Sterilized Interventions in the Form of Foreign Currency Repos: VECM Analysis Using Russian Data¹

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The study examines the foreign currency repo program launched by the Bank of Russia after financial sanctions were imposed on Russia in 2014. Russian 2014–2017 daily statistics were used to estimate three vector error correction models which revealed a statistically significant temporary effect of sterilized interventions in the form of foreign currency repos on the ruble exchange rate to the dollar. An impulse response of the exchange rate to the expansion in foreign-currency-denominated borrowings has the correct sign, reaches its maximum on the 9th business day and is found to be statistically significant within 7–14 business days after the auction date. The response of the exchange rate was found to be asymmetric: the winding down of the foreign currency repo program had no statistically significant effect on the exchange rate.

Keywords: *VECM, sterilized interventions, interventions' effectiveness, foreign currency repos*

JEL: *E58, F32*

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1. Introduction

During the global financial crisis, many central banks extensively used sterilized foreign currency interventions to prevent excessive weakening of national currencies arising from sizable capital outflows. This instrument helps moderate the transfer of exchange rate fluctuations to prices as balance of payments shocks arise, reduce exchange rate volatility, and maintain currency market liquidity. Sterilized foreign currency interventions can be used on a regular basis as part of the inflation targeting regime, provided that a central bank only uses them to normalize the operation of the foreign currency channel of monetary transmission.

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The main problem with the use of this instrument is its relative weakness, prompting many researchers to test its effectiveness². This study deals with the Bank of Russia's experience of using sterilized foreign currency interventions in the initial period of the financial sanctions (2014–2015). To estimate the response of the ruble/dollar exchange rate to the sterilized interventions in the form of foreign currency repos, the study uses the vector autoregression (VAR)³ technique. The study is an empirical one and aims to obtain statistical evidence of this instrument's effectiveness. A theoretical discussion of various transmission channels of sterilized interventions is beyond the scope of this paper.

The study makes a contribution to examining foreign currency intervention effectiveness, drawing on the 2014–2017 Russian data. The main finding of the study is generally in line with a wide range of research papers on this issue and provides evidence that the Bank of Russia is capable of affecting the exchange rate through foreign currency repo auctions. The vector error correction models (VECM) reveal a statistically significant temporary effect of sterilized foreign currency interventions on the ruble exchange rate. The effect reaches its maximum on the 9th business day after the foreign currency repo date. Also, the exchange rate was found to respond asymmetrically to positive and negative interventions. Ruble/dollar exchange rate response to positive interventions (an expansion in commercial banks' foreign currency borrowings from the Bank of Russia) has the correct sign and is statistically significant, while the response to negative intervention is not. This conclusion agrees with the result of Domanski et al. (2016), which found evidence of a statistically significant relationship between the Karnaukh et al. (2015) measure of foreign currency market illiquidity and foreign currency repo auctions in Russia. Domanski et al. (2016) emphasized that the purpose of foreign currency repo auctions was to support foreign currency market liquidity, while what caused its illiquidity as the financial sanctions were imposed in 2014–2015 was that it made medium- and short-term foreign currency borrowings impossible for banks. This brought about a foreign currency supply squeeze in the market at times, with liquidity declining and the dollar exchange rate rising. The foreign currency repo auctions were intended to substitute Bank of Russia loans for borrowings from foreign countries prohibited under the sanctions and thus support both foreign currency market liquidity and the depreciating ruble. The analysis of foreign currency tenders in Hungary described in Balogh et al.

² A number of studies dealing with comparative analysis of sterilized interventions in various countries, provide evidence of this instrument's effectiveness. Ghosh et al. (2015) draws a conclusion that 9 out of 13 empirical studies conducted in 1999–2011 to examine emerging markets, find sterilized interventions to be effective. Menkhoff (2013) surveys a multitude of empirical studies related to the issue of intervention effectiveness in Latin America, Asia, and Eastern Europe, and concludes that this approach has been quite successfully used in emerging market economies to make an impact on the exchange rate. Daude et al. (2016) uses quarterly panel data from 18 emerging market economies for estimating an error correction model in order to prove the effectiveness of foreign currency interventions. Fratzscher et al. (2015) analyzed 33 countries and found that 80% of were effective from the perspective of key criteria.

