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SHOCK-DEPENDENT EXCHANGE RATE PASS-THROUGH IN RUSSIA

Analytical Note

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CONTENTS

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Abstract

In this note, we study shock-dependent exchange rate pass-through (ERPT) to consumer prices in Russia. First, we estimate a traditional "shock-independent" ERPT on aggregate quarterly time series of the exchange rate, CPI, and control variables. Estimated coefficients confirm previous studies and official statements by the Bank of Russia. Rolling regression in different periods shows that the ERPT becomes more stable and more precisely estimated after 2014-2015 when the Bank of Russia switched to inflation targeting.

We compare results with the ERPT from an estimated structural model. We obtain a forecast of macroeconomic time series from a DSGE model conditional on foreign variables observed. We run the same regression on forecasted data and obtain estimates of the "shock-independent" ERPT from the structural model. We compute shock-dependent ERPT from model impulse responses. The magnitude of the ERPT varies for different shocks with the highest value attributed to domestic monetary policy shocks.

When estimating the pass-through of the exchange rate to prices, care must be taken of which shock caused changes in the exchange rate. Since monetary policy shocks appear to be associated with the highest ERPT, and the ERPT becomes more stable after 2014-2015, the Russian economy may be reaping an additional benefit of inflation targeting in the form of reduced monetary policy shocks and a more stable ERPT.

Introduction: Why Shock-Dependent ERPT?

Recently there has been a rise in interest in estimating shock-dependent exchange rate pass-through (ERPT) into consumer prices. Traditionally aggregate ERPT was estimated from a regression of changes in the consumer price index (CPI) on changes in the exchange rate. An implicit assumption of such estimation is that shocks to the exchange rate are exogenous. However, Forbes, Hjortsoe, and Nenova (2018) show empirically based on an estimated structural vector autoregression (SVAR) and theoretically based on a dynamic stochastic general equilibrium (DSGE) model that the effect of changes in the exchange rate on changes in consumer prices depends on which shock caused the change in the exchange rate.

In reality, it is hard to imagine a purely exogenous shock to the exchange rate. A shock to the central bank's reserves may come closest to resembling an exogenous exchange rate shock. Otherwise, the economy is subjected to various shocks that drive its business cycle. In case of Russia, the most important shocks that drive its business cycle are probably shocks to world commodity prices, especially to oil prices, country risk premium shocks, which represent changes in international capital flows, domestic monetary policy shocks, and government spending shocks. When an exogenous shock hits the economy, the exchange rate and consumer prices react endogenously in a particular way depending on the shock. Instead of speaking of the ERPT to prices, Ortega and Osbat (2020) prefer to call the reaction of prices to the exchange rate in response to some exogenous shock a Price-to-Exchange-Rate Ratio (PERR).

The purpose of this analytical note is to discuss shock-dependent exchange rate pass-through in Russia. The rest of the note is structured as follows. Next section shows a traditional one-equation estimation of the "shock-independent" ERPT. The subsequent section shows how to get shock-dependent ERPT in the context of an estimated DSGE model. Last section concludes.

Empirical Estimation

Traditionally the pass-through of the exchange rate into consumer prices is estimated from a single-equation regression. Since the purpose of this note is to compare empirical results from a "shock-independent" estimation to theoretical shock-dependent results from a model, the estimation is conducted on the same dataset on which the DSGE model is estimated. We use quarterly time series of macroeconomic variables from 2005q1 to 2019q4 (60 quarterly observations, or 15 years of data). We choose the following empirical specification that is closest to Campa and Goldberg (2005):

$$\Delta p_t = \beta_0 + \sum_{i=0}^{4} \beta_{e,i} \Delta e_{t-i} + \sum_{i=0}^{3} \beta_{y,i} \Delta y_{t-i} + \beta_{pus} \Delta p_t^{US} + \varepsilon_t$$

