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Money demand in post-crisis Russia: De-dollarisation and re-monetisation

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Abstract

Estimating money demand functions for Russia following the 1998 crisis, we find a stable money demand relationship when augmented by a deterministic trend signifying falling velocity. As predicted by theory, higher income boosts demand for real rouble balances and the income elasticity of money is close to unity. Inflation affects the adjustment towards equilibrium, while broad money shocks lead to higher inflation. We also show that exchange rate fluctuations have a considerable influence on Russian money demand. The results indicate that Russian monetary authorities have been correct in using the money stock as an information variable and that the strong influence of exchange rate on money demand is likely to continue despite de-dollarisation of the Russian economy.

Key words: money demand, vector error correction models, dollarisation, Russia
JEL codes: E31, E41, E51, P22

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Tiivistelmä

Tässä tutkimuksessa estimoidaan Venäjää koskevia rahan kysyntäyhtälöitä vuoden 1998 talouskriisin jälkeiselle ajanjaksolle. Kun estimoitavaan relaatioon lisätään vähenevä trendi, joka osoittaa rahan kiertonopeuden hidastuneen Venäjällä, tutkimuksessa löydetään vakaa rahan kysyntäyhtälön. Kuten teoria ennustaa, tulojen kasvu lisää reaalisen rahan kysyntää ja rahan tulojousto on lähellä yhtä. Inflaatio vaikuttaa siihen, miten estimoitu systeemi hakeutuu takaisin tasapainoon. Tulokset antavat aiheen olettaa, että Venäjän rahaviranomaiset ovat olleet oikeassa kiinnittäessään huomiota rahan määrän muutoksiin rahapolitiikan formuloinnissa. Lisäksi näyttää siltä, että valuuttakurssin vaikutus rahan kysyntään jatkuu, vaikka dollarisaatio onkin vähentynyt Venäjällä.

Asiasanat: rahan kysyntä, vektorivirheenkorjausmallit, dollarisaatio, Venäjä

1 Introduction

The role of the exchange rate in monetary policy remains significant for many small open economies as well as larger emerging market countries that traditionally have been extensively dollarised. In the following discussion, we assess the effects of exchange rate on money demand in Russia. Russia's economy was heavily dollarised until recently, when its economic policies gained a degree of credibility. Given that similar developments have taken place in many emerging market countries following the financial crises of the late 1990s, it is our hope that the case of Russia may highlight important features common to other emerging economies.

The Russian economy has undergone substantial changes since the August 1998 economic and financial crises. Economic growth resumed fairly soon after the rouble's drastic devaluation and a rebound in world energy prices. Rapid economic growth and soaring commodity prices have helped push Russia's government finances into strong surplus after a prolonged period of public sector deficits. The changes in the sphere of exchange rate and monetary policy, while less apparent, have also been profound. Prior to the August 1998 crisis, the rouble was pegged fairly tightly to the US dollar. Since the crisis and the failure of the exchange rate peg, the lynchpin of the Central Bank of Russia's (CBR) stabilisation efforts, the CBR has avoided explicit exchange rate targets. It has, nevertheless, influenced changes in the rouble exchange rate quite heavily. At the same time, the CBR has had a target band for inflation. However, this target has usually been overshot, as the CBR has given precedence to maintaining the nominal exchange rate close to a desired level.

In this paper, we estimate money demand functions for the post-crisis period for Russia. The evolution of the monetary policy regime over eight post-crisis years provides sufficient data to test econometrically for the presence of a stable money demand function. Several interesting research questions – all with clear policy implications – can be assessed within this framework. First, we can assess whether a stable money demand function can be said to even exist. We know that Russian households and companies have shown increasing trust in their currency and banks in recent years, which has led to a remonetisation of the economy. But can we find a statistically significant and stable relationship among money, prices, income and other relevant variables in such an environment? If so, does, for example, income elasticity of money demand differ from the values typically found in more mature economies? Second, we are interested in the role of foreign exchange in Russian money demand. Even though the demand for rouble deposits has clearly increased, foreign currency (especially US dollar) holdings of Russian residents remain large. We want to know whether the exchange rate has an effect on rouble money demand in Russia. Presumably, the larger the absolute value of this influence, the higher the remaining degree of dollarisation. This would justify a large role for the exchange rate in the conduct of monetary policy. This is likely the case also in other emerging market economies, where the exchange rate continues to play a significant role in the setting of monetary policy.

To answer these questions, we first look for a cointegrating relationship among the real rouble money stock, an indicator for GDP and various proxies for the opportunity cost of holding money. We find that when these variables are augmented by a trend, a stable long-run relationship among them seems to exist. This relationship can be interpreted as a money demand function, while the trend variable captures the monetary deepening we see in post-crisis Russia. We also see that including the exchange rate variable is supported by the data. Next, we employ a vector error correction model to study the impulse responses of our estimated system. It appears that exchange rate depreciation decreases the demand for real rouble balances. A positive shock to the money stock eventually increases inflation. These results suggest that money can serve as a useful indicator of future inflation pressures, and that the exchange rate continues to exert influence on money demand in Russia. Higher oil prices also induce appreciation of the currency.

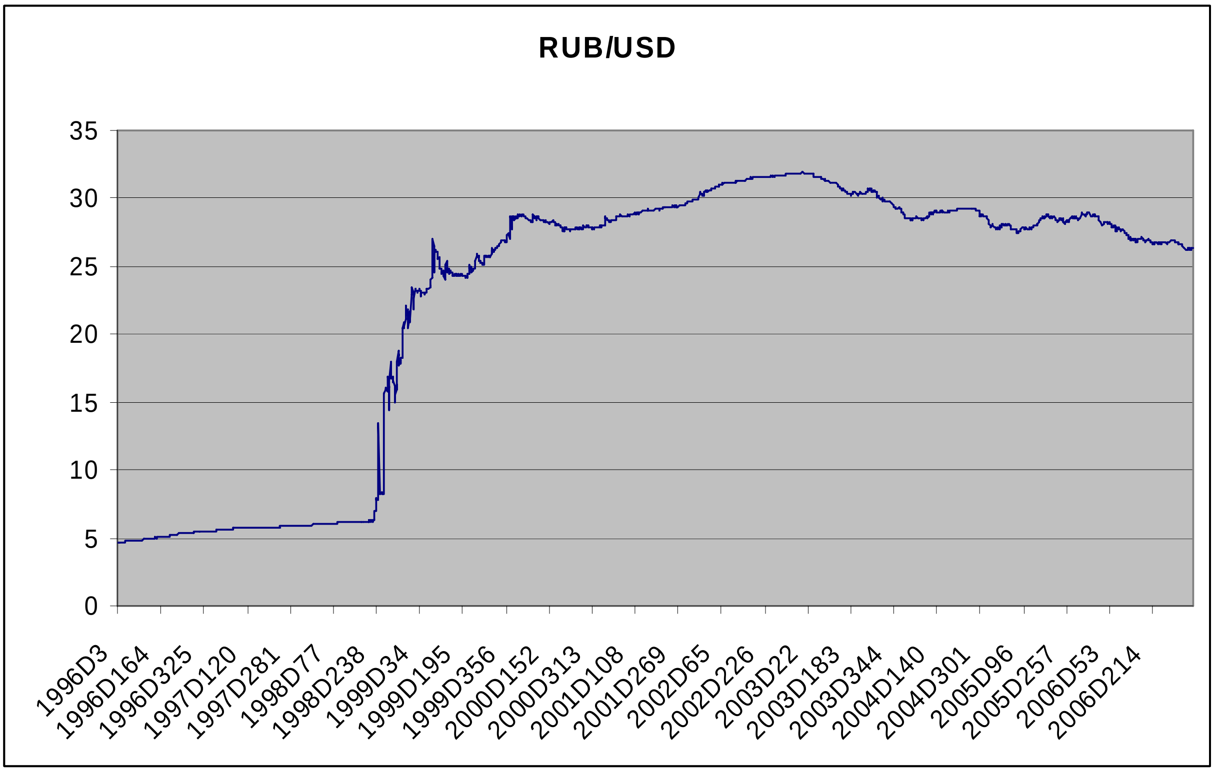
The novelty of this analysis is that we concentrate solely on the post-crisis data, which allows us to draw more relevant policy conclusions. We also include as an opportunity cost variable several indicators of the exchange rate, including the expected change in the rouble exchange rate, derived from the spot and forward rates. This provides a clearer indication of the significance of exchange rate movements for rouble money demand.