³ The foreign currency repo auctions are an example of foreign exchange derivatives discussed in Domanski et al. (2016), which offers evidence that the Bank of Russia's sterilized foreign currency interventions were effective following a switchover to the floating exchange rate regime in late 2014.

(2013) helps understand why similar banking liquidity support programs do not always produce a relationship between market liquidity and the exchange rate.

The paper consists of four sections. Section 2 describes the foreign currency repo program held by the Bank of Russia. Section 3 presents the results of estimating three VECMs. Section 4 discusses these results. The conclusion sums up the main findings.

2. Russian foreign currency repo auctions

In late 2014, the Bank of Russia discarded the foreign exchange adjustment rule adopted in February 2009 during the global financial crisis.⁴ The switchover to the floating exchange rate regime was originally scheduled for 2015, but a series of negative shocks at the end of 2014 led the Bank of Russia to speed up the introduction of this policy, as under those conditions the exchange band adjustment rule used at that time made exchange rate movements predictable, benefitting speculators. The inevitable problems arising from the switchover to the new regime coincided with a peak of adverse balance of payments shocks (giving rise to “a perfect storm”), which drastically increased foreign currency market volatility and depreciated the ruble. One of these shocks resulted from sanctions imposed on Russian commercial banks, making it difficult for them to obtain medium- and short-term financing abroad. To address the problem of shrinking currency market liquidity, the Bank of Russia launched foreign currency repo auctions which helped banks to substitute Bank of Russia loans for external borrowings.

Foreign currency loans provided by a central bank are deemed to be sterilized interventions, as in this case a central bank expands foreign currency supply without affecting domestic money supply. The Bank of Russia, however, refrained from using the term ‘intervention’ in order not to mislead economic agents, for this term had been previously used with reference to direct buying/selling of foreign currency into/from international reserves.

In April 2015, the amount of foreign currency lent to commercial banks via foreign currency repo auctions reached a peak of \$35 bln, accounting for 8% of the Bank of Russia’s international reserves.

Domanski et al. (2016) points out that authorities increasingly used FX derivatives or related instruments. This allowed them to provide hedges against FX risk and influence FX market liquidity and the exchange rate while economising on the use of FX reserves and retaining foreign reserve buffers. They also showed that in four emerging market economies (Russia, Brazil, Peru, and Turkey), interventions to provide foreign currency liquidity to the banking sector were effective in reducing the Karnaukh et al. (2015) measure of market illiquidity.

To make it clear why the foreign currency repo auctions can also affect the exchange rate, we will compare the case of Russia with Hungary’s foreign currency

⁴ Estimation of the exchange rate policy rule prior to and following the global financial crisis based on a DSGE model was conducted in Shulgin (2017a).

tenders described by Balogh et al. (2013). This paper says that the National Bank of Hungary established this instrument of supporting banking liquidity in September 2011, when the Hungarian Parliament ratified legislation that allowed Hungarian households, under certain conditions, to repay their foreign-currency-denominated mortgages at preferential, predetermined exchange rates. This created an open foreign currency position of significant but uncertain size on the balance sheet of the Hungarian banking system. The National Bank of Hungary decided to respond “in a structured manner with the aim of minimizing motivation for speculative sales of Hungarian forints”. As information on Hungarian banks’ demand for euros as part of the program was available to the central bank, it was able to prevent speculative pressure on the foreign currency market. The entire amount of foreign currency distributed by the central bank via the foreign currency tender program was used by Hungarian banks’ household customers to repay their foreign-currency-denominated mortgages rather than by banks themselves – for speculative purposes.⁵