Here, Δ denotes difference; p_t is the log of the Russian CPI; e_t is the log of the ruble-to-dollar exchange rate; y_t is the log of the Russian GDP as a measure of demand; p_t^{US} is the log of the US CPI as a measure of foreign prices. All series are tested for the presence of unit roots using the Augmented Dickey-Fuller (ADF) test. The lag lengths of the log Russian GDP and log US CPI are chosen based on Schwarz Bayesian Information Criterion (SBIC), while the lag length of the exchange rate is fixed at four because we are interested in the ERPT at horizons of up to one year[1]. Newey-West heteroskedasticity and autocorrelation consistent standard errors with an appropriate lag length based on the number of

[1] Results of the ADF test and the SBIC lag selection are not reported here to save space but are available upon request.

observations are used. The pass-through of the exchange rate to CPI is defined as the sum of estimated coefficients on the log exchange rate: $\beta_{e,0} + \beta_{e,1}$at a three-to-six-months horizon and $\sum_{i=0}^{4} \beta_{e,i}$ at a one-year horizon. We also perform a rolling regression estimation on windows of 30 quarterly observations (7.5 years of data) ending in periods from 2013q2 to 2019q4.

Since we are interested in sums of estimated coefficients, in Table 1 we report results for testing the null hypotheses $\beta_{e,0} + \beta_{e,1} = 0$ and $\sum_{i=0}^{4} \beta_{e,i} = 0$. The nulls are rejected at conventional significance levels. The pass-through of the exchange rate to CPI is empirically estimated to be 10.2% with a 95% confidence interval from 3.0% to 17.4% at a three-to-six-months horizon. At a one-year horizon, the ERPT is estimated to be 16.3% with a 95% confidence interval from 6.8% to 25.9%. These estimates confirm previous studies (Bank of Russia, 2016, p. 17) and official statements by the Bank of Russia (2018, p. 3).

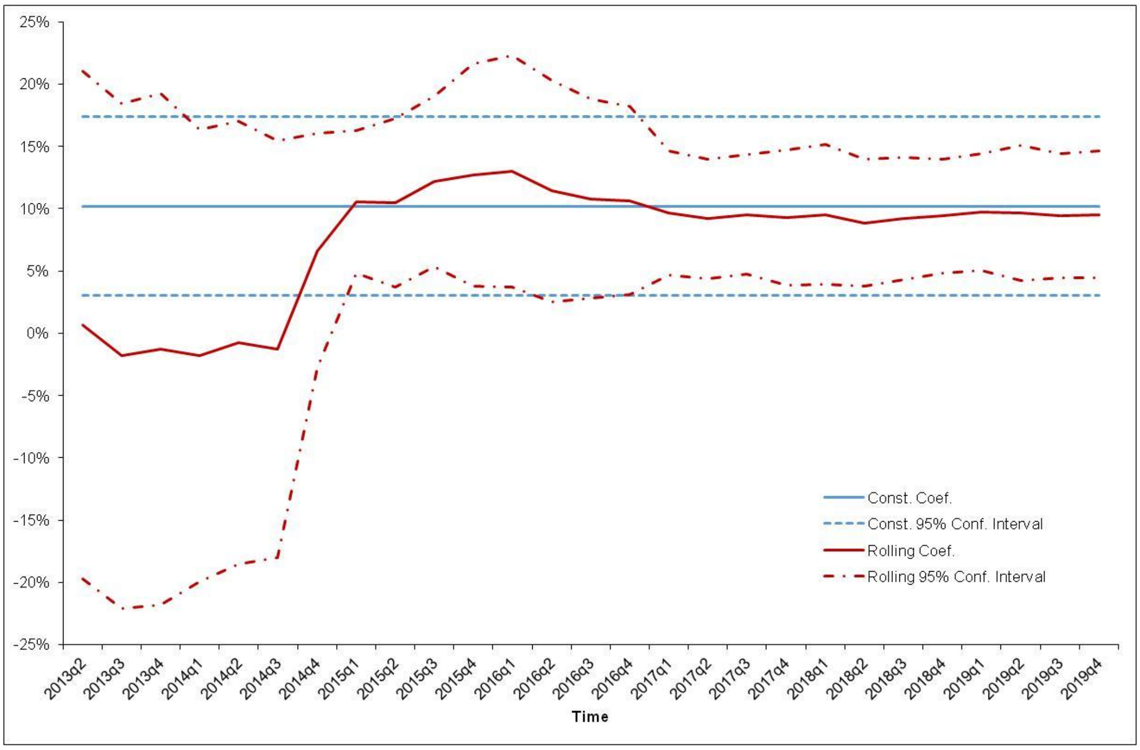
In Figures 1 and 2, we show the estimates of the ERPT from the rolling regression at a three-to-six-months and at a one-year horizon, respectively. It is interesting to note that the estimates of the ERPT at both horizons become more stable and their confidence intervals become narrower in estimation windows that end after 2014-2015. In estimation windows that end before 2014q4, the rolling estimates of the ERPT at a three-to-six-months horizon are statistically insignificant at –1.0% on average with very wide 95% confidence intervals in different periods from –22.1% to 21.1%. In the same estimation windows, the rolling estimates the ERPT at a one-year horizon are also statistically insignificant at 9.3% on average with 95% confidence intervals in different periods from –37.2% to 57.2%.