The paper is structured as follows. In section two, we present a brief outline of Russia's monetary policy during the post-crisis era, and review the existing literature on money demand in Russia. Section three presents the data and an examination of the time series. In the fourth section, we perform our estimations and discuss the results. Section five notes some key policy conclusions.

2 Description and selective literature survey of Russian monetary policy during the post-crisis era

The August 1998 financial crisis caused more than an abandonment of fixed peg for the rouble, it forced the Russian government to reschedule its loan commitments, an act tantamount to partial default on its debts. Many commercial banks went under, some of them owning substantial sums of money to foreign investors who had hedged their rouble risks by selling rouble forwards contracts. The underlying cause of the crisis was the inability of the Russian government to balance its finances. A vicious circle of increased domestic and international borrowing at ever-higher interest rates ended when the supply of external financing dried up. Russia was forced to abandon the fixed exchange rate and reschedule its loan commitments. Sutela (2000) provides a discussion concerning the crisis and the events leading up to it. Figure 1 shows the sharp depreciation of the rouble in 1998 and its subsequent stabilisation.

Figure 1 Rouble-US dollar exchange rate



The collapse made it clear an alternative regime was needed for monetary and exchange rate policies. The adopted (and current) regime might be described as a hybrid between inflation targeting and managed float. In its annual *Guidelines for the Single State Monetary Policy*, the CBR specifies the inflation target for the next year and includes a forecast range for growth of rouble money stock (M2). Table 1 lists these inflation targets and money growth projections, as well as actual outcomes, for 1999-2006. It is difficult to characterise conduct of monetary policy in the period as straightforward. The lack of monetary policy instruments and underdeveloped interbank markets compelled the CBR to rely heavily on foreign exchange interventions. The CBR announces annual ceilings for appreciation of the real rouble rate. During the post-crisis era Russian monetary policy has been helped in fighting inflation by the fiscal authorities. Strong budget surpluses and – especially from 2004 onwards – growth of the Stabilisation Fund have helped to regulate liquidity in the economy.

Keller and Richardson (2003) provide an overview of nominal anchors in the CIS countries. They find that almost all CIS countries, even if they claim to have floating exchange rates, are heavily involved in managing the external values of their currencies. This reliance on exchange rate interventions as the main instrument of monetary policy is partly explained by high degrees of dollarisation. The authors conclude that as inflation expectations decline and de-dollarisation gathers pace, other nominal anchors may become more optimal. Even so, direct inflation targeting appears to be out of reach to these central banks for a while.

Table 1 Inflation targets and M2 growth projections of the Central Bank of Russia

	Year-end inflation target	Inflation outcome	Year-end M2 growth projection	M2 growth outcome
1999	30%	36.5%	18-26%	57.2%
2000	18%	20.2%	21-25%	58.9%
2001	12-14%	18.6%	27-34%	40.1%
2002	12-14%	15.1%	22-28%	32.3%
2003	10-12%	12.0%	20-26%	45.9%
2004	8-10%	11.7%	19-25%	35.8%
2005	8.5% (original, later revised to 11%)	10.9%	19-28% (target for base money)	30.0% (outcome for base money)
2006	8.5%	9.0%	19-28%	40.5%

Previous research on money demand and prices in Russia includes a traditional money demand function approach along with estimation of various monetary policy rules. With a single exception, none of the studies reviewed here concentrate on the post-crisis period.

Nikolić (2000) estimates several models of inflation for Russia using data from the pre-crisis period. As one would expect, he finds that money Granger-causes inflation. However, the findings also suggest inflation may Granger-cause growth of the broad money stock, which would make strict control of monetary aggregates difficult for the central bank. In addition, velocity was highly volatile during the pre-crisis period, compounding the difficulties in implementing stabilising monetary policy.

Oomes and Ohnsorge (2005) augment traditional money demand functions by including estimates of foreign cash holdings in the monetary aggregates. When testing for cointegration between the monetary aggregate, output variable, deposit interest rate and exchange rate change, they find the most stable long-run relationship for the specification where both foreign currency deposits and cash holdings are included in the broad money aggregate. Under this specification, the coefficients on industrial production and deposit rate are significant and have expected signs. The exchange rate is, as expected, not significant when foreign currency holdings are included in the monetary aggregate. In the specifications with only the rouble money stock, the exchange rate change is always significant and a faster rate of depreciation decreases the demand for rouble balances.

Vymyatnina (2006) studies the monetary transmission mechanism in Russia between July 1995 and September 2004. The hypothesis is that demand for real rouble balances depends on income (proxied by real total trade), opportunity cost of holding money (proxied by an interbank interest rate) and the exchange rate against the US dollar. A cointegrating relationship is estimated among the variables, and all have expected signs in the specification. Higher interest rates decrease the demand for money, as does a weaker rouble. However, this cointegration relationship appears to be unstable, especially around the time of the 1998 crisis and from 2002 onwards. Estimating a single model for the whole data sample fails to pick up the deepening monetisation of the Russian economy of recent years (see Kim and Pirttilä, 2004). While the relatively long sample obviously yields more observations, the inclusion of the 1998 crisis complicates interpretation of the obtained coefficients.

