Feedback to the ECB's Monetary Analysis: The Bank of Russia's Experience with Some Key Tools*

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ABSTARCT

The paper investigates to what extent some basic tools of the ECBs monetary analysis can be useful for other central banks given their specific institutional, economic and financial environment. We take the case of the Bank of Russia in order to show how to adjust methods and techniques of monetary analysis for an economy that differs from the euro area as regards, for instance, the role of the exchange rate, the impact of dollarization and the functioning of sovereign wealth funds. A special focus of the analysis is the estimation of money demand functions for different monetary aggregates. The results suggest that there are stable relationships with respect to income and wealth and to a lesser extent to uncertainty variables and opportunity costs. Furthermore, the analysis also delivers preliminary results of the information content of money for inflation and for real economic development.

JEL classification: E41, E52, E58

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1. INTRODUCTION

Monetary analysis at central banks has different meanings across the world and over time. Some parts of the world may still focus on quantitative targets for (base) money and thereby

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blur the meaning of operational and intermediate targets and indicators or reference values. In contrast, in its two-pillar strategy, the ECB makes it clear that it uses the monetary pillar to collect information on medium- to long-term risks to price stability by focusing on the analysis of money and credit aggregates. It thus ensures a "full information approach" that may otherwise be dominated by the analysis of cyclical movements of the economy and the information on short-term risks[2]. Monetary analysis at the ECB has been an evolutionary process during which tools and techniques have developed as described in Papademos and Stark (2010). This process has been monitored by other central banks which set up new strategies for an autonomous monetary policy that focuses on internal price stability rather than on stable exchange rates. We describe the Bank of Russia's experience in this respect and to what extent some key tools of monetary analysis as practiced by the ECB can be useful for it. On the one hand, the Bank of Russia may benefit from tools that are already regularly used in the ECB's monetary assessment. The composition of drivers behind money-stock growth indicates that the Russian economy is evidently prone to exogenous money-supply shocks. Identifying these shocks and their macroeconomic consequences is an important practical task for day-to-day monetary policy analysis. The models developed to interpret monetary developments which constitute an essential part of the ECB's monetary analysis seem particularly suitable for this task. On the other hand, simply copying the tools would not be advisable as the economic and financial environment in Russia differs to some extent from the euro area. In both, their financial sectors have in common the fact that they are rather bank-based than capital-market-based. Financial markets in Russia, however, are less deep and less liquid compared to the euro area and money might be the most important financial store of value for a large proportion of the population. Furthermore, high inflationary and hyperinflationary periods are closer in the collective memory than in the euro area and foreign currency has often served as a safe haven. Currency substitution, or, in its broader definition, "dollarization" has inertia and monetary aggregates that include foreign denominated components should behave differently to those that do not. External nominal anchors have dominated monetary policy in the past and exchange-rate developments have triggered rapid reactions of money holders. Last but not least, Russia is an oil-exporting economy and sovereign wealth funds help to buffer the impact of commodity-price fluctuations and to save financial resources for future generations during normal times. During turbulent times they can also function as crisis tools and provide additional funding. Their behavior can significantly influence money creation and thereby, may be understood as exogenous factors or supply-side factors which influence monetary developments beyond the usual money demand factors.

We acknowledge these differences in our study and focus on some key tools of ECB monetary analysis as described in chapters 3 and 4 of Papademos and Stark (2010) which we apply to the Russian case. We start with a brief review of the role of money in the Bank of Russia's monetary policy since the early 1990s and a description of monetary developments, given in sections 2 and 3. Section 4 forms the core of the paper, as it presents money demand estimations for different monetary aggregates. In section 5 we analyze the information content of money for inflation and real economic activity and in section 6 we conclude.

2. THE ROLE OF MONEY IN THE BANK OF RUSSIA'S MONETARY POLICY – A REVIEW

The main stages of evolution of the conduct of monetary analysis and its role in the Bank of Russia's (CBR) monetary policy framework may be provisionally described by considering five different periods. They highlight the role of money in an economic environment which suffered

[2] Notably, after the Global Financial Crisis the role of monetary analysis is also emphasized in connection with financial stability objective and macroprudential policy. The analysis of this issue however remain beyond the scope of this paper.

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from periods of price and financial instability and shifted from a fixed to a managed exchange rate regime.

The early 1990s. The CBR paid serious attention to monetary analysis and the developments of monetary aggregates as soon as the first steps to liberalize the economy were taken in the early 1990s. The transition from a planned to a market economy caused drastic structural shifts in both the real and the financial sector in Russia. In these circumstances the CBR's monetary policy was conducted against the background of the hyperinflation that followed the lifting of price regulation, deep recession of the real sector, depreciation of the national currency and high macroeconomic uncertainty. The CBR had to find a balance between restraining inflation and supportive measures aimed at preventing the collapse of the real economy and the domestic financial system.

According to the "Guidelines for the Single State Monetary Policy" in early the 1990s, averting hyperinflation by limiting extraordinarily high money growth (see Table 1) had become one of the priority objectives of the CBR's monetary policy together with other tasks such as stabilizing the financial system and the exchange rate. In the Federal Law "On the Central Bank of the Russian Federation (Bank of Russia)", which was passed in 1990, setting targets for money supply growth was indicated as one of the principal tools and methods of the Bank of Russia's monetary policy[3].

During this period the efforts to achieve macroeconomic stability were generally framed in the context of IMF-supported programs. These programs had several components (the exchange rate regime, monetary and exchange rate policies, fiscal policy and structural reforms) and implied setting intermediate targets for a number of macroeconomic (including monetary) variables regarded as nominal anchors. An underlying relationship between money growth and inflation projected in the program was a key assumption, although in practice a much more eclectic set of macroeconomic theories and modeling techniques were used to provide analytical support for the policy design (see Ghosh et al. (2005)). The CBR also studied closely the strategies of other central banks, including the monetary targeting strategy of the Deutsche Bundesbank.

The CBR's monetary policy was conducted by setting limits for the growth of the narrow monetary base[4] and other positions of the central bank's aggregated balance sheet in the Monetary Program. This included strict limits on direct loans by the CBR to the government and the commercial banks. Setting limits for money supply growth was formulated in terms of the monetary aggregate M2 (national definition) that "includes all cash and non-cash funds of resident non-financial and financial institutions (except for credit institutions), and private individuals in rubles."[5] Quarterly targets for CBR's balance-sheet indicators were set and mostly fulfilled. According to these plans, money growth was to be stabilized and subsequently slowed down. Although the CBR changed its interest rates and the reserve requirements during this period its most important tool had undoubtedly been the volume of loans provided to commercial banks and the government.

