The Monetary and Exchange Rate Policy of the Central Bank of Russia under Asymmetrical Price Rigidity

par Victoria V. DOBRYNSKAYA

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INTRODUCTION

The welfare analysis of monetary policy has been at the centre of macroeconomics since the Great Depression. Empirical observations of the Phillips curve suggest that prices are sticky in the short run and, therefore, monetary policy may be used to smooth the business cycle and increase social welfare. In an open economy where foreign shocks may be passed into the domestic economy the task of monetary policy becomes even more complicated. Under high pass-through of exchange rate on to domestic prices, monetary policy stops being independent and is more likely to adjust to exchange rate shocks. Such a policy of smoothing exchange rate fluctuations is common in western economies (e.g. Parsley and Popper, 1998).

The problem of optimal monetary policy is extremely relevant for Russia. Although the monetary authority claims that inflation targeting is the main goal of the monetary policy, empirical findings suggest that real exchange rate targeting is of major importance (Voronina and Vdovichenko, 2004).

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Due to the rising flow of petrodollars, the Rouble has experienced significant real appreciation recently. But the fear of losing exports makes the monetary authority respond to this real appreciation by accumulating dollar reserves and increasing the money supply, thus preventing the nominal appreciation. Such a policy leads to high inflation and benefits some interested groups at the expense of others. That is why the optimal degree of intervention is in the centre of all political and economic discussions nowadays.

A number of theoretical papers propose that the optimal degree of intervention depends on the pass-through effect in an economy (e.g. Devereux and Engel, 2000). If pass-through is high, in the absence of intervention an exchange rate shock will be reflected in domestic prices. Therefore, some degree of intervention is desirable in order to reduce the pass-through effect and the domestic price volatility. But the pass-through effect, in turn, appears to be endogenous to the local monetary policy (Devereux and Yetman, 2003). It is observed to be higher in countries with higher average inflation and lower degrees of intervention.

Most theoretical models developed in this field are welfare-based optimizing general equilibrium models which try to capture real life peculiarities and, hence, are too complicated and cannot be solved analytically. The authors obtain their results from calibrations, but in such case comparative statics is not analysed. In order to fill this gap, we propose a simple general equilibrium sticky price model of a small open economy with incomplete pass-through. Our model is similar to the New Keynesian model of a closed economy, described in Clarida, Gali and Gertler (1999). By minimizing a social loss function, we obtain optimal monetary policy rule and analyse the parameters, responsible for the optimal degree of monetary intervention. In particular, we find that the higher is the pass-through and the more flexible are prices in an economy, the more significant should be monetary intervention in case of an exchange rate shock.

Recent empirical literature finds that prices are more sticky downwards than upwards. This effect is called “asymmetrical price rigidity” and may result from money illusion of workers, collusive behaviour of firms or search behaviour of consumers. Therefore, in our model we also assume downward price rigidity and determine the optimal monetary policy in case of positive and negative exchange rate shocks. We find that while depreciation of the domestic currency should be accompanied by a significant rise in the interest rate, its appreciation of the same size should be accompanied by a much smaller cut in the interest rate.

The empirical part of the paper deals with analysing the monetary policy of the Central Bank of Russia. Since pass-through effect is important for
determination of the appropriate monetary policy, we estimate it for different types of consumer goods using Vector Error Correction Model and constructing impulse-response functions. We analyse the period since the crisis of 1998 until 2005 and trace changes in the pass-through effect over this time span. Then we estimate the impact of the monetary policy on the pass-through in general and in cases of appreciation and depreciation of the Ruble. Finally, we compare the estimation results with the predictions of the theoretical model and make policy recommendations. The rest of the paper is organised as follows. In section 2 we review the most relevant literature on the pass-through effect, the optimal monetary policy and asymmetrical price rigidity. In section 3 we lay out the theoretical model and determine the optimal monetary policy. Empirical estimations of the pass-through effect and monetary policy in Russia are presented in section 4. Section 5 is devoted to conclusions, recommendations and further research.

LITERATURE REVIEW

Pass-Through Effect and Monetary Policy

In the earliest open economy macroeconomics it was common to think that purchasing power parity (PPP) is the reason why domestic prices react to exchange rate movements. According to PPP, an exchange rate shock should be passed on to the domestic price level to its full extent, implying complete pass-through and no arbitrage opportunities of trade between countries. But extensive literature on the pass-through effect (PTE) in different countries finds empirically that it is far from complete, although significant, and varies greatly across countries, industries and other parameters under consideration. For example, pass-through in developing countries appears to be much higher than in developed ones (see, for example, Dubravco and Marc, 2002). Korhonen and Wachtel (2005) find that pass-through effect in CIS countries during 1999-2004 was quite high, although far from complete. They report that the extent of pass-through is clearly higher in the CIS countries than in their comparison group of other emerging market economies. A couple of studies estimate PTE in Russia. For example, Dobrynskaya and Levando (2005) study the period 1995-2002 and estimate average pass-through elasticity of 40% on the consumer price index and 23% on the producer price index within 6 months. Shmykova and Sosunov (2005) study only the period after the crisis of 1998 and estimate 6% pass-through on CPI within 6 months during 1999-2001 and 26% during 2002-2004.
A number of theories have been proposed to explain why PTE is incomplete in real life. Some authors argue that the ultimate explanation comes from microeconomics. Obstfeld and Rogoff (2000) model assumes transportation costs, which increase prices of imported goods and preclude their perfect substitutability for the competing domestic goods. Also the presence of non-traded goods in consumption may explain low degrees of pass-through (Betts and Kehoe, 2001). Another argument is that the cost of imported inputs constitutes only a small part of the cost of a final good, the majority of costs being attributable to local inputs and non-traded services, such as marketing and distribution (Corsetti and Dedola, 2002; Burstein, Neves and Rebelo, 2000).

Several authors (Bergin and Feenstra, 2001; Bergin, 2001, Corsetti and Dedola, 2002; Bachetta and Wincoop, 2002) argue that PTE may be below 100% due to imperfect competition, which may create incentives for optimal price discrimination or strategic pricing. A theoretical basis for most of these studies was the work of Dornbusch (1987), which appeals to the arguments from industrial organization. Specifically, it explains the differences in PTE by market concentration, degree of import penetration and substitutability of imported and local goods. For instance, if profit-maximizing firms have significant market power in a given industry, PTE is expected to be high in spite of other factors (Phillips, 1988). On the contrary, if firms aim to maximise their market share instead of profits, PTE will be lower (Hooper and Mann, 1989; Ohno, 1990). Moreover, if opportunities to discriminate between markets exist, then the situation of pricing to market may occur, which will lead to different PTE in different segmented markets (Krugman, 1987; Gagnon and Knetter, 1992). Finally, if the imported good is an intermediate good, which has locally produced substitutes priced in domestic currency, the local producer may replace the imported input by the domestic one in response to exchange rate changes (Obstfeld, 2001). Such “expenditure-switching effect” may also exist in the market for final goods, reducing pass-through (Burstein, Eichenbaum and Rebelo, 2002).