The Russian foreign currency repo program can also be described as a structured response to foreign currency outflows upon the imposition of the financial sanctions. The difference of the Russian situation from the Hungarian one is that, first, in Hungary, foreign currency outflows were assumed to be permanent, changing the structure of Hungarian banks’ assets, whereas in Russia, they were temporary in nature, although of uncertain duration. This explains the fact that the National Bank of Hungary had to go accept a reserve contraction, whereas the Bank of Russia was able to use foreign currency derivatives (repos), thereby avoiding direct selling of foreign currency from reserves. The Hungary’s program also differs in that information on Hungarian banks’ demand for foreign currency is available to its central bank. This is not the case for the Bank of Russia, with Russian banks being able to buy excess foreign currency, which they could then use for speculation in the highly volatile market. This speculation has a stabilizing effect, as it helps to increase foreign currency supply when there is a shortage of it. As this speculation did not entail a long-term decline in international reserves, one can regard this kind of speculative activity as beneficial for the Russian economy.

Another distinction of Russia’s foreign currency repo program is that banks could be uncertain whether they would be able to obtain the entire amount of foreign currency they needed at one auction, which provoked them to buy foreign currency *in advance*. Banks could accumulate the amount of currency needed for their payments at several auctions, and, because of it, the response of the exchange rate to a foreign currency repo auction could be lagged.

The time span under analysis also includes the period of winding down the foreign currency auctions, beginning from May 2015, when the Bank of Russia was scaling down the amount of foreign currency provided to banks. The period of negative sterilized interventions was a quieter time stretch,

⁵ Balogh et al. (2013) notes that the Hungarian foreign currency tenders covered around 60% of EUR 4.35 bln of actual payments under this program. Banks obtained the other 40% from other sources, which could have been the cause of excess supply of forints in the market, possibly making a contribution to 12% forint depreciation in late 2011.

featuring a smaller measure of foreign currency market illiquidity than in the period of the sanctions. This means that the principle of using foreign currency interventions for regulating the measure of illiquidity remains the same as for positive interventions, but the exchange rate response to negative interventions can be essentially different, as both of the core features of positive interventions referred to above as excess and in advance are no longer relevant. This is a strong argument for assuming an asymmetric exchange rate response to positive and negative sterilized interventions.

3. VECM estimation

VAR technique is employed for estimating structural models which allow predicting the effect of “intervention” – intentional political activities or changes in the economy or nature of a certain type (Hurwicz, 1966). This technique is widely used to analyze the effectiveness of interventions based on daily data. Chen and Rogoff (2003) and Ferraro et al. (2015) showed that the most important fundamental exchange rate factor for commodity-exporting economies is the price of the commodity in the production of which this economy specializes. Russia undoubtedly falls under this group, hence the oil price is the required variable in the model claiming to explain foreign currency exchange rate movements. Based on this, a minimalist model (hereafter referred as VECM1) for estimating the effectiveness of sterilized foreign currency interventions should include the exchange rate, the oil price, and a variable for sterilized interventions. This variable can be split into the positive and negative parts if there are enough grounds to assume an asymmetric response of the exchange rate. It would make sense to complement the minimalist model with an interest rate as a conventional monetary policy instrument (model VECM2), which would allow separating the effect of an interest rate change from that of sterilized foreign currency interventions. This needs to be done, as the Bank of Russia used both instruments in the course of the 2014–2015 crisis. To enhance the robustness of the results obtained, the study estimates model VECM3, incorporating the exchange rate, the interest rate, and the oil price, as well as one variable for sterilized foreign currency interventions (it does not allow tests for an asymmetric response).

All the three models include an integrated in order one oil-price series which, under Chen and Rogoff (2003), renders the exchange-rate series also integrated of order one. The two series thus become cointegrated, and as such, VECM needs to be estimated in order to take account of the cointegration residual role in exchange rate movements.⁶

⁶ We will illustrate this role with the following abstract example: let the long-term oil price elasticity of the exchange rate defined by the cointegration vector be equal to -0.5. Then, if exchange rate short-term response to oil price movements is, for some reason, match a short-term elasticity of -0.4, then the difference between the long-term and short-term elasticities will be a factor of exchange rate movements in the near future which VECM is capable of capturing, while a conventional VAR would fail to take account of this.