Obviously setting an adequate quantitative target for money growth was extremely complicated during the period of transition. High uncertainty and volatility of the main macroeconomic indicators caused rapid fluctuations of the demand for money. The situation was hampered even further by the lack of statistical data. Nevertheless, using elements of monetary targeting in the CBR's monetary policy helped to cope with hyperinflation, stabilized the situation in the financial sector and prevented a systemic banking crisis.

The period 1995–1998. Starting from 1995 the CBR's monetary policy framework changed considerably. Direct CBR loans to the government were discontinued. The exchange rate was

[3] This clause is still present in the Federal Law "On the Central Bank of the Russian Federation (Bank of Russia)", article 35.

[4] The monetary base (narrow definition) consists of the currency issued by the CBR (including cash in the vaults of credit institutions) and required reserves balances on ruble deposits with the CBR.

[5] Money supply (national definition) "is defined as the sum of funds in the Russian Federation currency, intended for use as payment for goods, work and services and for the accumulation of savings by resident non-financial and financial organizations (except for credit ones) and individuals". Bulletin of Banking Statistics No 5 (216), 2011, pp. 233–234.

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used as the nominal anchor and an exchange rate band was introduced and defended by the CBR till the crisis of 1998. Domestic price stability was also mentioned as a monetary policy objective and the prevalent role of monetary expansion in determining inflation rates over the medium-term was acknowledged[6] .

The Monetary Program still included reference growth rates for the narrow monetary base, CBR's net foreign assets and net credit to the government and commercial banks, although its parameters were no longer viewed as strict targets. Under this framework, combined with the exchange rate policy, the CBR managed to bring inflation rates down to an annual 11% and money growth to 30% in 1997, although the state of the financial sector was still far from healthy, as problems with illiquidity and nonpayment of enterprises persisted, leading to widespread use of barter and monetary surrogates.

The CBR's analytical work in the area of monetary analysis in the 1990s was mainly focused on analyzing money demand, money velocity and money multiplier dynamics. Different components of money stock (including foreign-currency-denominated ones) as well as the sources of money growth were monitored. When foreign-currency-denominated deposits were legalized, in 1995 the CBR started to compile and report the dynamics of a broader monetary aggregate - broad money (or M2X)[7].

The crisis of 1998 which was due to unsustainable public finances in Russia and capital outflows from emerging countries, hit the Russian economy hard and determined the need to change the CBR's monetary policy. On the one hand, the CBR had to keep the monetary stance to prevent depreciation of the national currency and combat rising inflation. On the other hand, the dire problems in the financial sector and dysfunctions of the payment system called for liquidity-providing measures. In September 1998, the CBR abandoned the fixed-exchange-rate peg, allowed the ruble to depreciate sharply, and declared the transition to a managed floating exchange rate regime.

The period 1999–2008. In 1999 the objective of CBR's monetary policy was formulated as achieving stable economic growth in a low-inflation environment. Yet, as the capital inflows (mainly originating from the rise of oil and gas prices) increased, the CBR's commitment shifted towards exchange-rate management. Since 2003 a target for real exchange-rate appreciation was declared together with an inflation target. In 2005 the CBR introduced a bi-currency basket consisting of USD and euro (with current weights of 0.55 and 0.45 accordingly) as its operational target. In order to prevent the ruble's excessive appreciation, the CBR had to conduct substantial foreign exchange interventions which became an important liquidity-providing factor. In an environment of strong capital inflows and relatively high oil prices, the Russian economy grew strongly. From 2000 until mid-2008, the annual growth rates of M2 were above 30%.

Although the relationship between money and inflation in a relatively low inflationary environment was now less evident and the CBR no longer attempted to target money growth, the monetary aggregates retained their role as inflation risk indicators and were monitored closely. Every year the CBR published the references for M2 growth as well as the parameters of the Monetary Program in the "Guidelines for the Single State Monetary Policy". These estimates conform to the scenarios of macroeconomic development produced by the Ministry of Economy. Yet, in practice, the actual outcomes might deviate from these projections significantly. The analysis of causes and consequences of these deviations provides valuable information and is part of the analytical work in the area of monetary analysis. At this stage, the aspects of monetary analysis related to extracting information from monetary developments in order to assess the current monetary stance (as opposed to making the projections of monetary indicators contained

[6] CBR, Guidelines for the Single State Monetary Policy in 1997, p. 23.

[7] Broad money comprises cash issued by the Bank of Russia (excluding cash in vaults of the Bank of Russia and credit institutions), funds held by residents (individuals and organizations other than credit institutions) in settlement, current and deposit bank accounts denominated in rubles and foreign currencies, precious metals and all interest accrued on deposit operations.

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in the Monetary Program) started to gain importance. Naturally the relevant tools employed by the ECB for this purpose formed the basis of the analytical framework.

Money growth projections are traditionally formulated in terms of the M2 aggregate (national definition) as well as the general discussion about the monetary developments in Russia. Therefore the money demand studies conducted at the CBR originally concentrated on modeling this indicator. But as the role of monetary analysis expanded beyond the production of such projections, the need to explore the properties of other monetary aggregates and their linkages with other macroeconomic variables became apparent. In fact, the dynamics of broader aggregates that include foreign currency denominated assets are less prone to fluctuations arising from changing currency preferences and are therefore easier to interpret. Foreign currency deposits, as well as cash in foreign currency, serve as a store of value and as a safe haven during turbulent times.

The period after 2008. In recent years the CBR has adjusted the priority of its monetary policy objectives. This was partially a result of the crisis of 2008 which highlighted the impact of financial-sector imbalances on the real sector.