Other authors claim that incomplete pass-through is more a macroeconomic phenomenon, which results from price stickiness. For example, Chaudry and Hakura (2001) present cross-country evidence that pass-through varies systematically with the average inflation rate. They claim that high inflation countries exhibit higher degree of pass-through. Table 1 presents pass-through elasticities for three groups of countries, different by their inflation rates.
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Table 1 – Average pass-through elasticity of consumer prices

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<th>1 quarter</th>
<th>4 quarters</th>
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<tr>
<td>Countries with inflation lower than 10% pa</td>
<td>0.04</td>
<td>0.14</td>
</tr>
<tr>
<td>Countries with inflation 10-30% pa</td>
<td>0.09</td>
<td>0.33</td>
</tr>
<tr>
<td>Countries with inflation higher than 30% pa</td>
<td>0.22</td>
<td>0.5</td>
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Source: Chaudry and Hakura (2001)

But if pass-through is systematically related to the level of inflation, which, in turn, is determined by monetary policy, this would have important implications for appropriate monetary policy in an open economy. Thus, the degree to which pass-through is of endogenous origin is studied both theoretically and empirically in Devereux and Yetman (2003). They develop an open economy sticky price model where the degree of pass-through is determined by the frequency of price adjustments by importing firms. Since higher inflation implies higher frequency of price changes for a given size of menu cost, they claim that pass-through will be endogenous to the monetary policy regime. Their empirical test for 118 countries confirms that countries with higher inflation tend to have higher pass-through, but this relationship is non-linear.

The degree of foreign exchange intervention seems to be also responsible for the extent of pass-through. For example, Coricelli, Jazbec and Maston (2004) find in a cross-country study that pass-through is larger when there is less exchange rate management. So, what should be the optimal monetary policy in an open economy with sticky prices and incomplete pass-through? While in a closed economy the main problem of monetary policy is to overcome the trade-off between inflation and unemployment, which have been extensively studied in the New Keynesian Theory (e.g. Clarida, Gali and Gertler, 1999), in an open economy there is an additional trade-off between inflation and exchange rate targeting. An economy may either leave exchange rates floating freely and use its monetary policy to target domestic inflation, which will make the economy more dependent on external shocks, or alternatively reduce dependency on external shocks by targeting the exchange rate by means of interventions in the foreign exchange market; however monetary policy will then be endogenous to exchange rate changes and inflation targeting will be impossible. Such problems of optimal degree of intervention have been extremely relevant for Russia in recent years since the economy faces a clear trade-off between an appreciating domestic currency and high inflation.
A highly relevant study of optimal exchange rate intervention is performed in Devereux and Engel (2000). This is one of the earliest papers which attempts to analyze exchange rate regimes within an expected-utility-maximizing framework in the presence of nominal rigidities and incomplete pass-through. Specifically, they distinguish between two types of pricing strategies in an economy: producer currency pricing (full pass-through) and local currency pricing. In a welfare-based general equilibrium two-country model they analyze to what extent monetary policy should be employed in maintaining the exchange rate. They find that under local currency pricing, a fixed exchange rate regime would be optimal in the presence of real country-specific shocks, whilst a freely floating exchange rate is desirable when real shocks are insignificant and the country’s monetary sector is stable. On the other hand, under producer currency pricing, a country would never choose a clean float, even if it had a completely stable monetary sector, because exchange rate volatility would have a direct influence on anticipated consumption and lead to welfare losses.

Another theoretical paper on optimal monetary policy under incomplete pass-through is Devereux and Lane (2003). They build a general equilibrium sticky price model for an emerging market economy, which is assumed to be small and subject to external shocks to real interest rate and terms of trade. The key features of their model are a) the presence of nominal rigidities; b) lending constraints on investment financing; and c) incomplete exchange rate pass-through on to import prices. They evaluate three types of monetary rules: a fixed exchange rate rule, a CPI inflation targeting rule and non-traded goods inflation targeting rule – using second order approximation of utility function as a social welfare criterion. In calibration of their model they find that the degree of pass-through in import prices is central in determining the appropriate monetary policy rule. Under high pass-through it is advisable to stabilize prices of non-traded goods, since both fixed exchange rate and CPI targeting rules stabilize inflation at the expense of real output stability. With delayed pass-through, the trade-off between real stability and nominal stability disappears and the best rule is to stabilize CPI inflation. Thus, so they claim, a low degree of exchange rate pass-through may be an important prerequisite for the success of inflation targeting in emerging markets. But since lower pass-through is associated with lower inflation both theoretically and empirically, it becomes even more important to stabilize domestic inflation. So, this mutual endogeneity of PTE and inflation should be taken into account in designing appropriate monetary policy.

Another welfare analysis of different monetary policy rules is presented in Gali and Monacelli (2005). They lay out a New Keynesian small open economy general equilibrium model with endogenous monetary policy. In
contrast to the above study, they assume that the law of one price holds for the individual goods all the time. The authors analyze three types of rules: CPI inflation targeting, domestic inflation targeting and the effective nominal exchange rate peg. As in the study described above, they use second order approximation of the utility function as a social welfare criterion. Again, they calibrate the model in order to rank the rules according to the welfare losses they generate. They find that the domestic inflation-based Taylor rule dominates the CPI-based Taylor rule, which, in turn, dominates the exchange rate peg.

Sosunov and Zamulin (2005) analyze several types of monetary policy rules in a simulated model of the Russian economy, which faces external oil price shocks. Their results suggest that “the rule of responding to consumer inflation and the real exchange rate, allegedly followed by the Russian monetary authorities, gives better results in terms of output-inflation volatility than other conventional rules”.

**Asymmetric Nominal Rigidity**

The studies described above assume symmetrically rigid prices and usually study effects of currency depreciation on inflation. But what would happen if the domestic currency appreciates (which Russia has been experiencing recently)? According to the above studies, there should be a similar burst of deflation due to pass-through effect. Then, following the optimal rules, monetary policy should adjust to the same extent, but in the opposite direction.

But in reality we rarely observe deflation resulting from domestic currency appreciation (Dobrynskaya, Levando, 2005). Similarly, we hardly observe deflation resulting from a negative money supply shock (while we do observe a more significant drop in output) than in case of a positive money supply shock (Cover, 1992). Recent literature proposes asymmetrical nominal rigidities as the explanation for this phenomenon. For example, asymmetrical price rigidity means that prices are more sticky downwards than upwards.

Several theories are proposed to explain this phenomenon. The most traditional view is that the labour market is the primary source of asymmetry. Many papers show that a wage cut is a much rarer phenomenon than a wage increase (e.g. Holden and Wulfsberg, 2004; Altonji and Devereux, 1999; Holzer and Montgomery, 1993). In labour economics this is termed the “ratchet effect” and the first intuitive explanation for it was found in a possible money illusion of workers, as proposed by Keynes. Neo-Keynesian models (e.g. Ball, Mankiw and Romer, 1988) see wage rigidity arising endogenously in the bargaining process because of implicit contracts, imperfect
information, efficiency of wages and/or insider-outsider considerations. Most recent explanations of downward wage rigidity such as fairness considerations, reference points and loss aversion of workers, come from behavioural economics (e.g. Diamond and Tversky, 1997).

