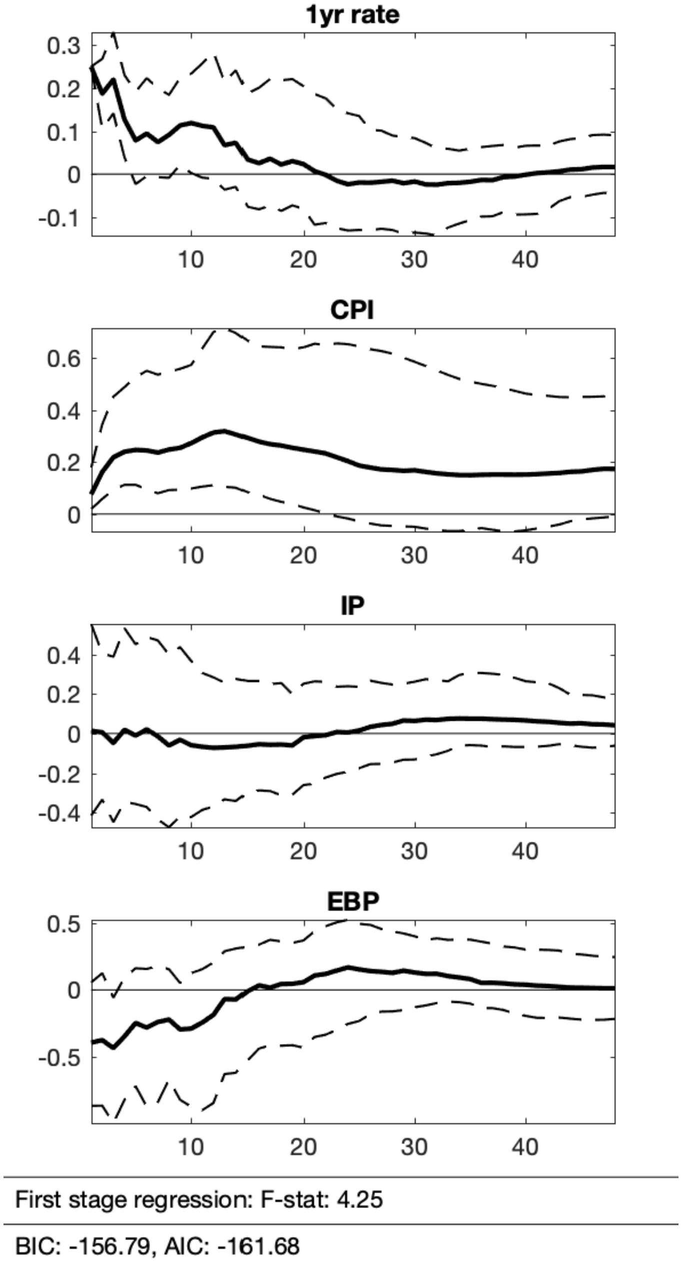


(b) Surprise at 2017-12-15, cut by 0.5%, new rate is 7.75%

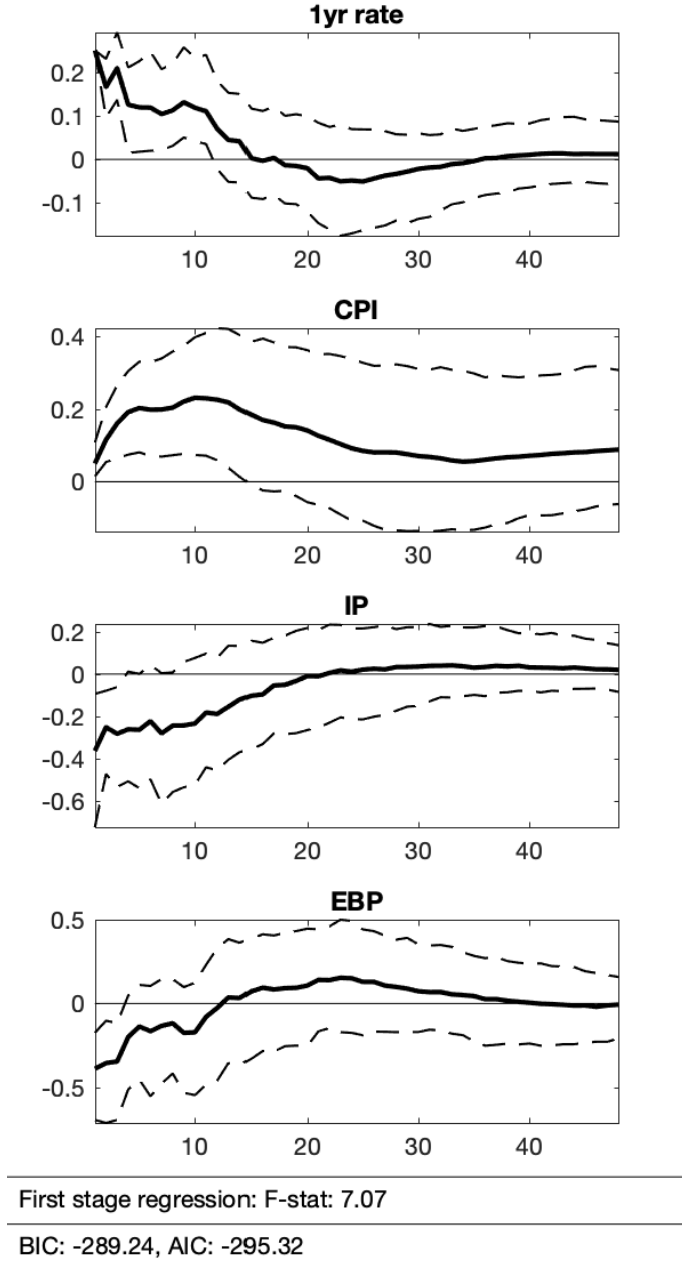