In 2008 the CBR declared in the "Guidelines for the Single State Monetary Policy" that lowering and subsequently maintaining low inflation is the main monetary policy objective[8]. Starting from 2009, the monetary policy horizon was extended to 3 years. The CBR also announced the gradual transition to a flexible exchange rate regime[9]. In 2010 the CBR declared that it would pay special attention to the broad analysis of money and credit developments for the purposes of financial stability and underscored the important role of credit and asset-price developments in identifying financial imbalances. In the "Guidelines for the Single State Monetary Policy in 2011 and for 2012 and 2013" it is noted that "… the Bank of Russia will pursue monetary policy by considering the situation on the financial markets and the risks arising from growth in monetary aggregates, credits and asset prices. It will pay special attention to a more comprehensive analysis of trends in monetary and credit indicators, to ensure that its timely actions in monetary policy and banking regulation and supervision help prevent imbalances in the financial sector of the economy, and thereby not only bring down inflation, but also maintain financial stability and a state of overall macroeconomic equilibrium."[10]

In the "Guidelines for the Single State Monetary Policy in 2012 and for 2013 and 2014" there is a declared intention to complete the transition to an inflation-targeting regime within a 3 year period[11]. At the same time, monetary analysis will retain its prominent role in identifying inflation risks in the medium and long-run. The CBR will also pay close attention to money, credit and asset prices developments for the purpose of maintaining financial stability[12]. As outlined by the CBR's First Deputy Chairman, Alexey V. Ulyukaev: "If you have rapid money growth you will most likely get high inflation or you could get a growth of asset prices, for example of housing or equities, that is not reflected in inflation measures …. We should cross-check inflation targeting with a monetary analysis approach. Methodologically that is what our colleagues in the ECB call two-pillars" (Ulyukaev, 2011).

Monetary analysis at the CBR therefore looks not only at price but also at financial stability, since financial imbalances have been more closely connected to high inflationary periods in Russia than in developed economies during the recent past.

8 CBR, Guidelines for the Single State Monetary Policy in 2008, I. Medium-term monetary policy principles, p. 3.

9 CBR, Guidelines for the Single State Monetary Policy in 2009 and for 2010 and 2011, I. Medium-term monetary policy principles, p. 4.

10 CBR, Guidelines for the Single State Monetary Policy in 2011 and for 2012 and 2013, I. Medium-term monetary policy principles, pp. 3-4.

11 CBR, Guidelines for the Single State Monetary Policy in 2012 and for 2013 and 2014, I. Medium-term monetary policy principles, p. 3.

12 CBR, Guidelines for the Single State Monetary Policy in 2012 and for 2013 and 2014, I. Medium-term monetary policy principles, p. 4.

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Table 1
Monetary aggregate M2 and CPI (annual growth, %)

	CPI	M 2
1992	2500	670
1993	840	410
1994	220	200
1995	130	130
1996	21,8	30,8
1997	11,0	29,8
1998	84,4	21,3
1999	36,5	57,5
2000	20,2	61,0
2001	18,6	39,9
2002	15,1	32,4
2003	12,0	50,4
2004	11,7	35,8
2005	10,9	38,5
2006	9,0	48,7
2007	11,9	43,5
2008	13,3	0,8
2009	8,8	17,7
2010	8,8	31,1

Source: CBR.

In Table 1, a comparison between inflation and annual rates of money growth suggests that the link is medium- to long-term, a short-term link being fairly difficult to establish. Empirical analyses also suggest that there should be a long-run link and that the link is closer for high-inflation regimes as discussed in Papademos and Stark (2010), chapter 1.[13] We therefore assess their co-movement for a very long time-sample and by applying filtering techniques in order to capture the trend movements and to eliminate the cyclical fluctuations. For this purpose we compile a historical dataset that although somewhat eclectic in our opinion provides an insight on inflation and money growth developments in Russia during the time span 1861–2010. This period however includes two episodes of hyperinflation: the first associated with the First World War and the Russian Revolution of 1917 and the second with the dissolution of the Soviet Union. As we do not consider these developments relevant for the objective of analyzing long-run trends in money and inflation, we deliberately remove these outliers from the data by means of the TRAMO-SEATS pre-adjustment procedure making use of a manually set sequence of deterministic variables over the periods of 1914–1923 and 1991–1993 and then apply the asymmetric Christiano-Fitzgerald filter to extract long-run trends from the data. As in Benati, 2009 we extracted the components with a frequency of oscillation over 30 years.

In Figure 1 we demonstrate the close co-movement of the two series, at the same time, the charts also suggest, however, that the strength of the correlation may be influenced by the monetary regime and the hyperinflationary regimes which – though filtered – still remain to have

[13] See, for example, Rolnick and Weber (1997) De Grauwe and Polan (2005) or Benati, 2009.

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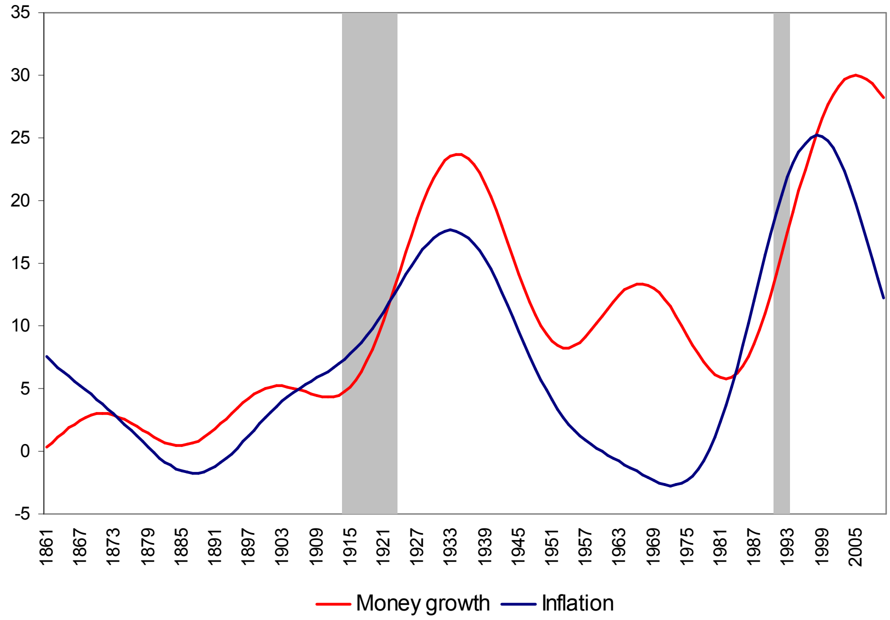
a strong influence. During the pre-soviet period the money growth and inflation rates seem to move closely. During the Soviet period of regulated prices, however, a substantial gap between money growth and inflation persisted in the 1960s and 1970s[14]. The post-Soviet period of the Russian economy was characterized by relatively high growth rates of both money and prices.

Figure 1
Long-run components of money growth and inflation, % (data over shaded periods were cleaned of outliers)



Source: authors' calculations.