Asymmetry is also widely observed in prices of final goods. For example, Peltzman (2000) studies over 240 markets for consumer as well as producer goods and finds that asymmetries are persuasive, substantial and durable, and exist in periods of low inflation as well as in periods of high inflation. These asymmetries also apply to price indices (Verbrugge, 1998). Bakytzhanova (2005) finds an asymmetric response of retail gasoline prices in Moscow due to positive and negative shocks in wholesale gasoline prices. Among theoretical explanations for asymmetrical price rigidity are: consumer search with learning from prices (Benabou and Getner, 1993), consumer search with reference prices (Lewis, 2003), tacit collusion among firms with past price serving as a focal price (Borenstein et al., 2003), implicit coordination among firms in an industry to increase prices after a positive cost shock while not to reduce prices after a negative one (Bhaskar, 2002), or positive trend inflation in an economy (Ball and Mankiw, 1994).

As claimed by DeLong and Summers (1988) and Ball, Mankiw and Romer (1988), asymmetries in wages and prices may have important implications for the conduct of appropriate stabilization policy. Nevertheless, such asymmetries are rarely incorporated into theoretical models of optimal monetary policy. For example, Holden (2002) builds a theoretical model of a wage setting in which the institutional framework crucially affects the existence and importance of downward nominal wage rigidity. His model predicts that downward nominal wage rigidity is likely to be stronger, the higher is the coverage of collective agreements and the more strict is the employment protection legislation. Under such conditions, aiming at very low inflation may involve considerable costs in the form of higher unemployment and lower output. Hence, downward nominal rigidity may give the rationale for positive target inflation.

A similar conclusion is drawn in Itskhoki (2004). He adds exogenously asymmetric menu costs to the Ball and Mankiw (1994) model of a closed economy in order to observe asymmetrical price rigidity even in case of zero trend inflation. Under this setting, he finds that positive long run inflation minimizes social losses. So, the literature on the optimal monetary policy under asymmetrical price rigidity is not rich in its recommendations. The main prescription is drawn for a closed economy, which speaks in favour of positive long-run trend inflation, since it alleviates price stickiness and smooths the business cycle.
THE MODEL OF THE OPTIMAL MONETARY POLICY

Set-up of the Model

In this section we lay out a simple stochastic sticky price model for a small open economy which is similar to the New Keynesian closed economy model popularized by Clarida, Gali and Gertler (1999).

The demand side of an economy is represented by a forward-looking IS-type equation of the following form:

\[ y_t = E_t[y_{t+1}] - b(i_t - E_t[\pi_{t+1}]) + cE_t[\Delta q_{t+1}] + \varepsilon_{1t} \]  

(1)

where \( y_t \) is the output gap, \( i_t \) is the nominal interest rate, \( q_t \) is the real exchange rate, an increase in which means real depreciation of the domestic currency, \( \varepsilon_{1t} \) is a demand shock (e.g. government expenditure shock), which is assumed to be normally distributed with the mean of zero, and \( a, b \) and \( c \) are positive coefficients.

The IS curve has survived the New Keynesian revolution and is nowadays derived from maximization of the expected discounted utility function by a representative consumer. For the microfounded derivation of IS curve similar to (1) see Gali and Monacelli (2005), where parameters \( a, b \) and \( c \) are functions of the primitive parameters of their model. If parameter \( c \) equals zero, equation (1) corresponds to the closed economy version of the IS curve, which is used in Clarida, Gali and Gertler (1999) and its step-by-step derivations are available in, for example, Woodford (1996) and Bernake, Gertler and Gilchrist (1998). Such New Keynesian IS curve is different from a traditional one since current output depends positively on expected future output due to consumption smoothing and bears negatively on the real interest rate due to inter-temporal substitution of consumption. Since net export is another component of aggregate demand in an open economy, the output gap also depends on expected changes in the real exchange rate.

The supply side of the economy is presented by a New Keynesian Phillips curve. In order to derive this, we distinguish between two types of firms in the economy. Firms of the first type are importing firms and they set prices according to the Law of One Price:

\[ P_{it} = P_{it}^* S_t \]  

(2)

where \( P_{it} \) and \( P_{it}^* \) are domestic and foreign prices of the i-th import good respectively and \( S_t \) is the nominal exchange rate. Aggregating (2) over all
such firms and log-linearizing, we obtain the following relationship for inflation in this “full pass-through” (FPT) sector of the economy:

\[ \pi_{t}^{FPT} = \pi_{t}^{s} + \Delta s_{t} \]  

(3)

Firms of the second type are either local firms or importing firms, which adopt a pricing-to-market strategy. This means that the pricing decisions of these firms are not affected by exchange rate considerations, implying zero pass-through, but are affected solely by local economic conditions. We assume that these firms set prices in a staggered fashion à la Calvo model (1983). This time-dependent modelling has become very popular in derivations of the New Keynesian Phillips curve mainly because it allows explicit analytical solutions to firms’ profit maximization problem to be obtained. The model assumes that in every period analyzed each firm receives a signal with some probability that it should keep its price fixed in this period and with probability 1-\( \theta \) that it should adjust. Hence, the average time over which a firm’s price is fixed is \( 1/(1-\theta) \). The higher is \( \theta \), the higher is the degree of price stickiness in an economy. Aggregating the pricing decisions of firms of the second type and log-linearizing about the steady state, we obtain the relationship for inflation in this “pricing-to-market” (PTM) sector of the economy:

\[ \pi_{t}^{PTM} = E_{t}[\pi_{t+1}] + d y_{t} + \epsilon_{2t} \]  

(4)

where the parameter \( d \) depends negatively on \( \theta \) and, hence, captures the degree of price stickiness. Equation (4) is usually called the New Keynesian Phillips curve and its step-by-step derivation can be found in, for example, Gali and Monacelli (2005). It is different from a traditional Phillips curve because here inflation depends on the expected future inflation and not on the expected current inflation. In our case this relationship is valid for the second-type firms only and it shows that their inflation depends on the expected overall inflation, the current output gap and a random supply shock with the mean of zero.

To derive a Phillips curve for our economy with two types of firms we assume that there is a share \( e \) of the firms of the first type and a share \( 1-e \) of the firms of the second type. Then the overall inflation is:

\[ \pi_{t} = e \pi_{t}^{FPT} + (1-e)\pi_{t}^{PTM} \]  

(5)

Substituting (3) and (4) into (5) and using the following relationship for the real exchange rate:
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\[ Q_t = \frac{S_t P_i^*}{P_i} \text{ or } \Delta q_t = \Delta s_t + \pi_t^* - \pi_t \]

we obtain the following version of a New Keynesian Phillips curve for the economy:

\[ \pi_t = \frac{e}{1-e} \Delta q_t + E[\pi_{t+1}] + dy_t + \varepsilon_{2t} \]  \hspace{1cm} (6)

This Phillips curve is different from the ones used in the literature since it explicitly shows the degree of pass-through, measured by the coefficient \( e/(1-e) \). The higher is the share of first-type firms \( e \), the higher is the pass-through effect in an economy. If we assume that \( e \) is less than 0.5, then there is incomplete pass-through, which is convincingly claimed by the literature. Our model assumes \( e \) to be exogenous, but in reality it may vary depending on economic conditions. For example, Devereux and Yetman (2003)’s model shows the pass-through effect as being endogenous to local monetary policy. They claim ‘looser’ monetary policy, which implies a higher mean of inflation and a higher volatility of the exchange rate, will lead to more frequent price changes and a higher rate of pass-through”. So, there are two reasons for price stickiness in our model: incomplete pass-through measured by parameter \( e \) (the higher is \( e \), the further the curve shifts as a result of exchange rate changes) and staggered pricing measured by parameter \( d \), which in turn depends on parameter \( \theta \) (the higher is \( \theta \), the flatter is the Phillips curve). The equilibrium in the economy is described by the system of IS and Phillips curves holding simultaneously.