The Bank of Russia switched from managing the exchange rate to a free float and a fully-fledged inflation targeting (IT) regime in 2014-2015. In estimation windows that end after 2014-2015, rolling estimates first rise then decline. They also become statistically significant and more precisely estimated. In estimation windows that end in 2017q1-2019q4, the rolling estimates of the ERPT at a three-to-six-months horizon are significant at 9.4% on average with 95% confidence intervals in different periods from 3.8% to 15.2%. In the same estimation windows, the rolling estimates the ERPT at a one-year horizon are 11.4% on average with 95% confidence intervals in different periods from –0.7% to 22.8%. The Russian economy may be reaping an additional benefit of inflation targeting in the form of a more stable ERPT.

Table 1. Empirical estimation of the "shock-independent" exchange-rate pass-through

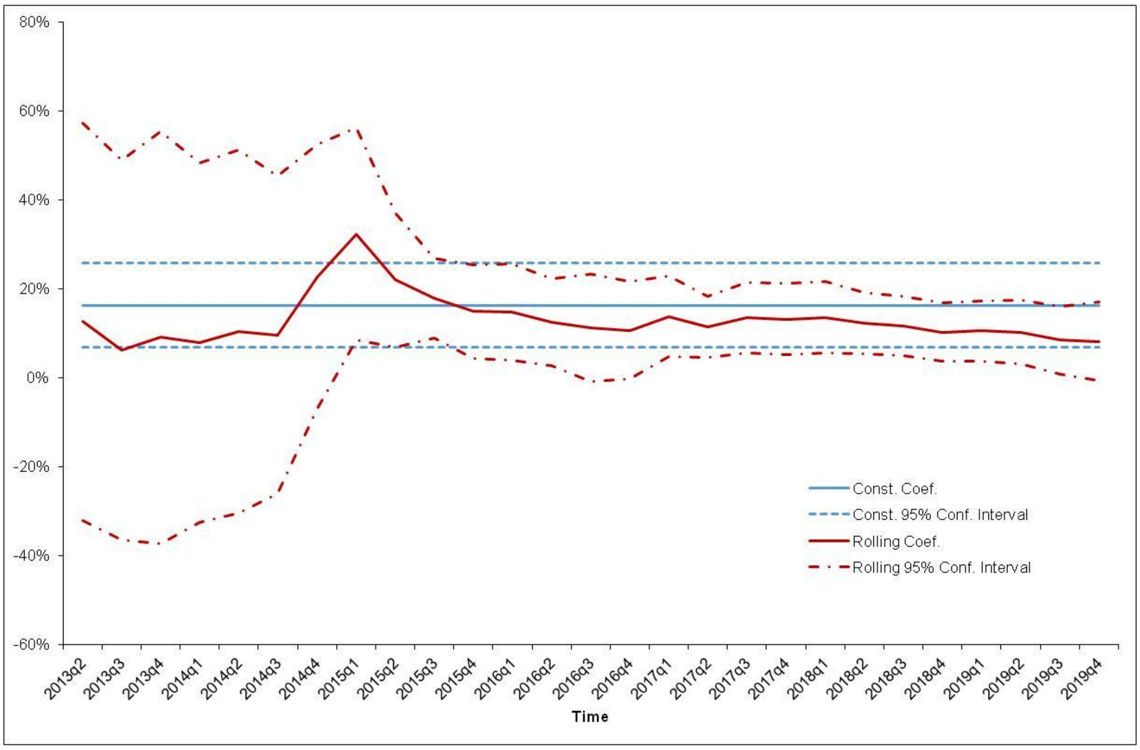
H_0: $\beta_{e,0} + \beta_{e,1} = 0$ (ERPT at 3-6-mo. horizon)					
Coef.	Std. Err.	t	$P > \| t \|$	95% Conf. Interval	
0.1022	0.0358	2.86	0.006	0.0302	0.1742
H_0: $\sum_{i=0}^{4} \beta_{e,i} = 0$ (ERPT at 1-yr. horizon)					
Coef.	Std. Err.	t	$P > \| t \|$	95% Conf. Interval	
0.1632	0.0473	3.45	0.001	0.0678	0.2585