3. MONETRAY DEVELOPMENTS IN RUSSIA

3.1. Types of monetary aggregates in Russia and their measurement

Definitions of monetary aggregates spread from narrow, i.e. more liquid aggregates to broader aggregates that also include less liquid components which serve the store-of-value rather than the transactional purposes of money. Moreover, definitions are influenced by the financial environment and the behavior of money holders, for example, financial institutions apart from credit institutions may also serve monetary purposes and some financial products have become so money-near that they should be included in the definition of money. While this has driven considerations for defining monetary aggregates in the euro area, broader Russian monetary aggregates reflect rather the importance of foreign-currency-denominated components.[15] M2 (national definition) is the major aggregate for the analysis and policy formulation at the CBR. Broad money (M2X), however, includes foreign-currency-denominated components (FC). This aggregate differs substantially in size and development from the aggregates that include only components denominated in national currency (NC). Over the last decades, the Russian economy has been subject to significant fluctuations in the demand for foreign currency. The flows between

[14] Interestingly, some researchers point out that the monetary overhang accumulated by the late 1980s was one of the reasons that triggered a hyperinflation spiral once prices were liberalized (see e.g. Kim, 1999).

[15] Since 2011 the CBR has published the data on deposits in national and foreign currency, set out by different sectors (financial institution (except credit organizations), public non-financial organizations, other non-financial organizations and households) in the Banking System Survey. This information provides a basis for further enhancing monetary analysis by using the data on sectoral money holdings.
See also "Sectoral structure of money holdings" (CBR, "Quarterly Inflation Review" 2011, Q1, pp. 24–26).

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ruble- and foreign-currency-denominated assets were particularly drastic during the periods of instability which impacted significantly on monetary aggregates. The recent crisis of 2008–2009 is one of the most evident illustrations and shows the need to analyze broader aggregates that partly consist of foreign currency denominated assets.

The data on the monetary aggregates M2 in national currency have been published by the CBR since 1997. The statistical sources are selected liabilities of the monthly consolidated balance sheets of Russian credit institutions and the Bank of Russia.

Two components are singled out as part of the monetary aggregate M2 (national definition)[16]:

The monetary aggregate M0 (cash in circulation) includes banknotes and coins in circulation less currency holdings (cash vaults) of the Bank of Russia and credit institutions.

Non-cash funds in national currency comprise the balances of funds kept by non-financial and financial institutions (except credit institutions) and private individuals in settlement, current, deposit and other demand accounts, including plastic-card accounts, and time-deposits opened with banks in the Russian Federation currency and accrued interest on them. Non-cash funds that are accounted for in similar accounts in credit institutions whose license has been recalled are not included in the composition of the non-cash funds.

The M1 aggregate can also be calculated from the liabilities of the consolidated balance sheet of the banking system. In our study we construct the **M1 aggregate**, which includes cash in circulation outside the banking system and transferable deposits which include current and other demand accounts (including bank card payment accounts) opened by Russian Federation residents (organizations and individuals) with the Bank of Russia and operating credit institutions in national currency[17].

Analyzing national currency monetary aggregates may be not sufficient, since financial dollarization is an important feature of the Russian economy (see Ponomarenko et al. (2013) for review). The hyperinflation that occurred in the early 1990s and the major depreciation events (most importantly, the currency crisis of 1998) increased the demand for reserve currency. Money holders however may use money for different purposes. Cash in foreign currency (mostly the USD), for example, served routinely for both transactional and store-of-value functions in the 1990s. Following macroeconomic stabilization and the increase of confidence in the banking system, the role of foreign cash has declined substantially but bank deposits denominated in foreign currency are still popular as a store of value. The shifts of currency preferences are a common reaction to exchange-rate fluctuations and increasing economic uncertainty.

The measure of money stock used by the CBR which includes foreign-currency-denominated deposits is the **broad money (M2X) aggregate.** The statistical data for this indicator was published in the Monetary Survey from 1995 to 2000 and in the Banking System Survey thereafter. Broad money comprises all the components of M2 and foreign-currency-denominated deposits.

In this study we also construct the monetary aggregate M2Y which includes foreign cash holdings in the non-financial sector. The M2Y aggregate is not published by the CBR and, as it includes cash denominated in foreign currency, the accuracy of its measurement is limited. In this study we use the indirectly measured foreign-cash holdings reported in the International Investment Position of the Russian Federation and Balance of Payments of the Russian Federation.[18] In Table 2 we summarize the components of the different monetary aggregates used in this study.

16 Bulletin of Banking Statistics No 5 (216), 2011, pp. 233–234

17 Data source: CBR, Banking System Survey.

18 We use the item “Cash foreign currency/Other sectors” from the International Investment Position of the Russian Federation and the Balance of Payments of the Russian Federation.

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Table 2
Components of monetary aggregates

Liabilities		M0	M1	M2	M2X	M2Y*
Currency in circulation	X	X	X	X	X	
Demand deposits in NC		X	X	X	X	
Time and saving deposits in NC		X	X	X		
Deposits in FC			X	X		
Cash in FC				X		

* authors' definition.

In our study we also use M2X and M2Y which we adjust for valuation effects of foreign-currency-denominated components (M2X_ADJ and M2Y_ADJ). It may be sensible to do this for the purposes of monetary analysis since the fluctuations caused by the changes in the exchange rate are not linked to any real transactions and could therefore be misleading.[19] On the other hand, the wealth effect caused by these re-evaluations could still have some macroeconomic impact. We therefore analyze both types of aggregates. These were estimated as follows.

First the growth rates were adjusted:

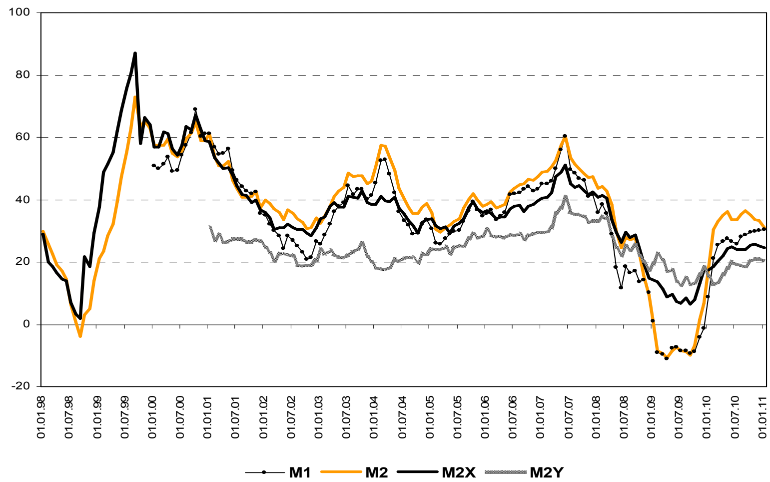
$$\Delta adj = w^{*}\Delta r + (1 - w)^{*}\, \Delta f/e \qquad (1)$$

where w is the share of ruble-denominated components at the end of previous period, Δr – growth rate of ruble-denominated components, Δf – growth of foreign-currency-denominated components and e – ruble's depreciation against the bi-currency basket. The base index is then constructed using adjusted growth rates.