Esanov et al. (2006) estimate several monetary policy rules for Russia for the period 1993/4-2002. Although this is not exactly the same as estimating money demand functions, the exercise is relevant. For example, the McCallum rule for monetary policy determines the growth of monetary base by the target and actual rates of growth of the nominal GDP as well as the change in velocity. In addition, the authors use the USD exchange rate in estimating both McCallum and Taylor monetary policy rules, as we do when estimating money demand functions for Russia. Esanov et al. also estimate a hybrid Ball rule for Russian monetary policy. They conclude that the McCallum rule, where monetary base is the policy instrument, best fits the data for the period. On one hand, the CBR has always paid attention to the monetary aggregates as evidenced by its public forecasts for M2 growth. This would make the result plausible. On the other hand, the exchange rate has figured prominently in CBR policy, both before and after the 1998 crisis. Furthermore, changes in velocity have meant that growth of the money stock has consistently overshot its target band in the post-crisis era. Yet the authors do not consider a policy rule where the exchange rate is the policy variable. Interpretation of the results is made all the more challenging by the presence of the large shifts in the levels of many variables following the 1998 financial crisis and despite the best efforts of the authors to control for this with dummy variables.

Ponomarenko (2007) estimates an error correction money demand function for Russia using real M2 as the dependent variable between March 1999 and September 2006. In the long-run specification the income variable is domestic absorption (household consumption, fixed capital formation and government consumption). The income elasticity of money seems to be quite high – over 2.5. An increase in the deposit rate is found to decrease the demand for money. This study uses a comparable sample period to our estimations, but differs in its choice of variables. In addition, it is estimated in a single equation framework, whereas we utilise a systems approach.

From the studies reviewed here, it appears that a money demand relation can also be found for Russia, even with the complications from widespread dollarisation and the August 1998 financial crisis. Nevertheless, it is apparent that these factors have introduced a large degree of uncertainty into the empirical results. Thus, we aim to provide more stable results by restricting ourselves to data from the post-crisis period. We also introduce an opportunity cost variable for the expected exchange rate change derived from forward rates.

3 Data

The present study uses monthly data from January 1999 to December 2006. This eight-year period, though short, provides enough observations for statistical inference about post-crisis behaviour of money demand in Russia. We have omitted the months immediately following the August 1998 crisis. The short time period means that any conclusions should be taken as preliminary, however.

In the main econometric model, we use monthly data on nominal M2 rouble money stock denoted m_t, consumer price index denoted p_t, GDP indicator denoted y_t, and nominal rouble exchange rate against the US dollar denoted e_t.[1] Figures depicting variables appear in the Appendix. We specify long-run real broad money demand in the Russian economy as

$$(m - p)_t = \beta_1 y_t + \beta_2 \pi_t + \beta_3 e_t + u_t \,, \qquad (1)$$

where all variables are in logarithms. Demand for real money balances is explained by real income, inflation and exchange rate. The latter two variables are included to account for the opportunity cost of holding money. When we assume rational expectations, the actual outcome differs from the expected one only by a stationary error term, which justifies the use of actual values for the exchange and inflation rates in our system. Moreover, the CBR can control the exchange rate level to some degree, at least in the short run. As the Russian economy remains highly dollarised, the exchange rate potentially has a large effect on money demand. Consumer price index and the nominal exchange rate against the US dollar are taken from the IMF's IFS database, while the nominal rouble stock comes from the Central Bank of Russia. The monthly GDP indicator comes from the Russia's statistical agency, Rosstat, which is based on output in five core sectors of the economy.[2] Most previous studies on Russian money demand use industrial production as a proxy for income. Given the growing importance of e.g. services and construction in the Russian economy, we feel the GDP indicator better captures the dynamics of the overall economy.

[1] When checking for the robustness of our results, we also use the nominal effective exchange rate and the expected change of the US dollar exchange rate.
[2] The five core sectors are industrial production, retail trade, construction, transport and agriculture.

The order of integration of the series has important implications for the chosen estimation approach. We tested for unit roots by the commonly-used Augmented Dickey-Fuller (ADF) tests. The maximum number for lags was set to 10, and seasonal dummies were included for all other series except the exchange rate and oil prices. Table 1 below reports results using the lag length suggested by the Schwarz information criterion.

Table 2 Augmented Dickey-Fuller test for unit roots

Series	Det. Term	Lagged differences	Test stat.
$\Delta(m\text{-}p)$	Constant	0	-7.23***
$(m\text{-}p)$	Constant, trend	1	-1.72
$\Delta\pi$	Constant	2	-7.16***
π	Constant, trend	0	-5.47***
Δy	Constant	0	-10.35***
y	Constant, trend	0	-3.88**
Δe	Constant	0	-5.58***
e	Constant, trend	1	-2.13
Δ*oil price*	Constant	0	-9.79***
oil price	Constant, trend	0	-3.06

Notes: * indicates significance at 10% level, ** at 5% and *** at 1% level. Sample: 1999M2-2006M12. Seasonal dummies are included in the testing procedure for money, prices and output.

For real money, oil price and the exchange rate, a unit root cannot be rejected for the series in levels, whereas we reject a unit root in first differences, even at 1% level. For the inflation rate and output in levels we can reject a unit root, suggesting these series are actually trend-stationary. However, when three lags are included in the testing procedure, the unit root cannot be rejected at conventional levels of significance for output and at 1% level for inflation. Taking these outcomes together and considering results from various model specifications, we prefer modelling inflation and output as I(1) variables for Russia, although in principle stationary variables can also be accommodated in vector error correction (VEC) systems. Given the volatility and downtrend in the inflation rate, especially after the Russian crisis, we consider this assumption reasonable.

As our unit root tests suggest the series can be modelled as integrated of order one, it is possible that the series are driven by common stochastic trends. If so, they are said to be cointegrated. Thus, a VEC specification is the preferred setup as it allows us to distinguish between short-run and long-run relationships. Theoretical relationships such as a money demand relation are typically defined in terms of the levels of the series, while a lack of cointegration could lead to spurious regressions when the variables are integrated of an order higher than zero. We test for cointegration utilising the test proposed by Saikkonen and Lütkepohl (2000), including a constant, linear trend and seasonal dummies in the testing procedure since some series trend over time. Oil price is not included, as it only appears in our estimated system as an exogenous variable. The results are reported in Table 2.

Table 3 Saikkonen-Lütkepohl cointegration test

Sample	Lagged levels	Null hypothesis	Test stat.
1999M2-2006M12	1	$r = 0$	74.47***
		$r = 1$	24.59
		$r = 2$	5.43
		$r = 3$	0.04
1999M2-2005M12	1	$r = 0$	61.84***
		$r = 1$	18.10
		$r = 2$	6.68
		$r = 3$	0.00
2000M1-2006M12	1	$r = 0$	53.32***
		$r = 1$	22.02
		$r = 2$	11.20
		$r = 3$	0.09

* indicates significance at 10% level, ** at 5% and *** at 1% level. Deterministic terms include a constant, a linear trend and seasonal dummies for all systems.