To complete the model, we assume that the real exchange rate follows non-stationary AR(1) process (a random walk):

\[ q_t = q_{t-1} + \eta_t \] \hspace{1cm} (7)

where \( \eta_t \) is a normally distributed shock with the mean of zero. Such specification is close to reality, since real exchange rates are often observed to be non-stationary. For example, a unit root test for the real exchange rate of the Russian rouble did not allow us reject the null hypothesis of a unit root even on 1% confidence level.

**Optimal Monetary Policy under Discretion**

As has become common in the literature on optimal monetary policy, we assume that the monetary authority minimizes the following loss function:

\[ L_t = (\pi_t - \pi_T)^2 + \lambda y_t^2 \] \hspace{1cm} (8)
Such a loss function is not *ad hoc* and can be derived by second order approximation of the utility losses by a representative consumer (see Rotemberg and Woodford, 1999 and Woodford, 2003).

Substituting the Phillips curve (6) into the loss function (8) and making use of (7) and minimizing with respect to \( p_t \) we obtain the following reaction function of optimal inflation to expected inflation:

\[
\pi_t = \frac{d^2}{d^2 + \lambda} \pi_t^r + \frac{\lambda}{d^2 + \lambda} E[\pi_{t+1}] + \frac{e\lambda}{(1-e)(d^2 + \lambda)} \eta_t + \frac{\lambda}{d^2 + \lambda} \varepsilon_{2t} \tag{9}
\]

Taking expectations of both sides of (9), solving for expected inflation and substituting it back into the reaction function, we obtain the expression for the equilibrium inflation, which minimizes the losses of society:

\[
\pi_t = \pi_t^r + \frac{e\lambda}{(1-e)(d^2 + \lambda)} \eta_t + \frac{\lambda}{d^2 + \lambda} \varepsilon_{2t} \tag{10}
\]

We see that in order to minimize social loss, inflation should be adjusted to exchange rate and supply shocks. It should be noticed that there is no dynamic inconsistency here since expected inflation equals the target inflation and there is no incentive to deviate from this target unless unexpected shocks occur.

Substituting (10) into (6) we find the equilibrium output gap:

\[
y_t = \frac{ed}{(1-e)(d^2 + \lambda)} \eta_t - \frac{d}{d^2 + \lambda} \varepsilon_{2t} \tag{11}
\]

The final step is to derive the optimal instrument rule where the real interest rate serves as an instrument for monetary policy. To do this we substitute (11) into the IS curve (1) and solve for \( r \):

\[
r_{t, opt} = \frac{a}{b} + \left[ \frac{ed}{b(1-e)(d^2 + \lambda)} \right] \eta_t + \frac{d}{b(d^2 + \lambda)} \varepsilon_{2t} + \frac{1}{b} \varepsilon_{1t} \tag{12}
\]

This rule states that in order to minimize the social losses the real interest rate should be adjusted to all types of shocks in the economy: exchange rate shock, supply shock and demand shock – with positive coefficients. This means, for example, that positive shocks, being inflationary, should be accompanied by a contractionary monetary policy, leading to negative output gap and lower equilibrium inflation, than would be the case without intervention. Figure 1 illustrates the optimal reaction of the real interest rate to a positive exchange rate shock \( \eta_t \), assuming that demand and supply shocks equal zero.
Assume that initially the economy is at point A with the target inflation and zero output gap. The corresponding interest rate is r₀. An unexpected positive exchange rate shock (depreciation of the domestic currency) shifts the Phillips curve upwards due to pass-through effect and shifts the IS curve rightwards due to higher net export. If the interest rate is not adjusted, the economy will move to point B with positive output gap and very high inflation. The corresponding losses of society can be illustrated by the circle coming through point B. We can see that in order to minimize social losses the interest rate should be increased to r₁ so that the economy comes to point C. So, a contractionary monetary policy is desirable in the case of depreciation of domestic currency. By the same logic, a negative exchange rate shock should be accompanied by a reduction in the interest rate meaning expansionary monetary policy.

**Proposition 1.** The optimal monetary policy should react to the exchange rate movements and should counteract the exchange rate changes reducing pass-through on to domestic prices. The adjustment in the interest rate should be more significant if:
- the pass-through effect is higher (parameter e/(1-e) is higher)
- prices are less sticky (parameter d is higher, provided that d < √λ )
- the elasticity of consumption with respect to interest rate is lower (parameter b is lower)
- the government cares less about the output gap (parameter λ is lower)

**Proof.** To prove this we differentiate the coefficient in front of the exchange rate shock in equation (12) with respect to each of the parameters and determine the signs of the corresponding derivatives. This finding is in line with Devereux
and Engel (2000) who claim that although low pass-through freely floating exchange rates (a monetary policy in which exchange rates are not a consideration) may be optimal in some circumstances, this is never true in case of producer currency pricing leading to full pass-through.

The above analysis assumes that prices are symmetrically rigid upwards and downwards. But the empirical evidence described in section 2.2. suggests convincingly that prices are more rigid downwards than upwards. Such asymmetrical price rigidity can be captured by two parameters in our model: $d$ and $e$. First, parameter $d$ may be higher for upward changes in prices than for downward ones. This will result in a kink of the Phillips curve at zero level of inflation. Secondly, pass-through may be lower in cases of appreciation of the domestic currency than in cases of depreciation (as reported in Dobrynskaya and Levando, 2005) as more firms may adopt pricing-to-market strategy instead of reducing their prices. Also the model of Devereux and Yetman (2003) suggests that lower pass-through is associated with higher price stickiness and *visa versa*. Asymmetric pass-through will result in unequal shifts of the Phillips curve due to positive or negative exchange rate shocks of the same size. Figure 2 analyses the optimal monetary policy in cases of positive and negative exchange rate shocks of the same size under asymmetrical price rigidity.

*Figure 2 – Monetary policy reaction under asymmetric price rigidity*

![Figure 2](image)

The kinked Phillips curve shifts further as a result of a positive exchange rate shock than a negative one due to asymmetric pass-through effect. In the
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case of a positive shock the loss minimizing point is point C, which corresponds to an increased interest rate to r_u. In the case of a negative shock the optimal point is point D. To reach this point interest rates should be reduced, but the magnitude of the change should be much less. The same conclusion will be true for positive target inflation, although the difference in required interest rate changes will be less significant.

**Proposition 2.** Under some conditions, the optimal monetary policy is asymmetrical depending on appreciation or depreciation of the domestic currency. The degree of monetary intervention should be higher in the case of a positive exchange rate shock than in the case of a negative one of the same size due to higher downward price rigidity and lower downward pass-through.