3.2. Evolution of different monetary aggregates and counterparts

Figures 2 and 3 show the evolution of different monetary aggregates in Russia since 1998. In Russia, distinguishing between monetary aggregates that include and those that exclude money denominated in foreign currency is particularly useful. As previously mentioned, attributing the store-of-value function mainly to deposits in foreign currency and the transactional function to foreign cash would simplify the microeconomic behavior of different money holders.

Figure 2
Monetary aggregates (y-o-y growth, %)



Source: CBR, Rosstat.

[19] Russian monetary statistics so far cannot disentangle changes from transactions as it is the case for monetary data in the Eurosystem.

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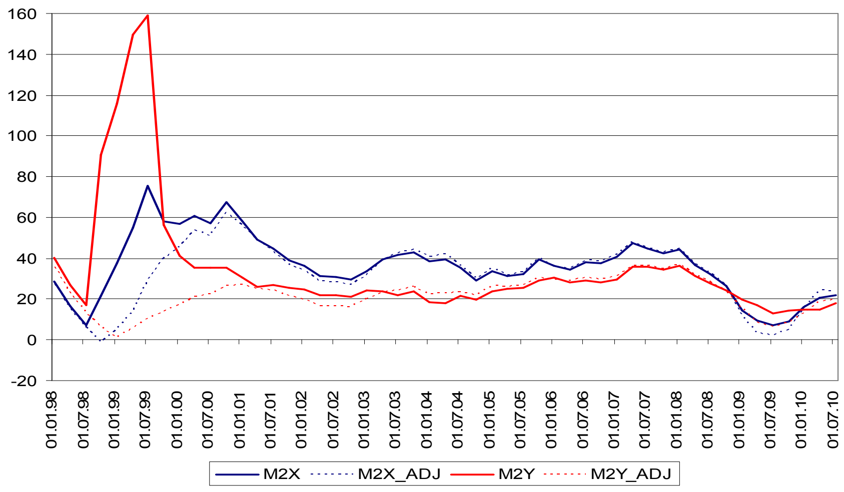
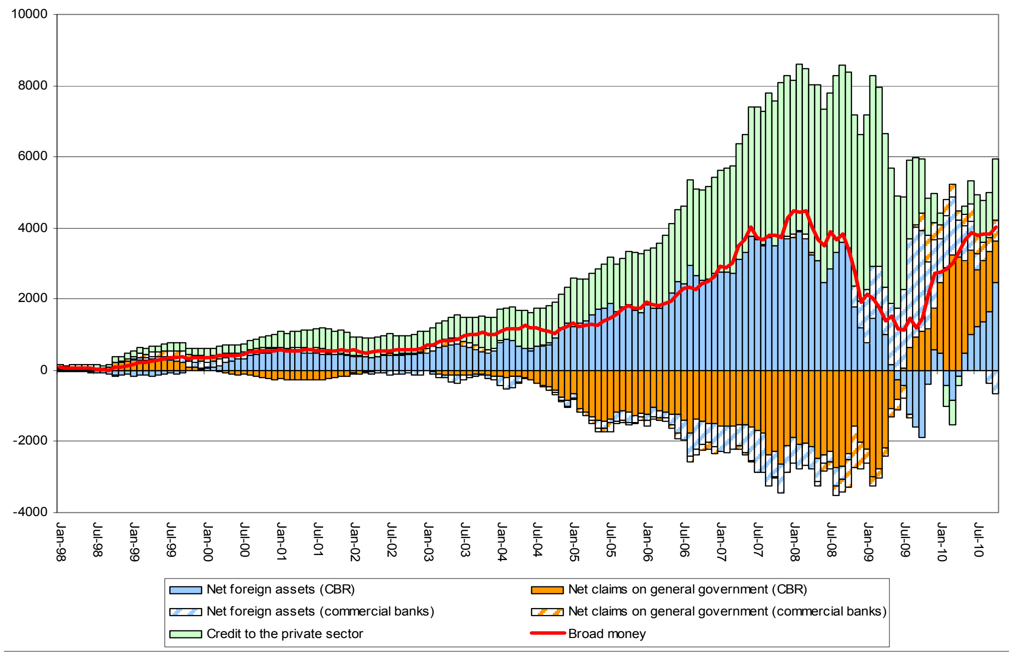
Figure 3
Headline and adjusted monetary aggregates (y-o-y growth, %)



Source: CBR, authors' calculations.

Figure 4
Money and its counterparts (annual changes, bln. rubles)



Source: CBR.

Looking at the evolution of the counterparts of Russian broad money (M2X) in Figure 4 reveals the domestic and external driving forces of monetary developments. The most important counterparts of money growth have been the CBR's foreign assets, the CBR's net claims on the government (reflecting the transactions of real domestic sector with the foreign sector) and banks' credit to the non-financial sector. Changes in the CBR's net foreign assets are generally the key driving force of changes in M2X. Changes of net claims to the general government (CBR) reflect the workings of the sovereign wealth funds, since international inflows of foreign currency are partly deposited in a sovereign wealth fund held on the CBR's balance sheet. The presence of significant exogenous growth sources means that the link between money and credit growth may not be very close – we will discuss the drivers behind different episodes of money growth later in thispaper. It also means that nominal money stock may be driven by factors totally unrelated to

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money demand fundamentals. This does not mean however that the money-demand relationship is non-existent (as money growth may trigger the adjustment of other macroeconomic variables towards new equilibrium) or that it is of no practical use. The composition of drivers behind money-stock growth indicates that the Russian economy is evidently prone to exogenous money-supply shocks (as opposed to endogenously-driven money-demand shocks). Identifying these shocks and their macroeconomic consequences is a crucial task for monetary analysis. Using money demand models to assess the degree of correspondence between realized money growth and macroeconomic fundamentals could be regarded as one of the methods of such identification.