For our benchmark post-crisis sample, the Saikkonen-Lütkepohl test suggests the existence of one cointegration relation, as a cointegration rank of zero can be rejected at the 1% level, and a rank of one cannot be rejected at any conventional level. As a robustness test, we considered truncated samples 1999M2-2005M12 and 2000M1-2006M12, respectively. These alternative samples do not change our finding of a cointegrating rank of one, even at the 10% significance level. We continue with the assumption that a single cointegration relationship exists among the system variables.

4 Estimation results and their interpretation

Like most recent research on money demand, we adopt a vector error correction (VEC) model. Our choice is justified by our cointegration tests, which found that the variables share common stochastic trends that could plausibly be written in the form of a money demand relation (although this can only be tested in the context of system estimation). When we omit the deterministic terms and include exogenous variables, a reduced form VEC-model can be expressed as

$$\Delta x_t = \Pi x_{t-1} + \Gamma_1 \Delta x_{t-1} + \ldots + \Gamma_{p-1} \Delta x_{t-p+1} + B_0 z_t + \ldots + B_p z_{t-p} + u_t , \qquad (2)$$

where p denotes the order of the VEC-model. We include K=4 endogenous variables. $x_t = (x_{1t}, ..., x_{Kt})'$ is a (K×1) random vector and Γ_i are fixed ($K \times K$) coefficient matrices. z_t are unmodelled stochastic variables and thereby assumed to be exogenous, while B_i are parameter matrices. Our system includes one exogenous variable. The $u_t = (u_{1t}, ..., u_{Kt})'$ is a K-dimensional white noise process with $E(u_t) = 0$. When the variables are cointegrated, Π has reduced rank $r = rk(\Pi) < K$. It can be expressed as $\Pi = \alpha\beta'$, where α and β are ($K \times r$) matrices that contain the loading coefficients and the cointegration vectors, respectively.

We estimate the model with 6 lags in both the endogenous and exogenous variables. As the observations for 1999M2-1999M8 are used as presample values, the effective estimation sample runs from 1999M9 to 2006M12. We include a constant, seasonal dummies and a linear trend as the deterministic variables in the system. The trend is restricted in the cointegration relation. Our choice for the lag length is based on tests for misspecification and stability. We estimate the cointegration relationship by the simple two-step (S2S) procedure, which effectively utilises feasible Generalized Least Squares (GLS). The S2S estimator displays substantially better small-sample properties than the maximum likelihood (ML) estimator, as Brüggemann and Lütkepohl (2005) show. The cointegration relationship is estimated as (standard errors in parentheses):

$$\underset{}{(m-p)_t} = \underset{(0.329)}{1.441 y_t} - \underset{(2.952)}{3.337 \pi_t} - \underset{(0.122)}{0.965 e_t} + \underset{(0.001)}{0.011 t} + u_t \qquad (3)$$

The estimated coefficients have the signs suggested by theory. A higher level of output increases the demand for real money, while a higher opportunity cost of holding money leads to a fall in money demand. However, the coefficient on the inflation rate is not statistically significant at the 10% level. Our estimated income elasticity of money demand is relatively high, reflecting increasing monetisation of the Russian economy after the 1998 crisis. However, an income elasticity of unity is within two standard error bounds. In their analysis of earlier surveys on money demand, Knell and Stix (2006) report that the average income elasticity of broad money for non-OECD countries is very close to unity, but the standard deviation of elasticity observations tends to be quite high, ranging from 0.36 to 0.53. Therefore, our estimate for income elasticity is not far off from the results found for other non-OECD countries. It should be noted that the elasticity is lower than in Ponomarenko (2007), who uses a somewhat narrower definition of income.

As can be seen from Table 3, our estimated cointegration relation remains relatively robust to changes in the chosen VEC-order when the S2S estimation procedure is used. In contrast, the ML estimation procedure provides less robust estimates; this is evident especially from the coefficient estimates obtained with 5 lags in the Johansen framework. Moreover, the inflation rate always obtains the wrong sign in the ML estimation. The lag length for the exogenous variable (oil price) is identical to the chosen one for the endogenous variable in all systems in the table.

Table 4 Estimated cointegration vectors with alternative methods and lag lengths

Method	Lags	$\beta(y)$	$SE(y)$	$\beta(\pi)$	$SE(\pi)$	$\beta(e)$	$SE(e)$
S2S	6	1.441	0.329	-3.337	2.952	-0.965	0.122
ML	6	1.004	0.442	7.731	3.965	-0.757	0.163
S2S	7	1.339	0.252	-4.487	2.385	-0.950	0.091
ML	7	0.455	0.394	6.797	3.734	0.711	0.142
S2S	5	1.402	0.327	-3.985	2.505	-0.941	0.117
ML	5	1.439	0.666	25.866	5.095	-0.358	0.238

Testing with an exchange rate measure derived from forward contracts offers additional insight as the exchange rate sensitivity of the demand for Russian domestic broad money may vary using different exchange rates. To our knowledge, forward contracts have not previously been used in studies of Russian money demand. Using 1-month forward data, we calculate the expected exchange rate change as the difference between the current spot rate and the forward rate, with both variables expressed in logarithms.[3] A caveat here is that the estimation sample only starts in 2000M9 due to data limitations (the forward data is only available from 2000M1 onwards) and significant outliers in the beginning of the year 2000. Nevertheless, this variable is statistically significant with the expected sign, although the income elasticity now increases to 3.64. We continue with the benchmark specification of using the actual USD/rouble exchange rate (level) as the sample is longer, but note that the forward data bring about correctly signed and significant coefficient estimates for the expected exchange rate change in the Russian money demand equation.[4]

Table 5 Estimated cointegration vectors with spot rates and forward contracts

Method	Exchange rate change	Lags	β (y)	SE(y)	β (π)	SE(π)	β(e)	SE(e)
S2S	spot RUB/USD	6	1.441	0.329	-3.337	2.952	-0.965	0.122
S2S	1-month forward	5	3.640	0.651	-3.528	7.099	-5.924	2.982

The short-run parameters of the VEC system are estimated by feasible GLS. Model reduction was achieved by a procedure where the parameter with the lowest *t*-value was checked and possibly eliminated from the system. We report the results from a model, where only coefficients with a higher *t*-value than 1.67 are maintained. The estimated cointegration relation – or error correction term – is denoted by ec_{t-1}, and standard errors are reported in parentheses. The exchange rate variable is the USD/rouble rate.