**Proof.** Recall from the proof of proposition 1 that the derivative of the coefficient in front of the exchange rate shock in equation (12) with respect to pass-through effect (e/(1-e)) is positive and the derivative of the same coefficient with respect to price flexibility (d) is also positive, provided that \(d < \sqrt{\lambda}.\) Since it is assumed that pass-through effect and price flexibility are higher in case of an inflationary shock than in case of a deflationary one, the adjustment in the interest rate should also be greater.

This result is new to the Keynesian literature and has interesting practical implications for the conduct of monetary policy. It predicts that in order to minimise social losses, the monetary authority should determine not only the direction of the required policy instrument change, but also its magnitude depending on the sign of a shock. If the monetary policy rule is specified so that it does not take into account such asymmetries, then following this rule may result in equilibrium between the inflation and output gaps, which is far from optimal.

Our model predicts that in a country with high pass-through, rather flexible prices and low sensitivity of consumption to interest rates, monetary policy should adjust to exchange rate changes asymmetrically in order to minimize the losses of society. The next section of this paper is devoted to empirical tests of the assumptions and prescriptions of the model for Russia.

**EMPIRICAL ESTIMATIONS**

**Data**

Our analysis for Russia covers the period from January 1998 till May 2005. The year 1998 is remarkable due to the default of the Russian government and the resulting balance of payments crisis when the rouble depreciated by
more than half in a month and a number of structural changes occurred in the economy such as import substitution. That is why we include this year in our sample, but we study it separately and compare to it with the more recent period. The following monthly time series, all in natural logarithms, are used:

Endogenous variables:

Consumer prices \((p)\). We analyse the consumer price index on aggregate and at 2 levels of disaggregation:

– foodstuffs: bread and bakery products, groats and beans, pasta products, meat and poultry, fish products, milk and dairy products, butter, vegetable oil, fruit and vegetables, granulated sugar, alcoholic beverages;
– non-food goods: fabrics, clothing, knitwear, footwear, detergents, tobacco products, electric appliances, TV and radio sets, gasoline, medicine;
– services rendered to the population: housing and public utilities, public health, passenger transport, communications, cultural institutions, sanatoria, resorts and health care institutions, child-care in preschool institutions, education, everyday services.

All price indices are transformed into Laspeyres-type indices with the base period either January 1998 or the first month when a series was first calculated and published.

The source of the data is the monthly journal “Socio-economic performance of Russia” published by Goskomstat (State Statistical Committee of Russian Federation).

Money supply \((m)\) is aggregate M2, provided by Goskomstat.

Nominal effective exchange rate (NEER) is the trade-weighted exchange rate of the rouble, an increase in which means depreciation of the rouble against a basket of currencies. The source is International Financial Statistics.

Exogenous variables:

Real income \((ry)\) is the seasonally adjusted real money income of the population, published by Goskomstat. The base period is December 1992.

All time series have been tested for stability. ADF tests have not allowed us to reject the hypothesis of a unit root. But the unit root hypothesis has been rejected for basic flaws. Therefore, we treat the data as non-stationary I(1) processes.

**Pass-through Effect**

**Methodology**

Our theoretical model predicts that the degree of pass-through is crucial for determination of optimal monetary policy; under high pass-through adjusting the money supply to exchange rate shocks is more welfare-enhancing than under low pass-through. That is why we start our empirical analysis with estimating the pass-through effect on different consumer goods. Since we deal with several endogenous variables, so as to take into account their mutual influence we estimate the following Vector Error Correction Model:

\[
\Delta y_t = A + \sum_{i=1}^{3} B_i \Delta y_{t-i} + C \Delta x_t + D v_{t-1} + \psi_t
\]  

(13)

where \( y_t \) is a vector of endogenous variables (p, m, NEER), \( x_t \) is a vector of exogenous variables (ry, oil), \( v_{t-1} \) is a series of lagged residuals obtained from co-integration of the endogenous variables, \( \psi_t \) is an error term and A, B, C and D are coefficient matrices. We include three lags of endogenous variables because the major adjustments usually occur within a quarter. Inclusion of more lags would lead to too many coefficients to be estimated and reduction in power of the test. If co-integration between the endogenous variables exists, the model can be estimated by OLS method since all variables are stationary.

Such a model allows us estimate the influence of lagged exchange rate changes on inflation separately from the influence of other variables by constructing an impulse-response function with the Cholesky ordering:

\[
m \rightarrow \text{NEER} \rightarrow p
\]

We use E-Views 4.0 to estimate VEC and accumulated responses of prices to Cholesky degrees of freedom adjusted impulses to the exchange rate.

**Results**

First of all we concentrate our analysis on the *aggregate consumer price index*. We find that pass-through is 35% during 12 months. Since our sample includes the year of crisis, a number of changes might have occurred in the
Russian economy. Therefore we are interested in changes of pass-through over this time period. We estimate a model (13) for a two-year rolling window starting from 1998 and ending 2005 because we are interested in changes in pass-through from year to year; however 12 observations are not enough to estimate the model. Hence, we obtain pass-through elasticities for 7 two-year sub-periods. Twelfth-month elasticities are shown on Figure 3.

Figure 3 – 12 month PTE on CPI over time

We see that the average pass-through of 35% is a biased estimate since PTE was significantly different during the crisis from the rest of the sample. During the crisis a shock to the exchange rate caused a 40% change in CPI in 6 months, and 63% change in 12 months. Quite the same result was obtained in Dobrynskaya Levando (2005) where Error Correction Model was used to estimate 43% pass-through on CPI over 6 months during 1998-1999.

After the crisis we observe a significant drop in pass-through to almost zero, probably due to a high degree of import substitution. Again, a similar result is obtained by Dobrynskaya, Levando (2005), who estimate 6% pass-through over 6 months during 2000-2002. But as the Russian economy recovers, yearly PTE stabilises at about 8% after 2003. This looks similar to the findings for some European countries before the introduction of the Euro, presented by Hufner and Schroder (2002). They estimate 7% pass-through after 12 months in France, 8% in Germany, 12% in Italy, 11% in the Netherlands and 8% in Spain. So, our further analysis will be concentrated on studying the period 2003-2005.

To get further insight into changes in pass-through during the period studied, we estimate model (13) for three categories of consumer prices: foodstuffs, non-food goods and services rendered to the population. We estimate pass-through elasticity for the whole period and separately for 2003-2005. The corresponding impulse responses are presented on Figure 4.
The monetary and exchange rate policy of the Central Bank...

Figure 4 – Impulse-responses of CPI, foodstuffs, non-food goods and services

The monetary and exchange rate policy of the Central Bank...

The figures show that all estimates of PTE are much higher for the whole sample than for the later period. The reason is the same as for CPI: inclusion of the crisis period, characterized by high pass-through, biases our estimates upwards. Nowadays PTE on all consumer prices is much lower than during the crisis but higher than just after the crisis. High pass-through during the crisis may be explained by foreign currency pricing prevailing at that period. The sharp depreciation of the Rouble made Russian citizens substitute purchases of import goods with domestic ones. Also, some firms which previously exported goods to Russia established their production locally using local inputs. All these facts can explain almost zero pass-through at that period. Nowadays, the real income of Russian citizens grows and purchases of import goods increase, with pass-through rising and making the economy again more dependent on external shocks. Therefore, it becomes more important to follow a policy of exchange rate targeting by adjusting money supply to exchange rate shocks.