In the early 1990s, the transformation from the planned economy in Russia was followed by galloping inflation, a deep recession, a depreciation of the national currency and large permanent government budget deficits. Money growth rates were extremely high. The new Russian banking sector at that time was just emerging and could not provide efficient financial intermediation. In these circumstances the CBR's credit to the government, to commercial banks as well as to selected non-financial enterprises was practically the only source to satisfy money demand. The direct monetization of the government budget deficit played an important role in money growth.

As the direct CBR's credit provision to the government was discontinued in 1995 the growth rates of monetary aggregates in 1996–1997 as well as inflation rates were much lower as compared to earlier 1990s.

During the 2000s, the Russian banking sector underwent a significant transformation. Although it remained small in terms of net assets to GDP, when compared to other emerging economies (Fungáčová and Solanko, 2009a), credit flows to the real sector have increased rapidly in recent years and become an important determinant of cash flows in the economy. The rapid growth of deposits (resulting in part from the cross-border cash inflows in conditions of a heavily-managed exchange-rate regime) have provided banks with a rich resource for lending. Similar conditions have been seen in Asian economies with similar monetary-policy regimes (Mohanty and Turner, 2010).

Russia turned to the fiscal mechanism of the sovereign wealth fund to absorb foreign currency from central bank interventions. In 2004 the sovereign wealth fund (the so-called Stabilization Fund which was reorganized into Reserve Fund and National Welfare Fund in 2008) was created within the Russian public finance framework. This institution proved to be very important for monetary developments and has affected the dynamics of the money stock ever since. The main source of the sovereign wealth fund's formation is taxes on oil and gas extraction and custom duties on oil exports. These funds are placed in special accounts of the Federal treasury in the CBR and are managed by the CBR. From 2005 till late 2008 the budget had a large surplus, mainly due to high oil and gas prices, which determined the accumulation of reserves on the sovereign wealth fund's accounts effectively containing money growth[20]. Changes in net foreign assets held at the CBR and net claims on the general government held at the CBR have been the driving counterparts of M2X since 1998. They reflect the functions of the sovereign wealth fund in an oil-rich economy. Its stabilizing effects, for example, are reflected in increasing positive contributions of CBR's net claims on general government after the crisis in 2008 that largely determined the recommencement of M2X growth. This reflects the buffering function of the sovereign wealth funds.

An important distinction between Russian and Asian banks was that the size of the lending booming exceeded deposit growth in 2006−2008, causing funding gaps to emerge. Russian banks relied on external borrowing to finance this gap; interbank lending in particular became dominated by transactions with foreign counterparties (Fungáčová and Solanko, 2009b).

20 Although the CBR also used liquidity absorbing tools (such as bond issuance) the absorption through fiscal mechanisms had clearly the most important impact on the monetary stance.

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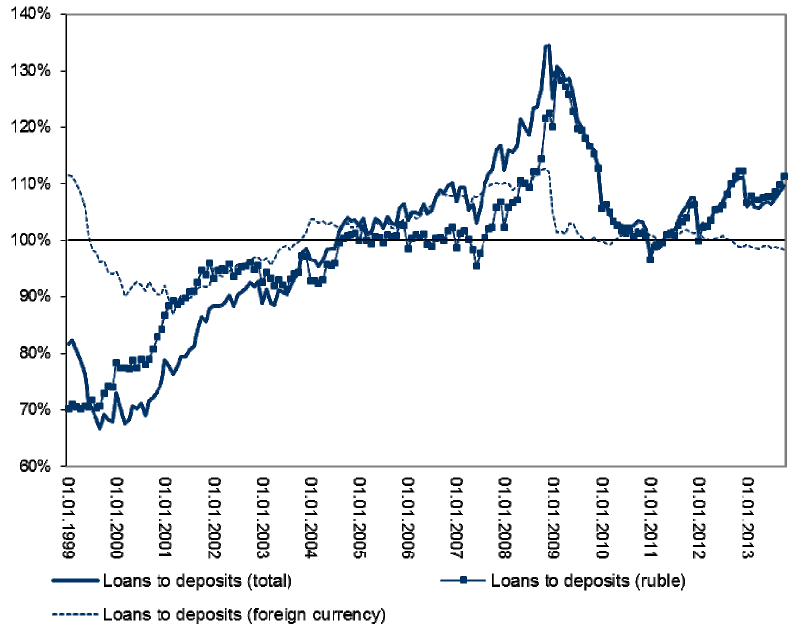
Figure 5
Loans to deposits ratio



Source: CBR.

4. MONEY DEMAND MODELS

An important aspect of the empirical properties of monetary aggregates is the existence of a stable money-demand function. The money-demand function is a fundamental relationship that captures the interactions between money and other important economic variables such as income and wealth. The role of opportunity costs is influenced *inter alia* by the depth and breadth of financial markets and the degree of substitution between domestic and foreign currencies. Thus a robust relationship between monetary aggregates and other macroeconomic variables can help to explain and interpret monetary developments. From a normative perspective, money-demand models are a starting point for developing benchmarks of the level or growth of money. In this study we are able to analyze money demand for different monetary aggregates as described in section 3.

Previous studies on money demand functions in Russia (e.g. Oomes and Ohnsorge (2005); Korhonen and Mehrotra (2010); Mehrotra and Ponomarenko (2010)) report stable money-demand relationships over the pre-crisis period. In our study we will examine if there is still a robust relationship when 2009-2010 observations are added to the sample and we will check that for different monetary aggregates. Interestingly, Oomes and Ohnsorge (2005) also conducted their estimates for several monetary aggregates and found, based on the confidence-intervals width and the recursive estimates of cointegrating vectors' coefficients that the M2Y money demand function was the most stable, while narrower ruble aggregates did not produce stable relationships. We compare these findings with more recent results.

4.1. Model specification and data issues

Our specification of the long-run real money demand in the log linear form is:

$$(m-p)_t = \beta_0 + \beta_1 y_t + \beta_2 w_t + \beta_3 OC_t + \beta_4 unc_t + \xi_t, \qquad (2)$$

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where $m - p$, y and OC are the monetary aggregate deflated by the price level, the scale variable and the vector of opportunity costs accordingly. Modern money-demand studies (e.g. Greiber and Setzer (2007); Beyer (2009)) also control for the wealth effect (which as discussed in Mehrotra and Ponomarenko (2010) may be important for Russia) by adding a real-wealth variable into the money-demand function. Another addition to the traditional specification could be an uncertainty variable as in e.g. Greiber and Lemke (2005), which could also be relevant for emerging economies (see Özdemir and Saygili (2010)) particularly when attempting to model crisis developments. Recent studies by de Bondt (2009) and Seitz and von Landesberger (2010) include both wealth and uncertainty indicators into the money demand function. Therefore we add real wealth (w) and uncertainty (unc) variables into our model. We estimate four different models with real M1, M2, M2Y and $M2Y^{adj}$ as money stock variables. We do not report the results for real M2X and $M2X^{adj}$ as we fail to find any meaningful money demand relationship for these aggregates. This result is somewhat puzzling. One possible explanation is that the developments of the M2X aggregate are affected by changes of preferences between foreign-cash holdings and foreign-currency-denominated bank deposits. These changes may be difficult to model formally (at least when based only on money-demand fundamentals).