[3] Bofinger (2001) uses data on the exchange rates of four major currencies against the US dollar to investigate the fit of a regression where future spot rates are explained by data on current forward contracts. He shows that when the exchange rate data are in differences, the fit of the model is quite poor compared to estimations where the data are in the form of non-stationary levels. Froot and Thaler (1990) provide an overview of the literature on the topic. For our purposes, the issue is whether forward data provide similar estimates in the money demand system as the spot rate with the perfect foresight assumption.

[4] This behaviour of the forward exchange rate may be symptom of the well-known peso problem. For a substantial part of our sample Russian interest rates have been higher than in the US, and thus the expected change in the rouble exchange rate is depreciation. However, since 2003 the rouble has tended to appreciate. We also tested for the inclusion of the (change in the) nominal effective exchange rate, but our estimates for the long-run money demand did not remain robust when this variable was used. The US dollar remains the most widely used foreign currency in Russia in terms of economic transactions, savings accounts and even in pricing.

Table 6 Vector error correction model

Equation	$\Delta(m\text{-}p)$	Δy	$\Delta\,\pi$	Δe
ec_{t-1}	-0.087 (0.020)	0.284 (0.029)	0.001 (0.000)	-0.099 (0.019)
$\Delta(m\text{-}p)_{t-1}$	---	---		---
$\Delta(m\text{-}p)_{t-2}$	---	---	---	0.196 (0.042)
$\Delta(m\text{-}p)_{t-3}$	0.168 (0.050)	---	---	---
$\Delta(m\text{-}p)_{t-4}$	-0.155 (0.046)	---	0.060 (0.011)	---
$\Delta(m\text{-}p)_{t-5}$	---	---	---	-0.111 (0.039)
$\Delta(m\text{-}p)_{t-6}$	---	---	0.080 (0.013)	---
Δy_{t-1}	---	---	---	-0.238 (0.036)
Δy_{t-2}	---	---	---	-0.165 (0.035)
Δy_{t-3}	---	---	0.022 (0.005)	-0.175 (0.024)
Δy_{t-4}	-0.144 (0.028)	---	0.039 (0.006)	-0.123 (0.024)
Δy_{t-5}	---	0.161 (0.032)	---	-0.193 (0.025)
Δy_{t-6}	---	---	-0.023 (0.006)	-0.058 (0.022)
$\Delta\,\pi_{t-1}$	---	-3.104 (0.468)	-0.345 (0.051)	0.353 (0.204)
$\Delta\,\pi_{t-2}$	---	-2.349 (0.539)	-0.278 (0.056)	---
$\Delta\,\pi_{t-3}$	---	---	-0.284 (0.068)	---
$\Delta\,\pi_{t-4}$	---	---	---	---
$\Delta\,\pi_{t-5}$	---	---	---	-0.340 (0.164)
$\Delta\,\pi_{t-6}$	-0.861 (0.266)	---	---	---
Δe_{t-1}	-0.573 (0.110)	0.364 (0.198)	-0.077 (0.027)	0.536 (0.084)
Δe_{t-2}	---	---	---	0.231 (0.089)
Δe_{t-3}	---	-0.640 (0.228)	---	---
Δe_{t-4}	---	0.631 (0.240)	---	---
Δe_{t-5}	---	0.577 (0.192)	0.081 (0.024)	0.139 (0.069)
Δe_{t-6}	---	---	---	-0.235 (0.065)
Δoil_{t}	---	---	---	---
Δoil_{t-1}	---	---	---	-0.014 (0.008)
Δoil_{t-2}	---	---	-0.007 (0.003)	---
Δoil_{t-3}	0.035 (0.012)	---	-0.009 (0.003)	---
Δoil_{t-4}	---	---	---	---
Δoil_{t-5}	-0.021 (0.012)	---	---	---
Δoil_{t-6}	---	0.040 (0.022)	---	---

LM(5)=95.32 [0.12] LM(4)=73.95 [0.19] LM(1)=19.79 [0.23]

JB_1=0.77 [0.68] JB_2=0.99 [0.61] JB_3=3.06 [0.22] JB_4=0.83 [0.66]

VARCH-LM(5)=498.11 [0.52]

Notes: Standard errors shown in parentheses. Constant and seasonal dummies are not displayed. The LM-test for autocorrelation is conducted at 1, 4 and 5 lags. *JB* is the Jarque-Bera test for non-normality for four individual system equations. VARCH-LM is the multi-variate ARCH-LM test at 5 lags. *p*-values for test statistics are shown in brackets.

The adjustment coefficients on the cointegration relation ec_{t-1} are of interest, as they indicate the possible adjustment of our system towards long-run equilibrium. We find that the coefficient on the equation for real money (-0.087) is statistically significant and negative, indicating that excess liquidity is corrected within our system. The speed of adjustment is relatively rapid. Excess liquidity in the Russian economy results in inflation pressure and higher real GDP, as indicated by the statistically significant adjustment coefficients in the inflation and output equations.[5] Somewhat unexpectedly, excess liquidity also seems to fuel appreciation of the currency. This may be evidence of the exchange rate as a policy variable, i.e. the central bank responding to excessive liquidity with a stronger exchange rate to contain inflationary pressures.

Regarding the short-run coefficients, there is feedback in the system between the money and price variables as they enter both equations. Similarly, feedback is detected between real money and the exchange rate, emphasizing the importance of the exchange rate in Russian money demand behaviour. Finally, in the short run, an increase in oil prices leads to an increase in Russian GDP.

Misspecification tests, reported in Table 5, include the LM-test for autocorrelation, the Jarque-Bera test for nonnormality, and the multivariate VARCH-LM test for ARCH-effects in model residuals. None of these tests suggest misspecification. The investigation of model stability is of special interest in money demand investigations. A stable money demand relation is a prerequisite for a meaningful specification of money growth targets, and could also be useful if concepts of excess liquidity, such as monetary overhang, are considered. We test for system stability by recursive eigenvalue tests, proposed by Hansen and Johansen (1999). The short-run parameters are concentrated out based on the full sample, and only the long-run part is estimated recursively. The standard errors to construct the 95% confidence intervals are estimated based on the full sample. The recursive eigenvalue remains relatively stable during the maximum period available for investigation, as shown in Figure 2a. Additionally, the τ-statistic in Figure 2b remains much smaller than the 5% critical value. The Chow forecast test, utilizing bootstrapped p-values obtained by 1,000 replications, also suggests model stability. We test for a possible break date for every observation, commencing in 2004M2, which corresponds to the longest available sample in our case. For no observation are we able to reject parameter stability even at the 10%

[5] The t-values of the adjustment coefficients in the inflation and output equations are 5.213 and 9.816, respec-

level.[6] We continue with the assumption that the estimated model displays stability over time.