3.1. Dataset

The time series used to estimate the models include 618 observations (business days) from November 6, 2014, to April 20, 2017 and are presented in Figures 1 and 2 (see Appendix). Oil price $P_{oil,t}$ is the OPEC basket price per barrel in USD terms. Exchange rate S_t is the average spot price for delivery TODAY on the Moscow Exchange, in terms of rubles per dollar. The model uses natural logarithms of both oil price $P_{oil,t}$ and exchange rate S_t (denoted in capital letters) in order to enable the oil price elasticity of the exchange rate to be measured. The interest rate, standing for monetary policy, is key rate $i_{k,t}$ in percent terms. We will define cumulative sterilized intervention Z_t as the Bank of Russia's total claims on commercial banks in terms of US dollars resulting from foreign currency repo auctions as of day t .⁷ Then sterilized interventions ΔZ_t are the amount of US dollars distributed at a foreign currency repo auction on day t less the amount of dollars repaid by banks on day t as liabilities assumed at previous foreign currency repo

auctions. Series ΔZ_t can be split into the positive $\Delta Z_t^+ = \begin{cases} \Delta Z_t & \text{if } \Delta Z_t > 0 \\ 0 & \text{if } \Delta Z_t \leq 0 \end{cases}$ and negative $\Delta Z_t^- = \begin{cases} \Delta Z_t & \text{if } \Delta Z_t \leq 0 \\ 0 & \text{if } \Delta Z_t > 0 \end{cases}$ parts, so that $\Delta Z_t = \Delta Z_t^+ + \Delta Z_t^-$.

Then the cumulative positive and negative interventions will amount to

$$Z_t^+ = \sum_{j=0}^{t-1} \Delta Z_{t-j}^+ \quad Z_t^- = \sum_{j=0}^{t-1} \Delta Z_{t-j}^- \quad Z_t = Z_t^+ + Z_t^- \quad (1)$$

For more details of data used in estimation, see Shulgin (2017b).

Figure 1 (see Appendix) presents the cointegration of series S_t and $P_{oil,t}$, which can be confirmed by all tests for cointegration at the 1%-level of statistical significance.⁸ This figure also shows that the foreign currency repo auctions were quite large in volume⁹ and mostly held until May 2015 (when they were wound down). The negative sterilized interventions were predominant from May 2015 and more smoothed in time than positive interventions. May 2015 saw a peak of auctions, with the Bank of Russia providing about \$35 bln to commercial banks, or 8% of its international reserves.

⁷ The Bank of Russia website provides information on the regulator's foreign currency repo requirements for credit institutions (https://www.cbr.ru/hd_base/repo_debtusd/). For the purposes of this study, Bank of Russia data was shifted three business days backward (two days for foreign currency delivery plus one day for the data to be cited as of the end of business day rather instead of the beginning of it, as provided on the Bank of Russia's website. In this mode, the data conforms to information on the foreign currency repo auctions (https://www.cbr.ru/hd_base/repofx/).

⁸ The study confirms this relationship in estimating the cointegration vector: the coefficient at $P_{oil,t}$ shows to be statistically significant at the 0.1% level. (Table 1).

⁹ For instance, the amount of foreign currency distributed via the foreign currency repo auctions from December 2014 to March 2015 accounted for 6.5% of the spot foreign exchange market total turnover on the Moscow Exchange over the period.