We follow Mehrotra and Ponomarenko (2010) and use a real-asset price index as a proxy for real wealth. The index is the weighted[21] average of housing and equity price indices. Housing wealth may be viewed as constituting a significant part of households' wealth. The 2002 national census found only about 3% of households rent a house or an apartment and that about 20% of households owned a secondary dwelling (mainly for seasonal use). Equities are not a significant component of household financial wealth, but their price can be viewed as a proxy for corporate wealth. As discussed in Mehrotra and Ponomarenko (2010) the rapid growth of asset prices in Russia in 2005-2007 could have positively affected transactions demand for money as transactions in asset markets increased. The increase in wealth due to the growth of asset prices may also be associated with increased demand for other liquid assets (including money) that are part of the wealth portfolio.

We have tested various indicators of uncertainty (e.g. the unemployment rate, oil-price volatility, government budget balance). Based on the models' performance and following Greiber and Lemke (2005) who propose stock-market volatility as one possible indicator of uncertainty we selected the variance of RTS index returns over rolling periods of 180 days as the metric for uncertainty. Interestingly, the interplay between this variable and various monetary aggregates may be different. Increasing uncertainty is generally associated with growing precautionary demand for money, but in case of Russia it may also result in additional demand for foreign-currency-denominated assets at the expense of ruble money stock. Therefore the positive effect on the demand for money may be more pronounced in case of broad monetary aggregates.

The choice of the opportunity-cost indicator is quite complicated in the case of Russia. The relative underdevelopment of the financial market precludes the use of money market interest rates for this purpose. On the other hand, the exchange-rate fluctuations were identified as important money-demand determinants in Russia by all previous studies as well as in other emerging market economies (see e.g. Dreger et al. (2007)). Interestingly national currency depreciation can be considered as opportunity cost only for holding ruble aggregates, since interflows between ruble and foreign-currency-denominated deposits would not affect broad money measures. In fact national currency depreciation would increase the implied ruble yield of foreigncurrency-denominated components of broad aggregates. Another opportunity-cost indicator that may be considered (as in e.g. Korhonen and Mehrotra (2010)) is the inflation rate. This leaves us with a range of variables that could be potentially used to proxy for opportunity costs/own yield.

[21] Similarly to Gerdesmeier et al. (2010) the weights are inversely proportional to the variables' volatility, i.e. Δ *Asset prices* = $\sigma_{sp}/(\sigma_{sp} + \sigma_{hp})$ Δ*Housing prices* + $\sigma_{hp}/(\sigma_{sp} + \sigma_{hp})$ Δ*Equity prices*, where σ is the standard deviation of the respective variable. The resulting weights equaled 0.86 for housing and 0.14 for equity prices and seem economically meaningful and consistent with weights used in Mehrotra and Ponomarenko (2010).

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Including all these simultaneously into the estimated relationship is hardly appropriate due to length limitations in time series. Instead we choose more parsimonious approach and construct aggregate opportunity costs/own yield measures.

The own yield of ruble components is measured by the interest rate on households' long-term ruble time deposits. The own yield of foreign currency components is the weighted average of interest rates on euro and USD deposits (with time-varying weights equal to those in the CBR's bi-currency basket[22]) plus the ruble's depreciation against the bi-currency basket over the two last quarters, which presumably proxies the exchange rate expectations. The aggregate yield of return is the weighted average (with weights proportional to the shares of ruble and foreign currency deposits in the total amount of deposits) of ruble and foreign-currency components' yields. All opportunity-cost variables are in quarterly terms.

For the money demand functions with M1 we use the aggregate yield of return as the *OC* variable and expect the β_3 coefficient to be negative, since M1 does not include appreciably remunerated components. For money-demand functions with M2 we use the exchange-rate depreciation against the bi-currency basket over the two last quarters as a proxy of the spread between ruble and foreign-currency components' yields and also expect the β_3 coefficient to be negative[23]. For money-demand functions with M2Y we use the spread between the aggregate yield of return and the realized two quarters CPI inflation rate and expect the β_3 coefficient to be positive. The overall dynamics of the resulting aggregate indicators over tranquil periods are mostly determined by changes of interest and inflation rates, but largest variations are due to exchange rate fluctuations (most notably in 1999 and 2008–2009).

We use GDP as a scale variable and the GDP deflator to calculate money and wealth variables in real terms. All variables except *OC*s and *unc* are in logs. The time sample under review is 1999Q1–2010Q2 which gives us 46 quarterly observations. The order of integration of the variables is determined based on the results of Phillips-Perron, KPSS and ADF-type test which controls for possible structural break over the crisis period (Lanne et al. (2002)) unit root tests (Table A1 in Annex A). Despite some indication from the Phillips-Perron test that *M2Y*, $M2Y^{adj}$ and *y* could be trend-stationary we assume that with the possible exception of *OC*s and *unc* all variables are I(1) and we therefore proceed with the cointegration analysis. This decision was supported by the test for the stationarity of the variables within cointegrated VAR conducted at later stages (Table A2 in Annex A).

4.2. Cointegration analysis

As a starting point of our analysis we refer to the most commonly applied method in testing for cointegration proposed by Johansen, 1996. The procedure efficiently includes the short-run dynamics in the estimation of the long-run model structure in the system of equations framework. We use the conventional VEC model of the form:

$$\Delta x_t = \Pi x_{t-1} + \Gamma_1 \Delta x_{t-1} + \ldots + \Gamma_p \Delta x_{t-p} + CD_t + \varepsilon_t, \quad (3)$$

where x_t is a (K x 1) vector of endogenous variables and the Γ_p are fixed (K x K) coefficient matrices. We further assume that ε_t follows a white-noise process with $E(\varepsilon_t) = 0$. When some or

[22] While the structure of foreign-currency deposits in Russia is unavailable, other subsidiary indicators justify the use of bi-currency basket's weights for this purpose. The bi-currency basket is the operational target of the CBR and consists of the combination of USD and euro with time-varying weights.