Figure 2a Recursive eigenvalue

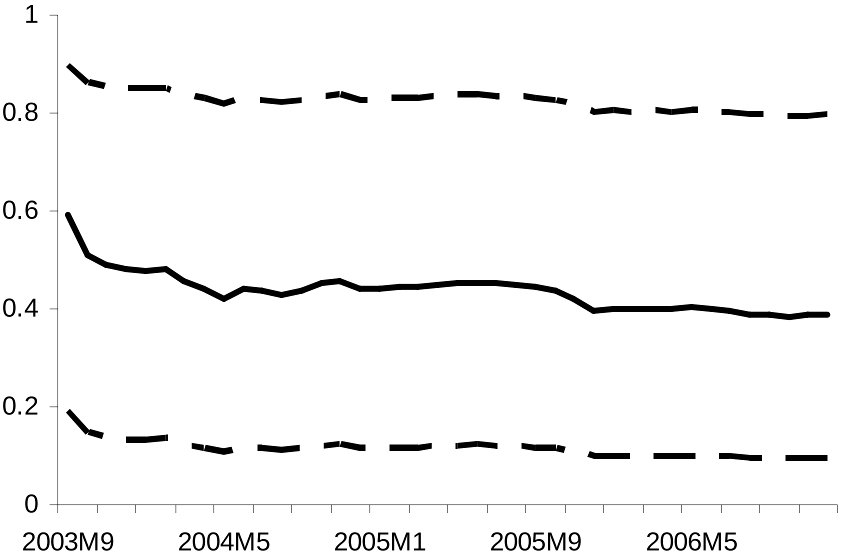
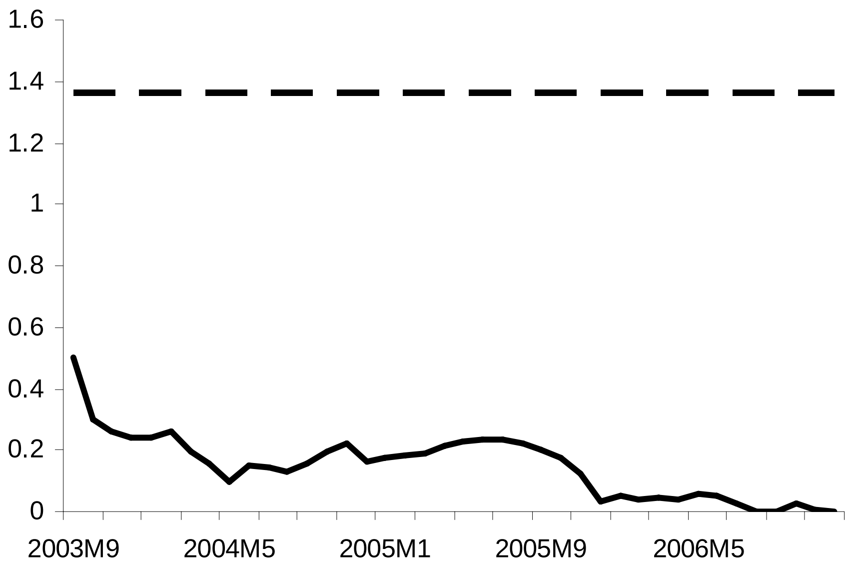


Figure 2b. Stability test statistic

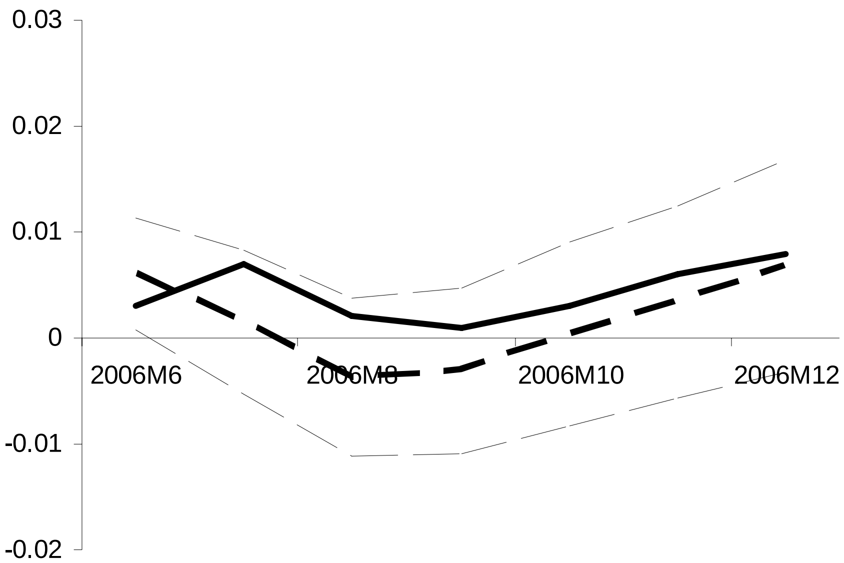


tively.

[6] These results are available on request.

To examine the forecasting performance of our money demand system in terms of the inflation rate, we estimated the model until 2006M5 and created out-of-sample forecasts for inflation seven months ahead. For the exogenous oil price variable, the actual outcomes during 2006M6-2006M12 were imposed. Figure 3 shows the forecast (bold dashed line), together with the actual outcome (bold solid line), and the confidence intervals (two thin dashed lines). All actual values fall inside the confidence intervals, providing support for our estimated system. Shortening the estimation sample by one month and forecasting eight periods ahead scarcely weakens the forecasting performance, as one actual observation just crosses the confidence interval (in 2006M8). The forecast in the end of the period (2006M12) again falls quite close to the actual outcome.

Figure 3 Out-of-sample inflation forecast



As our estimated money demand system displays stability over time, deviations of the money stock from the long-run equilibrium could, in principle, provide information about inflation pressures in the economy. Svensson (2000) points out that this "real money gap," written as $(m_t - p_t) - (m^*_t - p^*_t)$, is equivalent to the negative of the price gap in P^* models (see e.g. Hallman et al., 1991; Tödter and Reimers, 1994). Here $(m^*_t - p^*_t)$ denotes the equilibrium money stock obtained by substituting the actual outcomes for real money, output, the inflation rate and the exchange rate to the estimated long-run money demand equation. We examine the forecasting performance of the real money gap in terms of the inflation rate by tests for Granger causality, where causality is determined by a variable's ability to improve the forecasts of another variable. However, the inflation rate in our VEC system is seasonally unadjusted and the inclusion of seasonal dummies may significantly lower the power of the causality test by notably increasing the number of estimated coefficients. Therefore, we included the year-on-year inflation rate (in first differences to ensure stationarity), together with the real money gap in the estimated system for the Granger causality test. This bivariate system, using 2 lags, passes tests for autocorrelation and nonnormality, similarly to the estimated VEC model above. We find that the null hypothesis of Granger non-causality from the real money gap to prices can be rejected; the test statistic is 3.126 (p-value 0.047). Therefore, the real money gap estimated within our money demand system has some predictive power over future inflation.