Figure 1. Constant and rolling regression estimates of ERPT at a 3-to-6-mo. horizon



Source: Author's calculations.

Figure 2. Constant and rolling regression estimates of ERPT at a 1-yr. horizon



Source: Author's calculations.

Results from a Structural Model

In order to compute shock-dependent ERPT, we employ one of the DSGE models regularly used for forecasting at the Research and Forecasting Department of the Bank of Russia – the Model of the Russian Economy (MORE) with the banking sector. Detailed description of the model is available in Kreptsev and Seleznev (2017).

When we perform a traditional empirical estimation of the "shock-independent" ERPT, we inevitably estimate the effect of a mix of different shocks hitting the economy. To simulate results with different shocks, we take initial conditions in 2004q4 and produce a 60-quarter long forecast of the Russian economy. MORE is a small open economy DSGE model in which foreign variables affect domestic ones but not vice versa. Therefore, to produce an accurate forecast and to obtain a realistic ERPT, we forecast conditional on the historical path of foreign variables: US federal funds rate, US GDP, US CPI, and Urals oil prices. We run the same regression on forecasted data as we did on empirical time series and report results in Table 2.

Table 2. Estimation of the “shock-independent” exchange-rate pass-through on forecasted data

H_0: $\beta_{e,0} + \beta_{e,1} = 0$ (ERPT at 3-6-mo. horizon)					
Coef.	Std. Err.	t	$P > \| t \|$	95% Conf. Interval	
0.1348	0.0088	15.26	0.000	0.1170	0.1526
H_0: $\sum_{i=0}^{4} \beta_{e,i} = 0$ (ERPT at 1-yr. horizon)					
Coef.	Std. Err.	t	$P > \| t \|$	95% Conf. Interval	
0.1638	0.0125	13.09	0.000	0.1386	0.1890

The pass-through of the exchange rate to CPI in forecasted data is estimated to be 13.5% at a three-to-six-months horizon and 16.4% at a one-year horizon. These estimates are close to empirical ones and are well within the 95% confidence interval of the empirical estimates.

To demonstrate shock-dependent ERPT, we use the method of Burlon, Notarpietro, and Pisani (2018). For each shock of interest, we compute impulse responses of the exchange rate and the Russian CPI in the DSGE model. We define the shock-dependent ERPT to be the ratio of the cumulative impulse response in the level of CPI to the cumulative impulse response in the level of the exchange rate. Ortega and Osbat (2020) prefer to call shock-dependent ERPT a Price-to-Exchange-Rate Ratio (PERR). Results for the five shocks of interest – central bank’s reserves, oil price, country risk premium, domestic monetary policy, and government spending – are presented in Table 3. Graphs of original impulse responses as well as shock-dependent ERPT are presented in Appendix.