Not only did the degree of pass-through change during the period studied, but also the relative sensitivity of different consumer goods to exchange rate changes. If during the crisis the most sensitive were prices of non-food goods and the least sensitive were prices of services (as in Dobrynskaya, Levando, 2005), the picture changed in recent years. We see that food prices became the most exchange rate elastic, the elasticity of service prices remained approximately the same as before, but prices of non-food goods became almost insensitive to exchange rate changes. Since services are non-traded goods, it is no surprise that pass-through on service prices is low and constant. The most interesting is the behaviour of non-food goods prices. Such a low pass-through may be explained by an expansion in local production of goods and wide adoption of pricing-to-market strategy by exporting companies. Most likely, in order to retain market shares, exporting compa-
nies choose to alter their mark-ups in response to exchange rate changes rather than to change prices.

To get a better understanding of why food prices are now much more exchange rate-elastic than prices of goods, and why prices of services still have some pass-through, we estimate PTE for detailed categories of consumer goods. In Table 2 we report 6, 12 and 24 month accumulated responses of prices to exchange rate impulses. The graphs of impulse responses are provided in Appendix 1 (the solid lines).

Prices of all goods have pass-through elasticity less than 100% during 12 months. This finding supports our assumption that pass-through is incomplete and the parameter “e” in our model is less than 0.5. Among food prices the highest pass-through is observed for fruit and vegetables (112% during a year), bread and bakery products (22%) and groats and beans (14%). The least exchange rate elastic appeared to be prices of alcoholic beverages (1%) and vegetable oil (2%). Only prices of sugar appear to have negative pass-through. All non-food goods are insensitive to exchange rate changes with the highest pass-through of 4-5% during one year on prices of knitwear, clothing and tobacco products. On the contrary, prices of most services are fairly sensitive to exchange rate shocks. Prices of communications exhibit very high pass-through of 70% during one year, probably due to foreign currency pricing prevailing for internet and mobile services. We can also notice that education, services of cultural institutions, sanatoria, resorts, health care institutions and child care in pre-school institutions show pass-through effect of about 10% during a year.

Thus we can conclude that although at present pass-through is much lower in comparison with the crisis period probably due to more stable exchange rates resulting from exchange rate targeting policy of the central bank, nevertheless prices of some goods exhibit significant sensitivity to exchange rate changes, which makes the Russian economy somewhat dependent on exchange rate shocks. Since our optimal interest rate rule (12) is derived from minimization of the loss function (8), which in turn can be derived from maximization of expected discounted consumer’s utility function of the form:

$$\max U_t = E\sum_{\tau=t}^{\infty} \beta^{\tau-t} u(\sum_i a_i C_i^t; L_t)$$

where $a_i$ is a share of good $i$ in the consumer’s shopping basket, it becomes particularly important to adjust the money supply to unexpected exchange rate shocks in order to minimize consumers’ welfare losses if the goods with high pass-through are necessities and constitute major shares in consumer spending.
Table 2 – Estimates of pass-through on detailed categories of consumer goods

<table>
<thead>
<tr>
<th>Prices \ Period after a shock</th>
<th>6 months</th>
<th>12 months</th>
<th>24 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPI</td>
<td>0.04</td>
<td>0.08</td>
<td>0.16</td>
</tr>
<tr>
<td><strong>Foodstuffs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bread and bakery products</td>
<td>0.08</td>
<td>0.22</td>
<td>0.50</td>
</tr>
<tr>
<td>Groats and beans</td>
<td>0.05</td>
<td>0.14</td>
<td>0.37</td>
</tr>
<tr>
<td>Pasta products</td>
<td>0.03</td>
<td>0.09</td>
<td>0.19</td>
</tr>
<tr>
<td>Meat and poultry</td>
<td>0.00</td>
<td>0.02</td>
<td>0.09</td>
</tr>
<tr>
<td>Fish products</td>
<td>0.02</td>
<td>0.07</td>
<td>0.05</td>
</tr>
<tr>
<td>Milk and diary products</td>
<td>0.05</td>
<td>0.11</td>
<td>0.21</td>
</tr>
<tr>
<td>Butter</td>
<td>0.02</td>
<td>0.06</td>
<td>0.12</td>
</tr>
<tr>
<td>Vegetable oil</td>
<td>0.00</td>
<td>0.02</td>
<td>0.05</td>
</tr>
<tr>
<td>Fruit and vegetables</td>
<td>0.47</td>
<td>1.12</td>
<td>2.33</td>
</tr>
<tr>
<td>Granulated sugar</td>
<td>-0.03</td>
<td>-0.12</td>
<td>-0.28</td>
</tr>
<tr>
<td>Alcoholic beverages</td>
<td>0.01</td>
<td>0.01</td>
<td>0.02</td>
</tr>
<tr>
<td><strong>Non-food goods</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fabrics</td>
<td>0.00</td>
<td>0.01</td>
<td>0.02</td>
</tr>
<tr>
<td>Clothing</td>
<td>0.02</td>
<td>0.04</td>
<td>0.08</td>
</tr>
<tr>
<td>Knitwear</td>
<td>0.02</td>
<td>0.05</td>
<td>0.10</td>
</tr>
<tr>
<td>Footwear</td>
<td>0.01</td>
<td>0.02</td>
<td>0.04</td>
</tr>
<tr>
<td>Detergents</td>
<td>0.01</td>
<td>0.02</td>
<td>0.04</td>
</tr>
<tr>
<td>Tobacco products</td>
<td>0.01</td>
<td>0.04</td>
<td>0.09</td>
</tr>
<tr>
<td>Electric appliances</td>
<td>0.00</td>
<td>0.01</td>
<td>0.30</td>
</tr>
<tr>
<td>TV and radio sets</td>
<td>0.00</td>
<td>0.01</td>
<td>0.02</td>
</tr>
<tr>
<td>Gasoline</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Medicine</td>
<td>0.00</td>
<td>0.00</td>
<td>0.03</td>
</tr>
<tr>
<td><strong>Services rendered to population</strong></td>
<td>0.04</td>
<td>0.05</td>
<td>0.14</td>
</tr>
<tr>
<td>Housing and public utilities</td>
<td>0.03</td>
<td>0.05</td>
<td>0.10</td>
</tr>
<tr>
<td>Public health</td>
<td>0.01</td>
<td>0.02</td>
<td>0.05</td>
</tr>
<tr>
<td>Passenger transport</td>
<td>0.02</td>
<td>0.05</td>
<td>0.09</td>
</tr>
<tr>
<td>Communications</td>
<td>0.20</td>
<td>0.70</td>
<td>2.17</td>
</tr>
<tr>
<td>Cultural institutions</td>
<td>0.06</td>
<td>0.12</td>
<td>0.25</td>
</tr>
<tr>
<td>Sanatoria, resorts and health care institutions</td>
<td>0.03</td>
<td>0.09</td>
<td>0.22</td>
</tr>
<tr>
<td>Child care in pre-school institutions</td>
<td>0.05</td>
<td>0.10</td>
<td>0.20</td>
</tr>
<tr>
<td>Education</td>
<td>0.04</td>
<td>0.09</td>
<td>0.17</td>
</tr>
<tr>
<td>Everyday services</td>
<td>0.01</td>
<td>0.02</td>
<td>0.03</td>
</tr>
</tbody>
</table>
The structure of the shopping basket in Russia is presented in Appendix 2. We see that among the three aggregate categories, foodstuffs constitute the largest share of consumption (about 43%) and food prices have the largest pass-through among these categories. The share of food in low-income families is even higher, since food is the basic necessity. Therefore, if the government is concerned about the welfare of consumers, exchange rates should be targeted more carefully since a shock is reflected in food prices to a greater extent. If we look at particular goods, meat and poultry (10.71% of total consumption), alcoholic beverages (7.12%), fruit and vegetables (3.96%), clothing and underwear (5.19%), housing and public utilities (8.9%) are the main components of the shopping basket, and all of them except alcoholic beverages have fairly high pass-through of exchange rate shock on to domestic prices. Thus we can conclude that following a monetary rule like (12) and adjusting money supply to unexpected exchange rate shocks is preferable to a freely floating exchange rate regime from the social welfare point of view.