For our system with a cointegrating relationship, we implement the standard impulse response analysis in the context of a structural VEC model where contemporaneous restrictions are used to identify the system. The structural VEC model is expressed as

$$\mathrm{A}\Delta x_t = \Pi^* x_{t-1} + \Gamma_1^* \Delta x_{t-1} + \ldots + \Gamma_{p-1}^* \Delta x_{t-p+1} + \mathrm{B}\varepsilon_t \,. \tag{4}$$

The structural shocks ε_t are mutually uncorrelated. We assume that $\varepsilon_t \sim (0, I_K)$. In (4), Π^* and Γ_j^*(j = 1, ..., p - 1) are structural form parameter matrices. A is an invertible matrix and allows for modelling of the instantaneous relations. The structural shocks are related to the reduced form residuals by linear relations, specifically

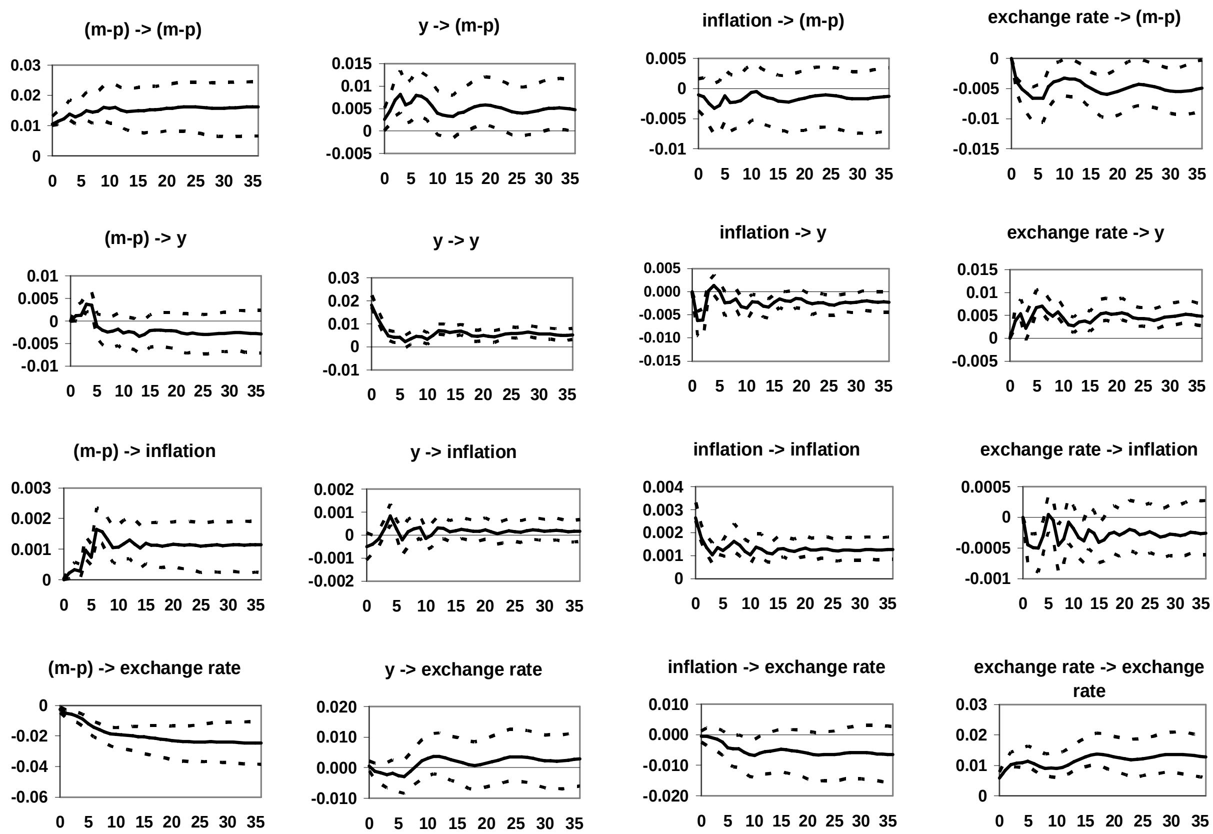
$$u_t = \mathrm{A}^{-1}\mathrm{B}\varepsilon_t \,. \tag{5}$$

We identify the model by considering restrictions on the parameter matrix B, with our ordering of the variables specified as $(m\text{-}p)$, y, $\Delta\pi$, e. In particular, we impose

$$\mathrm{B} = \begin{bmatrix} * & * & * & 0 \\ 0 & * & 0 & 0 \\ 0 & * & * & 0 \\ * & * & * & * \end{bmatrix} \quad , \tag{6}$$

where asterisks denote the unrestricted elements. Note that such an identification scheme effectively amounts to a Cholesky decomposition of the variance-covariance matrix with the ordering of the variables specified as output, prices, real money, and the exchange rate. Output is the most rigid variable in our system, as it does not react within the same month to shocks in prices, real money or the exchange rate. In the model by Sims and Zha (2006), there are significant adjustment costs and inertia associated with real economic activity. Considering real money an indicator of monetary policy stance, the non-contemporaneous impact of real money on output and prices is consistent with most work on reduced form modelling of monetary policy. Prices adjust slowly due to menu costs, or because they are changed at exogenously determined random intervals as in Calvo (1983). Finally, the exchange rate is allowed to react rapidly to any news about the economy, or indeed any macroeconomic shocks that affect real output, prices and money in our system.

Figure 4. Impulse responses



Impulse responses 36 months ahead are illustrated in Figure 4. Hall 95% bootstrapped percentile confidence intervals with 1000 replications were used. In our system, a permanent shock to real broad money leads to a statistically significant and permanent increase in the inflation rate. As predicted by theory, an inflation shock leads to a decline in the real money stock, although this result is not significant at 95% level. The same shock also leads to a fall in output, which is in line with the Russian experience from the post-crisis period when the economic recovery has been accompanied by steadily declining inflation. Interestingly, a rouble depreciation leads to a fall in the rouble money stock, which is consistent with our result for the cointegration relationship. As expected, the exchange rate shock also leads to an increase in the level of GDP. Perhaps surprisingly, rouble depreciation leads to decelerating inflation.[7] The rouble depreciated against the US dollar almost constantly from 1999 until the end of 2002, while inflation decelerated (and the real exchange rate appreciated). This negative correlation may be driving the results at least partially. Burstein et al. (2002) examined why inflation was low in large post-1990 contractionary devaluations relative to the rate of these devaluations. They argued that substitution away from imported goods to lower quality local goods could account quantitatively for the behaviour of prices.

We examined further the dynamics between the exchange rate and money stock by replacing the USD/rouble exchange rate (perfect foresight) by the expected depreciation obtained by using forward data. We find that an appreciation shock in the expected exchange rate change increase the demand for real rouble balances, again consistently with our finding from the cointegration analysis. These results are available from the authors upon request.