Table 3. Shock-dependent exchange-rate pass-through from DSGE impulse responses

ERPT at 3-6-mo. horizon				
Central bank's reserves	Oil price	Country risk premium	Domestic monetary policy	Government spending
0.0922	0.1138	0.1544	0.4297	–0.9270
ERPT at 1-yr. Horizon				
Central bank's reserves	Oil price	Country risk premium	Domestic monetary policy	Government spending
0.1233	0.1578	0.2279	0.6658	–1.5964

The magnitude of the ERPT increases for shocks to the central bank's reserves, oil price, country risk premium, and monetary policy in that particular order. The ERPT values for the first three shocks are within 95% confidence intervals of the estimated empirical values in Table 1. This result probably confirms our intuitive hunch that these shocks were important in explaining business cycle fluctuations in Russia over the estimation period. These shocks produce co-movements in the exchange rate and CPI of the same magnitude as estimated from empirical data.

Domestic monetary policy shocks produce very high positive values of the ERPT. In the model, home central bank is assumed a pure inflation targeter with a concern for interest-rate smoothing over the entire sample period (2005-2019). A monetary policy shock is a random (albeit from a distribution known to agents) disturbance from the systematic IT and interest-rate smoothing rule. To the extent that the systematic rule captures the actual behaviour of the Bank of Russia, the systematic reaction of the policy rate to expected inflation due to depreciation of the home currency should already be reflected in the estimated rule coefficients[2].

The observation that domestic monetary policy shocks are associated with high positive values of the ERPT is in line with results in Comunale (2020) who also finds the highest shock-dependent ERPT in case of monetary policy shocks in the euro area. This result may be of particular interest in case of Russia. Carrière-Swallow, Gruss, Magud, and Valencia (2016) suggest that enhanced monetary policy credibility is associated with a

[2] The interest rate inertia coefficient is estimated on quarterly data to be $\phi_R = 0.8980$, and the weight on inflation stabilization is $(1 - \phi_R)\phi_\pi = 0.1609$.

decreased ERPT. As observed in Figures 1 and 2, rolling estimates of the ERPT produce highly uncertain values with very wide confidence intervals prior to 2014-2015 when the Bank of Russia switched from managing the exchange rate to a free float and a fully-fledged inflation targeting regime. Perhaps under the managed float, monetary policy was more uncertain; monetary shocks dominated and produced high ERPT. Under inflation targeting, monetary policy is more credible with less shocks, which perhaps produces additional benefits in the form of a more stable ERPT.

Another exception is government spending shocks that produce very high *negative* values of the association between the exchange rate and the CPI. Absent all disturbances, real government spending is a constant fraction of real GDP in the model. A government spending shock is a random (albeit from a distribution known to agents) disturbance in real government purchases as a fraction of real GDP. As observed in Figure A5 in Appendix, impulse responses of the exchange rate and the CPI to government spending shocks have opposite signs that result in a negative ERPT. Since the model is solved in a log-linear approximation, impulse responses and the shock-specific ERPT in the model solution are symmetric to positive or negative government spending shocks.

Conclusion

Increased interest in shock-dependent exchange rate pass-through originated from a realization that changes in the exchange rate are caused by various shocks, which may have different simultaneous effects on the exchange rate and the CPI. To check this hypothesis in case of Russia, first we perform a traditional “shock-independent” estimation of the ERPT on macroeconomic time series. Our empirical results confirm previous studies and official statements by the Bank of Russia.

To compute shock-dependent ERPT, we compare empirical results with results from an estimated DSGE model. Estimation of the same equation on data forecasted with all shocks produces results close to empirical estimation. Shock-dependent ERPT computed from impulse response functions shows that the association between exchange rate and CPI depends on the nature of the shock that caused changes in the exchange rate. This result has important practical ramifications as economic analysts often try to estimate the effect of a given change in the exchange rate on prices using the estimated “shock-independent” ERPT coefficients. When estimating the pass-through of the exchange rate to prices, care must be taken of which shock caused changes in the exchange rate.