**Monetary Policy Analysis**

**Symmetrical Case**

In order to analyze the impact of monetary policy on pass-through and prices we estimate a VEC model similar to (13) but we omit the money supply variable:

\[
\Delta z_t = A + \sum_{i=1}^{3} B_i \Delta z_{t-i} + C \Delta x_t + D \psi_{t-1} + \psi_t
\]

(14)

where \( z_t \) is a vector of endogenous variables (p, NEER) and \( \psi_{t-1} \) is a series of lagged residuals obtained from co-integration of these endogenous variables. As our theoretical model predicts and findings of Vdovichenko and Voronina (2004) confirm, a positive shock to the exchange rate should be accompanied by rising interest rates and falling money supply. Then, the inflationary effect of currency depreciation is counteracted by the contractionary effect of monetary policy. The opposite should be true for a negative shock. Thus, omitting money supply from the model, we shall observe lower pass-through, which is biased downwards by the money supply effect.

Such monetary policy is common in western economies. For example, the European Central Bank cited the possible inflationary effect of the weak Euro as one factor behind its tightening of monetary policy in 2000. A similar conclusion was obtained empirically by Parsley and Popper (1998) for

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the USA. But Dobrynskaya and Levando (2005) come to the opposite conclusion for Russia: during the period 1995-2002 monetary policy did not eliminate pass-through, but, on the contrary, strengthened it.

In order to see whether Russian monetary policy has changed recently, we estimate model (14) for the aggregate consumer price index for the whole period from 1998 till 2005 and separately for the recent period from 2003 till 2005. Then we construct impulse responses using Cholesky ordering NEER → CPI. In Figure 5 we plot the obtained impulse-responses for the model (14) (solid lines) and the model (13) (dashed lines).

Figure 5 - Impulse responses of CPI with and without money supply

As the dashed line lies above the solid line for the whole period, omission of money supply leads to higher estimates of pass-through. Since the whole period includes both the crisis period and the recent one, in which we observe opposite behaviour of monetary policy, the obtained estimates are the average ones. Therefore, the difference between the dashed line and the solid line solely for the crisis period would be even more significant than what is presented on the graph. This means that the sharp depreciation of the Rouble during the crisis was accompanied by expansionary monetary policy that provoked an additional inflationary effect on domestic prices. This finding is similar to what Dobrynskaya and Levando (2005) report. Such monetary policy led to greater social losses due to higher inflation than would be the case if money supply did not change or decreased in that period.

But the picture is remarkably different in the recent period. We see that today monetary policy indeed reduces pass-through. The combined effect of money supply and exchange rate changes on CPI is 3.5% during one year,
while it would be 8% if money supply were not adjusted. Therefore, we can conclude that monetary policy at present counteracts exchange rate changes, thus reducing pass-through on the consumer price index and hence its volatility. So nowadays the monetary policy of the Central Bank of Russia seems to be more optimal, since it leads to lower social losses than there would be otherwise.

To see the effect of present monetary policy on prices of food, goods and services we estimate model (14) for each price index separately. All impulse responses are presented in Appendix 1 (the dashed lines). We see that pass-through is reduced for all service prices and prices of non-food goods. For some prices it becomes even negative. Since the real exchange rate mostly appreciated during this period and, hence, the money supply increased, for these prices the inflationary effect of money supply overweighted the deflationary effect of the exchange rate, making the biased pass-through negative. But the behaviour of some food prices is surprising. For four food categories (bread and bakery products, pasta products, fish products and vegetable oil) pass-through, estimated in model (14) is higher than the actual one. This means that prices of these goods rise in response to decreased money supply and visa versa. A possible explanation for this phenomenon is negative income elasticity of demand for these goods.

**Asymmetrical Case**

We find that during 2003-2005 monetary policy in Russia was endogenous to exchange rate changes and the real appreciation of the Rouble was accompanied by rising money supply, thus reducing pass-through. Such behaviour is quite optimal from the theoretical point of view. If the monetary authority indeed follows such a rule, then depreciation of the Rouble should be accompanied by a reduction in the money supply. Moreover, our model predicts that the change in money supply should be higher in case of depreciation of the domestic currency than in the case of appreciation due to asymmetrical price rigidity. Therefore, we should observe in the data that the depreciation of the Rouble should lead to a fall in the money supply, while only major appreciations should be counteracted by increasing the money supply. However we observe the opposite situation in our data: among 88 observations in our sample there are 45 observations of nominal depreciations and 38 observations of real depreciations of the Rouble, but only 12 observations of reduction in the money supply. This means that the money supply is usually increased no matter what happens to the exchange rate. Such a policy may be optimal only in 50 cases of real appreciation, but not in the other 38 cases of real depreciation, being too inflationary.
Since it is claimed by the monetary authority that monetary policy is aimed at real exchange rate targeting, real appreciation should be accompanied by an increase in the money supply, making nominal appreciation less significant, while real depreciation should be accompanied by a reduction in the money supply, making nominal depreciation less significant as well. Such a relationship between changes in real and nominal exchange rates is illustrated by Figure 6A: under optimal monetary policy rule changes in the nominal exchange rate should be smoothed (the blue line is less volatile than the red line). Moreover, positive changes should be smoothed more than negative ones. Figure 6B plots the actual changes in nominal and real exchange rates. We observe quite the opposite relationship: the blue line exhibits the same volatility as the red line and lies almost always above it. Again we see the most significant difference during the crisis when real depreciation was accompanied by increasing money supply making nominal depreciation even more pronounced. But in the later period the situation is similar. Although real appreciation (negative changes in NEER) is smoothed by increasing money supply and hence results in lower nominal appreciation, real depreciation, on the contrary, is also accompanied by increasing money supply, making nominal depreciation even more significant. Such monetary policy is asymmetrical, but different from what our theoretical model proposes. Such policy is welfare-enhancing only in cases of real appreciation of the Rouble, but welfare-reducing in cases of real depreciation. In our sample 43% of all observations are observations of real depreciation, and in most of these cases monetary policy was inflationary and not optimal. This can explain why Russia suffers from high inflation.