5 Conclusion and policy implications

We have estimated different specifications for money demand in Russia. To our knowledge, such analysis in a VEC framework has not been applied solely to data from the period following the August 1998 financial crisis. While this approach limited the available data, it permitted us to concentrate on a period with a relatively homogenous monetary policy regime. The CBR has maintained fairly tight control of the nominal exchange rate,

[7] Higher inflation also seems to contribute to rouble appreciation. The role of the exchange rate as a (partial) policy variable (at least in the short-run) may affect the results.

while inflation has decelerated. Nevertheless, the CBR has failed repeatedly to meet its inflation targets. Inflation seemed to plateau around 10% in 2005, although quite recently (spring 2007) further declines have been registered.

We find a stable money demand function for Russia between years 1999 and 2006. Demand for real rouble balances depends – as predicted by the theory – on income (proxied by GDP) and the opportunity cost of holding money (proxied by inflation and the exchange rate). From a policy point of view, the crucial insight is that exchange rate movements influence the demand for real money balances. Managing the rouble exchange rate can have a direct effect on the re-monetisation of the Russian economy. These results are probably relevant for other emerging market countries where dollarisation prevails. The estimated income elasticity of real money is not significantly different from one, but it is somewhat higher than the average found for other non-OECD countries (Knell and Stix, 2006). This result is likely explained by re-monetisation of the Russian economy during our sample period. Even so, our results contain some counter-intuitive results. For example, exchange rate depreciation was found to lead to lower inflation. The role of the exchange rate as a policy variable – at least in the short-run – might explain the result.

The existence of a stable money demand function at least partly vindicates the CBR's policy of linking money growth (in the form of money growth forecasts) and inflation targets. Of course, the practical implementation of such policy has been made more difficult by the registered decline in velocity. In our model we capture this development with a linear trend, but we have the luxury of performing our analysis ex post. Given that our results also show the rouble's exchange rate remains an important determinant of money demand, the close attention paid by Russia's monetary authorities to the rouble rate seems well justified.

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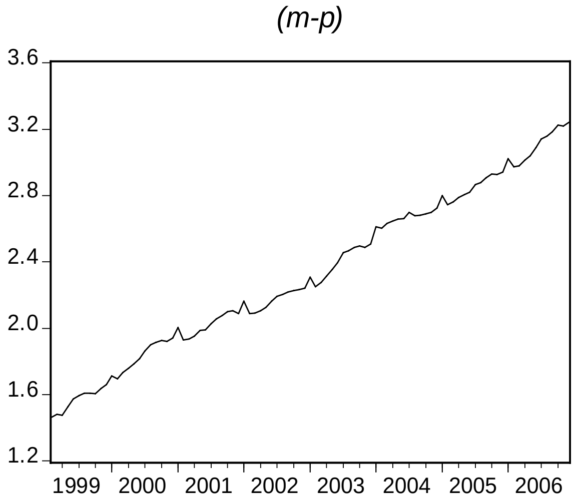
Appendix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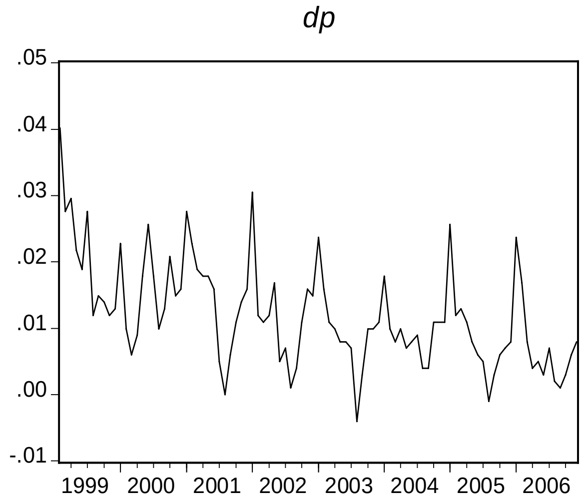
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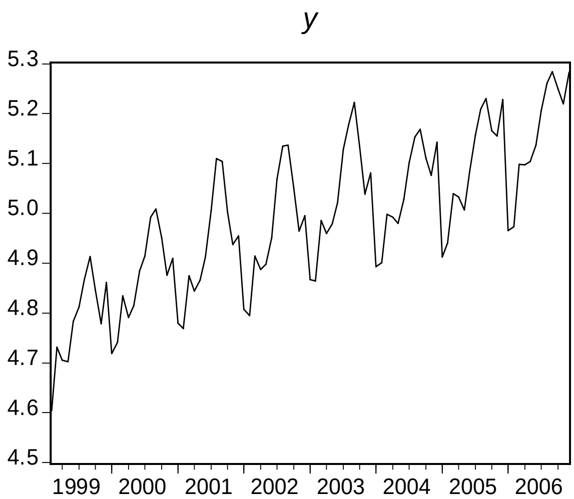
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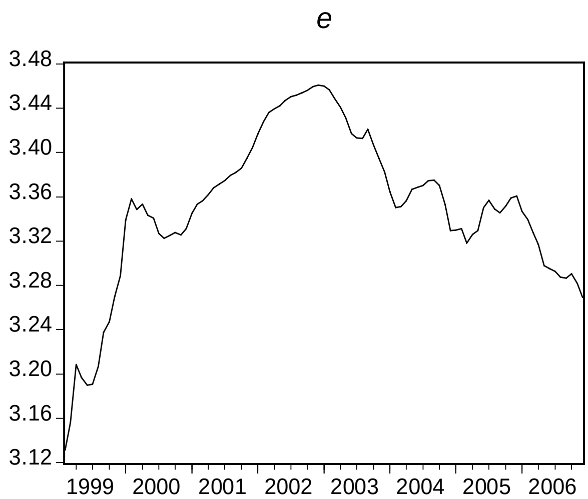
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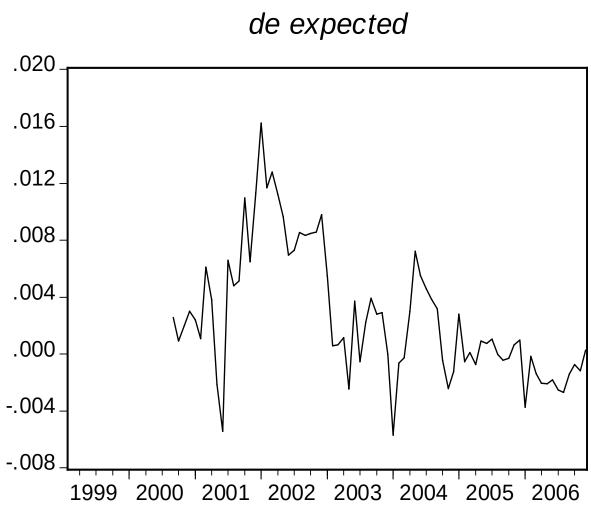
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