3.2. Results of VECM estimation

VECM are estimated in the JMulti (Lutkepohl and Kratzig, 2004) package using the canonical estimation form as follows:

$$\Delta y_t = \alpha [\kappa \quad \eta] \begin{bmatrix} y_{t-1} \\ 1 \end{bmatrix} + \sum_{j=1}^{20} \Gamma_j \Delta y_{t-j} + u_t \quad (2)$$

$$u_t = B e_t \quad (3)$$

where y_t is $N \times 1$ vector of N endogenous variables; α is the vector of use factors; $[\kappa \quad \eta]$ are cointegration vector coefficients $\begin{bmatrix} y_{t-1} \\ 1 \end{bmatrix}$; Γ_j is the parameter matrix with dimension $N \times N$; u_t is a an N -dimensional vector of unobservable random processes with zero mathematical expectation; B is the matrix determining the effect of structural shocks e_t on endogenous variables y_t in the current period. The logarithm of oil price $p_{oil,t}$ is included in the cointegration ratio and estimated as an exogenous random walk:

$$\Delta p_{Oil,t} = u_{p_{oil},t} \quad (4)$$

With a view to this, constraints are set on coefficients in Γ_j , α , and κ . The variables of cumulative sterilized interventions Z_t^* and Z_t^- are not included in the cointegration vector for VECM1 and VECM2, while key interest rate $i_{k,t}$ is not included in the cointegration vector for VECM2, for which purpose relevant constraints are set on α and κ ¹⁰.

All the three VECMs are estimated for a lag of 20 business days using a two-stage estimation procedure. In the first stage, the use of a simple two-step (S2S) estimation method enables the cointegration vector to be estimated with constraints imposed on the coefficients; the second stage uses the generalized least-squares (GLS) method to take account of constraints imposed on α and Γ_j (Lutkepohl and Kratzig, 2004). The structural equation (3) is estimated by the maximum likelihood method (Breitung et al., 2004). Standard errors, given in the parenthesis, are computed by the bootstrap method. Estimation of the matrix B coefficients uses the following assumptions: first, the structural shocks of all the endogenous variables may have an instantaneous effect on exchange rate S_t ; second, structural oil price shocks $e_{p_{oil},t}$ may have an instantaneous effect on all the endogenous variables. All other instantaneous effects of structural shocks are disregarded, which requires setting relevant constraints on the entries of matrix B . The latter causes an overidentified system to emerge, and the LR test does not allow rejecting a hypothesis that all constraints imposed on matrix are valid for all the three VECMs estimated.

¹⁰ This decision is confirmed by the statistical insignificance of coefficients at variables Z_t^* and $i_{k,t}$ in VECM3 cointegration vector (Table 1).

Table 1. The main results of estimating the three VECMs

	VECM1	VECM2	VECM3
Number of endogenous variables, N	4	5	4
Vector of endogenous variables	$[s_t \ Z_t^+ \ Z_t^- \ p_{Oil,t}]'$	$[s_t \ i_{k,t} \ Z_t^+ \ Z_t^- \ p_{Oil,t}]'$	$[s_t \ i_{k,t} \ Z_t \ p_{Oil,t}]'$
Number of lags	20	20	20
Cointegration vector	$EC_t = s_t + 0.418 p_{Oil,t} -$ -5.724 <small>(0.040)</small> <small>[10.33]</small>	$EC_t = s_t + 0.443 p_{Oil,t} -$ -5.817 <small>(0.037)</small> <small>[11.84]</small>	$EC_t = s_t + 0.443 p_{Oil,t} -$ $-0.0008 i_{k,t} + 0.0014 Z_t - 5.844$ <small>(0.041)</small> <small>(0.0085)</small> <small>(0.0012)</small> <small>(0.173)</small> <small>[-0.09]</small> <small>[1.23]</small> <small>[-33.72]</small>
Use factors	$[-0.046 \ 0 \ 0 \ 0]$ <small>(0.012)</small> <small>[-3.79]</small>	$[-0.045 \ 0 \ 0 \ 0 \ 0]$ <small>(0.011)</small> <small>[-3.91]</small>	$[-0.047 \ 0 \ 0 \ 0]$ <small>(0.012)</small> <small>[-4.03]</small>
LR test for validity of constraints on matrix B coefficients	$\chi^2(1) = 0.652,$ $prob. = 0.419$	$\chi^2(3) = 1.361,$ $prob. = 0.715$	$\chi^2(1) = 0.010,$ $prob. = 0.921$
Long-run oil price elasticity of exchange rate	-0.418 <small>(0.040)</small> <small>[10.33]</small>	-0.443 <small>(0.037)</small> <small>[11.84]</small>	-0.443 <small>(0.041)</small> <small>[10.89]</small>
t-test of hypothesis that long-run oil price elasticity of exchange rate estimated is not different from estimate obtained in Polbin (2017)	$t(275) = 1.023,$ $prob. = 0.153$	$t(277) = 1.339,$ $prob. = 0.091$	$t(275) = 1.310,$ $prob. = 0.096$
Statistically significant (95% confidence interval) exchange rate response to intervention	6–14 business days after positive intervention	7–14 business days after positive intervention	7–14 business days after intervention