Figure 6 – Changes in nominal and real exchange rate of the Rouble
To perform a more formal test of asymmetrical monetary policy, we include a dummy variable $d$, which equals 1 in case of rising exchange rate (depreciation) and 0 otherwise, into our VEC model:

\[ \Delta y_t = A + \sum_{i=1}^{3} B_i \Delta y_{t-i} + Ed\Delta neer_{t-1} + C\Delta x_t + Dv_{t-1} + \psi_t \]  

We estimate the above model for the aggregate CPI for the period 2003-2005. We are interested in the sign and significance of the coefficient of $d\Delta neer_{t-1}$ in the equation for money supply. This coefficient was estimated to be positive with $t$-statistics of 1.78. This means that monetary policy is indeed asymmetrical and inflationary.

The next step is to estimate responses of money supply to exchange rate impulses. We build impulse response functions separately for a positive shock, taking into account the dummy coefficient, and a negative shock. Each shock is normalised to 1 by absolute value. We find that money supply is increased by 3 after a negative shock. This confirms our hypothesis that Rouble appreciation is accompanied by an increase in money supply. But after a positive shock money supply also rises by 2.18 while in the symmetric case it should fall by 3.

The test formally shows that monetary policy of the Central Bank of Russia is asymmetrical: the money supply rises irrespectively of a change in the exchange rate. Such policy is too inflationary and leads to higher social losses in case of depreciation of the Rouble. In order to fight inflation and increase social welfare, the money supply should fall significantly in cases of Rouble depreciation, but rise insignificantly in case of Rouble appreciation. The extent of the optimal intervention depends on the degree of price stickiness in the economy. But, since prices are more sticky downwards than upwards, it is not so important to intervene in the FOREX market in cases of Rouble appreciation. Since at present the Rouble is experiencing significant real appreciation, the Central Bank of Russia should not pay as much attention to its targeting as it does presently. If the Central Bank continues its present policy of preventing nominal appreciation of the Rouble by accumulation of foreign currency reserves, the rising money supply will only lead to persistent inflation and higher social losses.

**CONCLUSION**

In the environment of rising oil prices and an appreciating Rouble, Russian monetary policy faces a clear trade-off between loss of export and inflation. Therefore, the debate on to what extent monetary policy should be employed
The monetary and exchange rate policy of the Central Bank...

in managing nominal exchange rates has been in the centre of many political and economic discussions in Russia recently.

In this paper we build a general equilibrium sticky price model of a small open economy where the real exchange rate behaves like a random walk (for example, due to exogenous oil price shocks). Using quadratic loss function as an approximation of social utility losses, we find that the optimal monetary policy rule is to adjust interest rates to exchange rate shocks, reducing pass-through. The optimal degree of intervention depends positively on the pass-through effect and negatively on price-stickiness in an economy.

Since pass-through is crucial for determination of appropriate monetary policy, in this paper we estimate PTE on prices of different types of consumer goods. We find that although average pass-through elasticity has decreased remarkably since the crisis period, it is still significant for necessity goods such as foodstuffs. Since food constitutes the largest share in total consumption, some degree of monetary intervention is desirable in order to reduce the impact of exchange rate shocks on consumption distortions. But, according to our model the optimal degree of intervention should be different in cases of positive and negative exchange rate shocks under asymmetrical price rigidity. We claim that currency appreciation should be paid less attention than its depreciation since prices are stickier downwards. We estimate that monetary policy in Russia indeed responded to currency appreciation by increasing money supply, but it responded to Rouble depreciation in the same way, applying inflationary pressures in the process.

So, based on our theoretical model and empirical estimation results, we have a number of propositions for Russian monetary policy. First, the degree of intervention during periods of Rouble appreciation should be reduced gradually. This will help reduce inflation and promote long-term growth, although in the short term the exporting sector might suffer. On the other hand, in the case of a drop in oil prices or some other exogenous shocks which may affect the exchange rate of the Rouble adversely, tight monetary policy should be employed in order to reduce the impact of exchange rate changes on prices in the light of the finding that pass-through on prices of necessities is still significant.

A more general suggestion is that Russian Central Bank should start using interest rates as a policy instrument. Interest rates are easier to adjust, especially in cases of contractionary policy, since open-market operations are ineffective in an economy which has lost trust in the government. But in order for this transmission mechanism to work effectively, significant institutional developments, such as increased transparency of Central Bank actions and the banking system as a whole and better legal protection, are required.
Further research could concentrate on analysis of monetary policy rules under asymmetrical price rigidity and cross-country comparisons of monetary policy practice. Also, more empirical evidence on asymmetrical pass-through and asymmetrical reaction of prices to positive and negative money supply shocks is desirable for Russia as well as for other countries. Besides that, a micro-founded theoretical explanation of asymmetrical price rigidity could contribute more to our understanding of the problem.

REFERENCES


APPENDIX 1

Responses of consumer prices to Cholesky degrees of freedom adjusted NEER impulses for 2003-2005. The solid lines are responses of model 13 and the dashed lines are responses of model 14.

1. Foodstuffs

![Graph of CPI](image1)

![Graph of Foodstuffs](image2)

![Graph of Bread and bakery products](image3)

![Graph of Groats and beans](image4)

![Graph of Pasta products](image5)

![Graph of Meat and poultry](image6)

![Graph of Fish products](image7)

![Graph of Milk and dairy products](image8)
2. Non-food goods
3. Services rendered to population

- Services rendered to population
- Housing and public utilities
- Public health
- Passenger transport
- Communications
- Cultural institutions
- Sanatoria, resorts and health care institutions
- Child care in pre-school institutions
- Education
- Everyday services
Appendix 2

The structure of the consumer shopping basket in Russia in 2006

<table>
<thead>
<tr>
<th>All goods and services</th>
<th>100</th>
<th>Services to population</th>
<th>23,55</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foodstuffs</td>
<td>42,71</td>
<td>Everyday services</td>
<td>2,71</td>
</tr>
<tr>
<td>Meat and poultry</td>
<td>10,71</td>
<td>Passenger transport</td>
<td>3,31</td>
</tr>
<tr>
<td>Fish products</td>
<td>1,88</td>
<td>Communication</td>
<td>2,66</td>
</tr>
<tr>
<td>Butter</td>
<td>1,60</td>
<td>Housing and public utilities</td>
<td>8,90</td>
</tr>
<tr>
<td>Milk and dairy products</td>
<td>2,84</td>
<td>Child care in pre-school institutions</td>
<td>0,28</td>
</tr>
<tr>
<td>Cheese</td>
<td>0,99</td>
<td>Education</td>
<td>2,02</td>
</tr>
<tr>
<td>Eggs</td>
<td>0,72</td>
<td>Cultural institutions</td>
<td>0,26</td>
</tr>
<tr>
<td>Cakes</td>
<td>2,33</td>
<td>Sanatoria, resorts and health care institutions</td>
<td>0,54</td>
</tr>
<tr>
<td>Tea and coffee</td>
<td>1,03</td>
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