(c) Surprise at 2013-11-08, keep rate at 5.5%

Figure 19: Minutes surprises

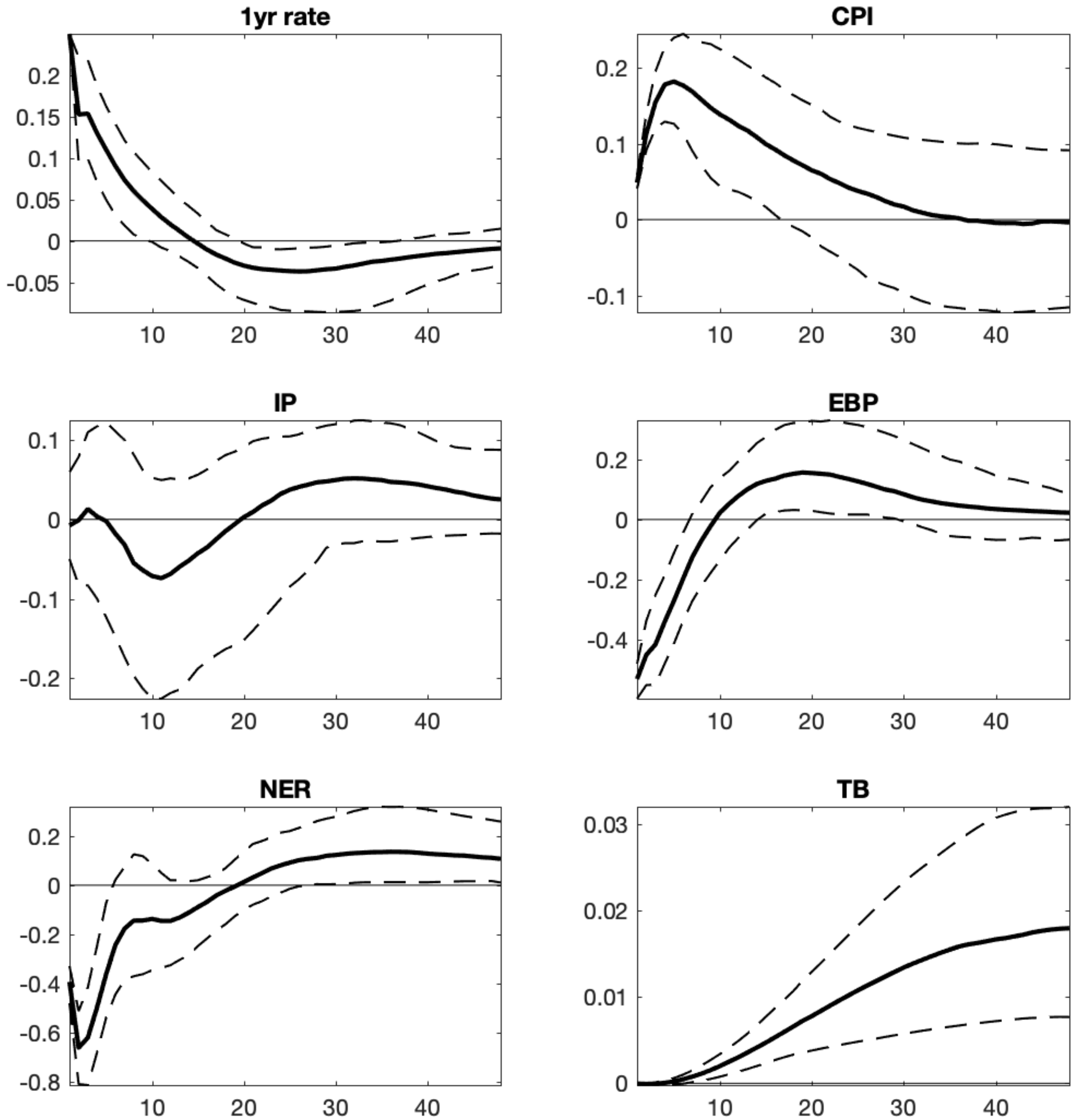


(a) MOEX futures #2



(b) RTS futures #2