The highest value of the ERPT is obtained from domestic monetary policy shocks. Empirical rolling estimates suggest that the ERPT became more stable and more precisely estimated following the introduction of inflation targeting in 2014-2015. This interesting result suggests that the Russian economy may be reaping an additional benefit of inflation targeting in the form of reduced monetary policy shocks and a more stable ERPT. A similar result about inflation targeting countries is suggested by Kartaev and Yakimova (2018).

Following Burlon, Notarpietro, and Pisani (2018), we computed shock-dependent ERPT as ratios of impulse responses from a log-linear solution to a DSGE model. A limitation of this approach is symmetry of impulse responses and, therefore, of the ERPT to positive and negative shocks. Andreev (2019) estimates several empirical models of traditional, “shock-independent” ERPT for Russia and finds possible asymmetry and non-linearity. Estimating asymmetric or non-linear shock-dependent ERPT in a DSGE model, which will require non-linear solution methods, as well as studying the effect of increased monetary policy credibility on the ERPT are promising topics for future research.

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Appendix

Figure A1. Standardised impulse response functions[3] (IRF) and exchange rate pass-through (ERPT) in response to a *positive* shock to central bank's reserves

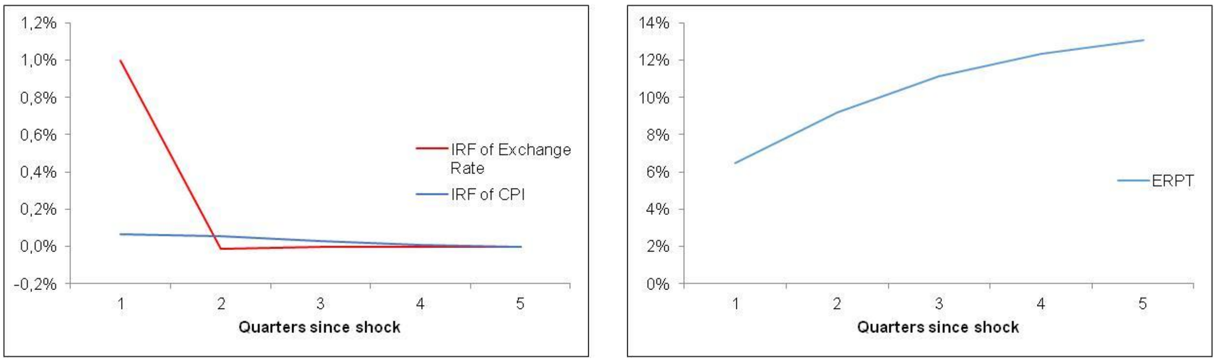
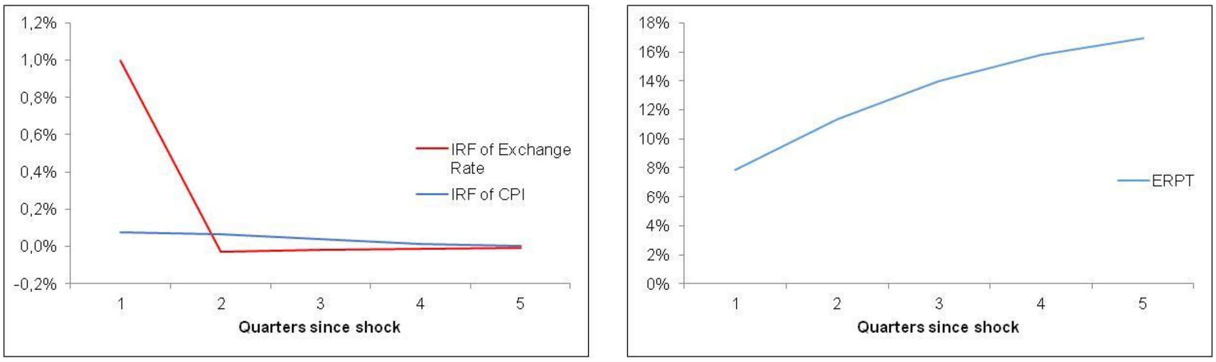