The functions of impulse response (IRF) are presented in Appendix (Figures 3–13). 95% confidence intervals were obtained by the bootstrap method using Hall (Hall, 1992) and Efron-Tibshirani (Efron and Tibshirani, 1993) algorithms.

For more data on the VESMs estimated, see Shulgin (2017b).

4. Discussion of results

The cointegration vector estimated in the first stage contains data on the long-term oil price elasticity of the exchange rate, found to be equal to -0.418 (VECM1) and -0.443 (VECM2 and VECM3). It can be seen from Table 1 that these estimates

are highly statistically significant and robust to the model specification. The absolute value of this elasticity was found to be higher than the estimate of Polbin (2017), which, based on 1999–2016 monthly data, obtained a value of -0.33. First, it should be noted that Polbin (2017) estimated real exchange rate long-run elasticity with respect to terms of trade (the real oil price), while the estimate based on daily data disregards the price mechanism of balance of payments adjustment to an oil price change. Second, the time span analyzed in Polbin (2017) includes a period when foreign exchange rules that limited exchange rate adjustment to oil price movements were in effect, which may have reduced the long-run elasticity. At the same time, from the statistical perspective, elasticities obtained in estimating the three models are not different from those in Polbin (2017): the hypothesis that they are equal cannot be rejected at the 5% significance level (see the results of the t-test in Table 1).

The use factor for ΔS_t is estimated respectively at -0.046 (VECM1), -0.045 (VECM2), and -0.047 (VECM3). Its statistical significance means that the cointegration residual (Figure 11, Appendix) is a significant factor of exchange rate performance. According to the estimate, around 5% of the difference between the previous exchange rate and its long-run value determined by the previous oil price (see the cointegration vector) will be adjusted on the next business day.¹¹ In order to analyze the adequacy of the estimated model as a whole, the impulse response functions (IRF) presented in Appendix (Figures 3–13) should be analyzed.

Figures 3, 7, 9, and 12 (see Appendix) show the main result obtained in the study: a statistically significant (within the 95% confidence interval) response of exchange rate S_t to positive intervention shock $e_{z,t}$ within 7–14 business days after the repo auction date. The exchange rate response has the correct sign, because the larger the amount of foreign currency distributed via the foreign currency auctions, the more the national currency strengthens. This response provides statistical evidence of sterilized foreign currency intervention effectiveness, obtained through the VAR technique using Russian daily data. This result is robust to the model's specification: the introduction of the interest rate into the model does not change the conclusion about the effectiveness of sterilized interventions. The effectiveness of foreign currency interventions is normally assessed based on the exchange rate response on the day of intervention or within 1–2 days, but Disyatat and Galati (2007) found that interventions on the Czech koruna market in 2001–2002 failed to have an immediate effect on the koruna exchange rate, while cumulative interventions did have a statistically significant, although limited from the economic perspective, short-term impact. Interventions on the Russian market in 2014–2017 showed a similar picture: a statistically insignificant response of the exchange rate within the first 5–6 business days after the auctions and a statistically significant short-term effect during the subsequent business week. This may suggest the inefficiency of the sterilized interventions' signal channel, adequately testified by the fact that the

¹¹ To illustrate this effect, a contribution of the cointegration residual to the expected ruble depreciation in late February 2015 was computed. The cointegration residual stood at around 0.12 at that point, and hence the expected ruble depreciation against the dollar was, under VECM1, estimated to be equal to $0.12 \cdot (-0.046) \cdot 100\% = -0.55\%$. For instance, if, on February 25, 2015, the US dollar exchange rate to the ruble equaled 62.36 rubles per dollar, then the exchange rate expected on February 26 was to stand at 62.02 rubles per dollar.