Figure 20: Closed economy, RTS index futures

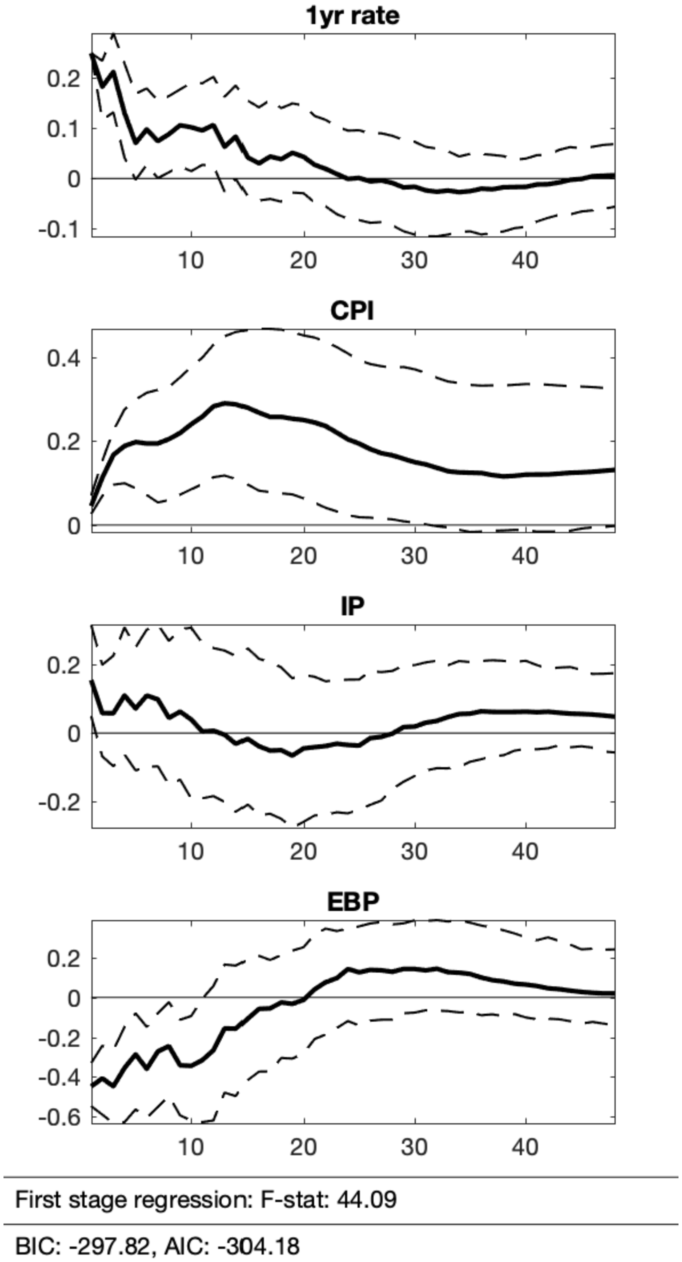


First stage regression: F-stat: 34.09

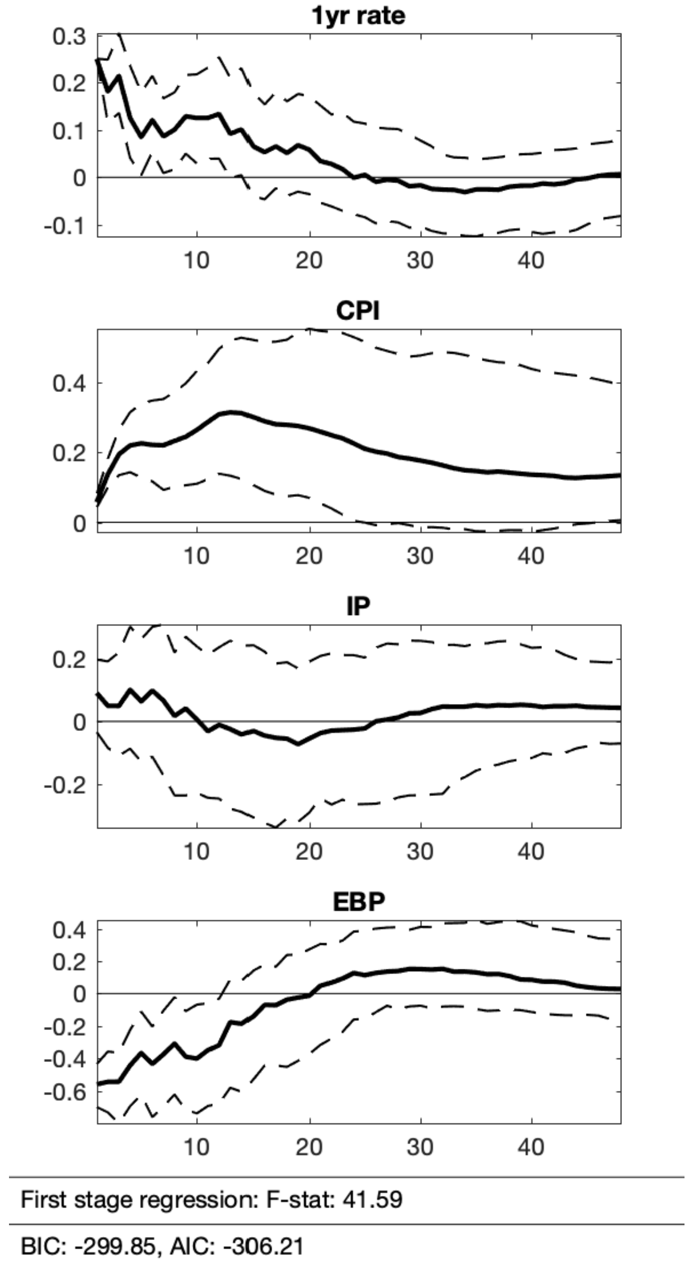