Figure A2. Standardised impulse response functions (IRF) and exchange rate pass-through (ERPT) in response to a *negative* oil price shock



[3] For purely illustrative purposes, impulse response functions in the left panel are Standardised to produce a 1% depreciation in the ruble-to-dollar exchange rate. The ERPT results in the right panel are independent of this standardization, i.e. independent of whether underlying shocks are positive or negative.

Figure A3. Standardised impulse response functions (IRF) and exchange rate pass-through (ERPT) in response to a *positive* country risk premium shock

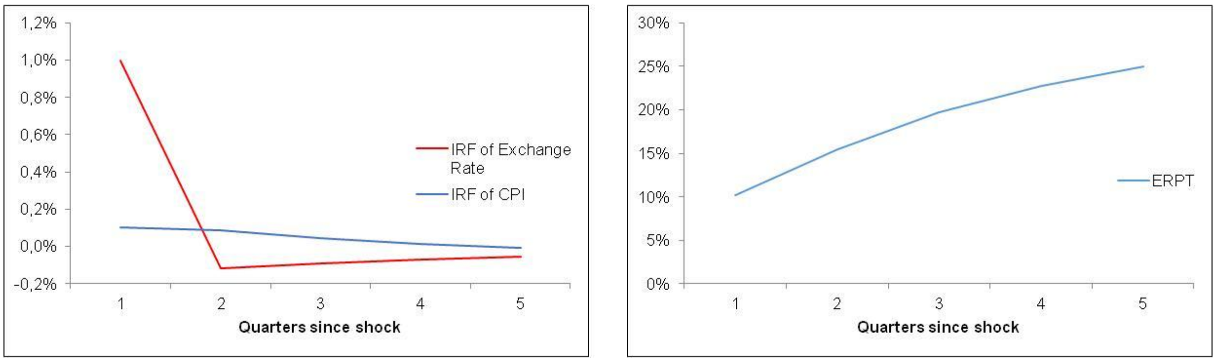


Figure A4. Standardised impulse response functions (IRF) and exchange rate pass-through (ERPT) in response to a *negative* domestic monetary policy shock

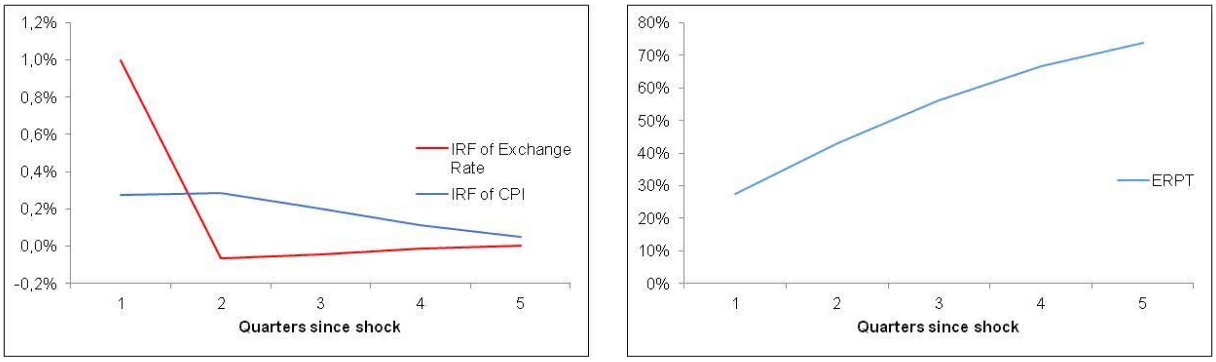


Figure A5. Standardised impulse response functions (IRF) and exchange rate pass-through (ERPT) in response to a *negative* government spending shock