Bank of Russia never referred to this instrument as foreign currency interventions, declaring instead the floating exchange rate regime.

Figures 3, 7, and 12 (see Appendix) demonstrate that the response of exchange rate S_t to negative intervention shocks $e_{z,t}$ is weak and statistically insignificant. This suggests the ineffectiveness of negative interventions, meaning that the winding down of the foreign currency repo program did not appreciably affect the exchange rate. This result is in good agreement with studies stressing the historical context of intervention effectiveness analysis. For instance, Guimarães and Karacadag (2004) found the Mexican peso and Turkish lira to respond asymmetrically to the buying and selling of US dollars. Under the dire economic conditions in both countries, buying international reserves did not affect their exchange rates, whereas stabilization sales of foreign currency had a statistically significant impact on them. The Bank of Russia introduced the foreign currency repo auctions at the end of 2014 in order to support the economy as it was experiencing severe balance of payments shocks. The Russian banks' rational behavior in response to the banking liquidity support program had a statistically significant effect on the exchange rate. This side effect was not seen as the foreign currency repo program was being wound down.

Figures 8 and 9 (see Appendix) show that VECM2 and VECM3 failed to reveal any statistically significant response of exchange rate S_t to interest rate shock $e_{i,t}$, which may have been due to a variety of circumstances, such as the small number of observations (just 10 key interest rate revisions in the time span under analysis), unaccounted interest rate revision expectations and a close correlation among the monetary policy instruments during the period in question. From December 2014 to April 2017, the Bank of Russia revised its key interest rate twice, on December 12 and December 16, in response to ruble depreciation stemming from negative financial shocks. Interest rate cuts were undertaken as the situation eased in the financial sector. This principle can be illustrated by the statistically significant response of key interest rate $i_{k,t}$ to exchange rate shock $e_{s,t}$, shown in Figures 8 and 10 (see Appendix).

Figures 12 and 13 (see Appendix) show the IRF of the exchange rate shock st to sterilized intervention shocks $e_{z+,t}$, $e_{z-,t}$, $e_{z,t}$ and interest rate shock $e_{i,t}$ for the three models estimated. It can be concluded that the IRFs are sufficiently robust to the choice of a model specification. In particular, the introduction of the key interest rate into the VECM2 model does not change the essential result obtained in VECM2, although slightly reducing the response of exchange rate st to positive intervention shock $e_{z+,t}$.

Figures 5, 8, and 10 (see Appendix) show the response of monetary policy instruments to exchange rate shock $e_{s,t}$. A sudden national currency depreciation triggers a positive statistically significant response of positive cumulative sterilized interventions Z_t^* and key interest rate $i_{k,t}$, possibly suggesting the Bank of Russia's countercyclical behavior. Figures 3 and 5 (see Appendix) show a typical picture of interaction between the monetary instrument and the monetary goal. Shock depreciation $e_{s,t}$ prompts the monetary authorities to increase the amount of foreign currency provided via their auctions, thereby helping national currency appreciation. The Bank of Russia countercyclical policy stabilizes and smooths exchange rate fluctuations.