BIC: -367.05, AIC: -373.42

Figure 21: Open economy with nominal exchange rate, no exogenous

B.3 Other robustness checks

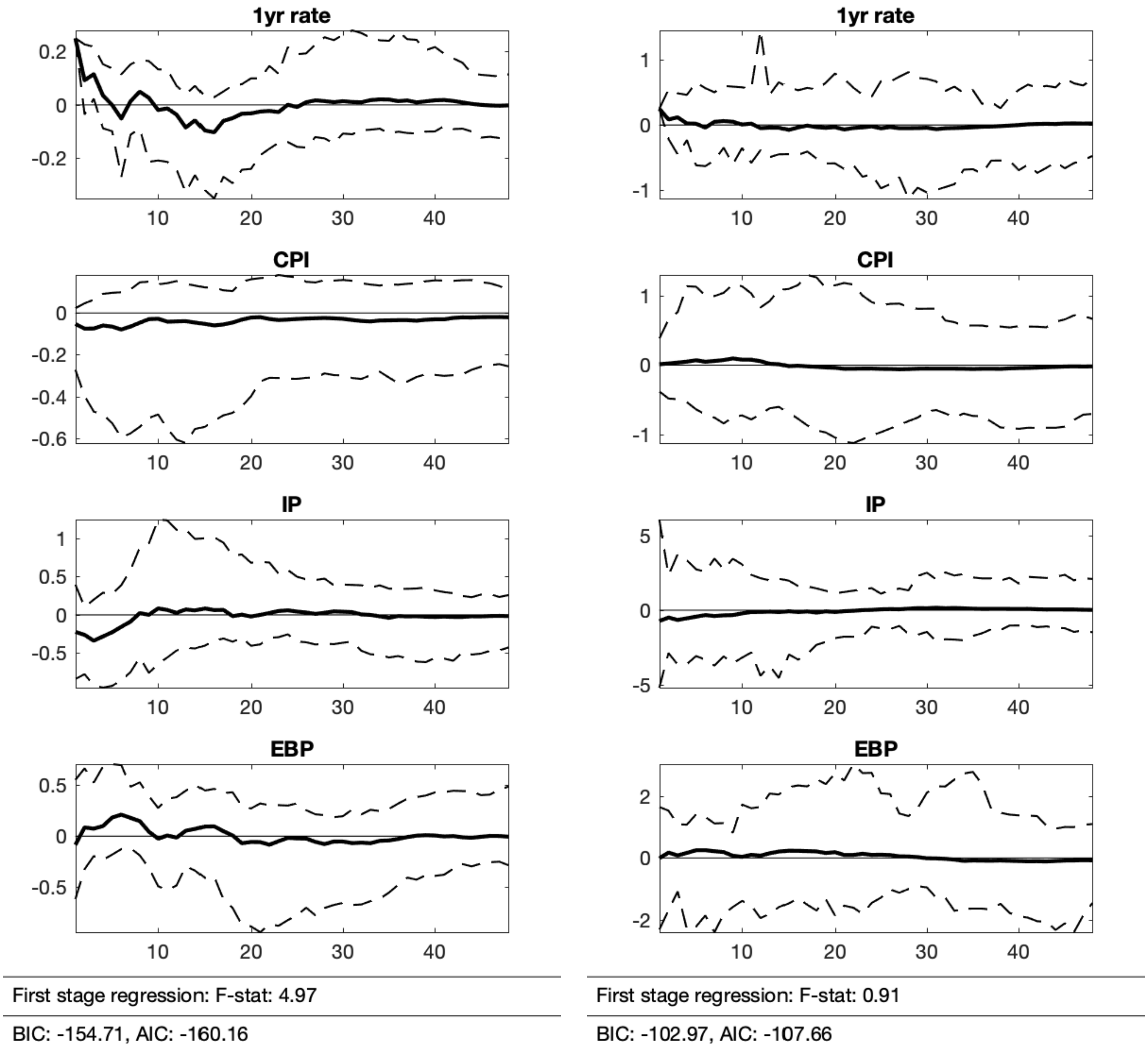


(a) 2 days after



(b) 2 days before

Figure 22: Robustness check



(a) USD/RUB Futures #2, daily data

(b) USD/RUB Futures #2, minute data

Figure 23: Restricted sample