Figure 6 (see Appendix) shows a statistically significant response of foreign currency s_t to oil price shock $e_{Poll,t}$ in VECM1. This shock $e_{Poll,t}$ induces a permanent effect on exchange rate s_t and oil price $p_{Oil,t}$ owing to the cointegration of these series. The exchange rate's instantaneous response to this shock is also statistically significant and slightly less pronounced than a long-term response with no effect of exchange rate overshoot arising.¹²

Figures 14–17 (see Appendix) display the contribution of the sterilized foreign currency interventions and the key interest rate to changes in the logarithm of the US dollar S_t in the period from December 5, 2014, to January 20, 2015, which saw a peak of problems stemming from the financial sanctions and an oil price drop, with the Bank of Russia trying to stabilize the situation in the financial markets through the use of instruments available to it (Figure 2, Appendix). Estimation, carried out for all the three models, produced fairly robust results. It can be seen from Figure 17 (see Appendix) that the stabilizing effect of monetary policy on the exchange rate reached its maximum on December 26, 2014 (-11% for VECM1; -12% for VECM2; -14% for VECM3), thereafter gradually declining in absolute terms. This figure also suggests that VECM2 and VECM3 attribute the depreciation suffered by the ruble on December 16–17, 2014 (14% over just two days) to mainly monetary factors. Figures 15 and 16 (see Appendix) make it clear that it is interest rate change that makes the main contribution to this counterintuitive result (+7% in VECM2; +9.5% in VECM3). In technical terms, this result follows from the form of exchange rate S_t IRF to interest rate shock e_{it} (Figures 8 and 9, Appendix) and is, most probably, and identification error, as the Bank of Russia raised the interest rate on December 16, 2014, in order to protect the Russian ruble from an even greater depreciation. VECM1 mainly attributes the December, 16–17 devaluation to the impact of exchange rate shocks $e_{s,t}$, which makes this model the most accurate of the three in identifying the contribution of shocks.

Analyzing the estimated VESMs allows clarifying the role which sterilized intervention could have played in the array of the Bank of Russia's instruments. This instrument was found to have a temporary effect on the exchange rate, so it can potentially be used for hedging the risk of temporary external financial shocks (for instance, those of financial sanctions or capital outflows) affecting the exchange rate. Analysis also shows that this instrument cannot, in effect, be used to stabilize the exchange rate under permanent shocks. This would call for a permanent expansion/reduction in Russian banks' foreign currency repo liabilities, producing a random walk of international reserves available to the Bank of Russia along with potential destabilization of Russia's foreign currency market. The conclusion about the effectiveness of sterilized foreign currency interventions will not necessarily hold for a steadier financial environment. The Bank of Russia has, since 2014, been making a point that it does not intend to engage in direct exchange rate manipulation, which, in the immediate future,¹³ leaves no chance for studying the effectiveness of this instrument under easier conditions. Regulation of the banking system's foreign currency liquidity using foreign currency repos in the

¹² VECM2 and VECM3 show the same picture.

¹³ At least while the Bank of Russia maintains its current stance on direct exchange rate control.

period of severe negative financial shocks sought to stabilize the foreign exchange market. This study, along with Domanski et al., (2016) provides evidence of this stabilization program effectiveness and leads us to conclude that the Bank of Russia has at its disposal an efficient instrument to be used in periods of negative financial shocks. At the same time, this paper cannot shed light on whether this instrument can or should be used under normal conditions.

5. Conclusion

This paper, drawing on Russia's 2014–2017 experience, makes a contribution to examining the effectiveness of foreign currency interventions. The study bases its estimation on daily Russian statistics of foreign currency repo auctions which the Bank of Russia held under severe negative balance of payments shocks in 2014–2015. The sterilized foreign currency interventions were found to have a temporary effect on the exchange rate, which was statistically significant within 7–14 business days and reached its peak on the 9th day after the auctions. This effect enables the Bank of Russia to hedge against the risk of temporary negative financial shocks, such as a shock of financial sanctions or capital outflows.

The main conclusion of the study, that about the effectiveness of sterilized foreign currency interventions, is related to an instrument operating via the channel of the banking system's foreign currency liquidity and is regarded as a part of anti-crisis monetary policy measures. The question of whether this instrument is effective under normal conditions remains open and is not very likely to be answered in the near future, as the Bank of Russia is declaring its renunciation of direct exchange rate control.

Appendix is available at
www.cbr.ru/money-and-finance

6. References

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