[23] While the most obvious choice for M2 model would be to use the spread between ruble and foreign-currency components' yields this approach did not produce meaningful results (the β_3 coefficient had the "wrong" sign). The reason for that could lie with the extremely high ruble interest rates in 1999–2000 (which determined the highly positive values of the spread). Taking into account the state of financial markets and the lack of confidence in the domestic banking system at that time, these interest rates might be not fully representative as an attractive alternative to foreign currency assets. We therefore decided to disregard these interest rates. In other periods the spread was mostly determined by the exchange-rate fluctuations, as the interest rates remained stable, so there were no big differences between the two indicators.

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all of the K endogenous variables are cointegrated, the matrix Π has reduced rank r. D_t contains the deterministic terms outside the cointegrating vector, and C is the coefficient matrix associated with the deterministic terms. In our set-up, the model includes unrestricted constant and seasonal dummy variables. The lag length was set to 4[24].

Table 3
Cointegration test results: Barlett corrected trace statistic (p-value)

Model	Rank			
	0	**1**	**2**	**3**
M1	88.45 (0.00)	48.44 (0.04)	22.69 (0.26)	9.94 (0.29)
M2	70.81 (0.04)	43.67 (0.12)	24.67 (0.17)	6.23 (0.67)
M2Y	89.93 (0.00)	40.52 (0.20)	31.28 (0.03)	13.96 (0.08)
$M2Y^{adj}$	85.47 (0.00)	40.62 (0.20)	26.33 (0.12)	13.50 (0.10)

The tests as shown in Table 3 confirm the possibility of cointegration in all models since the rank of zero is rejected. Although there is some indication that the matrix Π may have rank 2 in the M1 model for the sake of economic interpretability we proceed by assuming 1 cointegrating relationship in all the models. The recursively-estimated eigenvalues and Hansen and Johansen (1999) fluctuations tests confirm the stability of cointegrating relationships[25] (Figures A2-A3 in Annex A). Admittedly there is considerable uncertainty regarding this specification choice that could potentially bias the model's performance as well as the results of characteristics tests. An alternative way to proceed (assuming a cointegration rank of 2) would be to identify the second cointegrating vector (such as long-run wealth growth relationship in Beyer, 2009) in addition to the money-demand relationship and examine its relevance in the comprehensive system of the simultaneous equations framework. This kind of analysis however was not undertaken in this study.

Table 4
Tests for weak exogeneity of variables: F-statistic (p-value)

Variable	Model			
	M1	**M2**	**M2Y**	**$M2Y^{adj}$**
M	11.50 (0.00)	4.09 (0.04)	0.15 (0.70)	0.05 (0.82)
Y	30.15 (0.00)	1.85 (0.17)	5.12 (0.02)	6.37 (0.01)
W	0.10 (0.76)	15.04 (0.00)	8.16 (0.00)	9.72 (0.00)
OC	0.09 (0.77)	0.73 (0.39)	63.15 (0.00)	53.43 (0.00)
UNC	0.40 (0.53)	3.16 (0.08)	0.06 (0.81)	0.37 (0.54)

Null hypothesis: variable is weakly exogenous.

24 Most of the traditional information criteria would indicate that a longer lag-length is preferable. But for the reasons of parsimony given the short time sample and given the quarterly data used we limit the lag length to four. Later we examine to what extent the lag-length choice influences the cointegrating vectors.

25 At this stage we concentrate on the analysis of long-run relationship and therefore excluded the short-run part from the stability tests. The performance of short-run money demand models are discussed elsewhere in this paper.

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Although the analysis of the dynamic relationship between money and other macroeconomic variables is beyond the scope this paper we do examine the weak exogeneity tests based on the VEC model reviewed and show the test results in Table 4. There are notable differences in the results for different models: while the weak exogeneity of narrower ruble aggregates is rejected, the developments in the broader aggregates seem to be unaffected by the adjustment resulting from the cointegration relationship. This result may contradict the conventional theory associated with the money-multiplier concept which would presume narrow aggregates to be exogenous and broader ones to be endogenous. Yet these findings may be in line with the peculiarities of money-supply factors in Russia. We will further discuss the performance of the models in explaining money-stock developments later in this paper.

Instead of affecting money, the adjustment occurs through other variables such as GDP or real wealth. The results for OC variables are mixed – they seem to be weakly exogenous in the M1 and M2 models and endogenous in M2Y and $M2Y^{adj}$ models.

The cointegration vectors are estimated by the simple two-step estimator (S2S). As Brüggemann and Lütkepohl (2005) show, this estimator produces relatively robust estimates in short samples. The lag length is set to 4. Most of the cointegrating vectors estimated using different lag lengths were relatively robust.[26]

We cross-check the results obtained with S2S method by estimating the cointegration vectors using Fully Modified-OLS (Philips and Hansen (1990)) in a parsimonious single equation set-up. We use pre-whitening with the lag length determined by Schwarz criteria and Barlett kernel with the cut-off determined by the automatic Andrews (1991) procedure.

The cointegration vectors are estimated in the presence of unrestricted constant and seasonal dummy variables. The results are shown in Table 5.

Table 5
Cointegration vectors (t-statistics)

Variable	Estimation Method	Model			
		M1	**M2**	**M2Y**	**M2Yadj**
M	S2S	1	1	1	1
	FM-OLS	1	1	1	1
Y	S2S	-1.65 (-37.3)	-2.38 (-20.2)	-0.38 (-4.09)	-0.63 (-12.3)
	FM-OLS	-1.76 (-12.6)	-2.6 (-13.1)	-0.61 (-1.68)	-1.05 (-4.85)
W	S2S	-0.47 (-13.8)	-0.34 (-3.49)	-0.88 (-11.2)	-0.67 (-15.5)
	FM-OLS	-0.48 (-4.45)	-0.29 (-1.68)	-0.54 (-1.81)	-0.23 (-1.31)
OC	S2S	2.07 (13.1)	3.73 (9.15)	-3.47 (-5.34)	-1.62 (-4.89)
	FM-OLS	0.93 (3.17)	0.84 (1.25)	2.18 (2.13)	-0.4 (-0.72)
UNC	S2S	-118 (-8.25)	-45.1 (-1.81)	-67.4 (-2.13)	-128.5 (-7.61)
	FM-OLS	-8.4 (0.48)	-44.7 (-1.21)	-152 (-3.16)	-109.8 (-3.86)

[26] The results are presented in the working paper (ECB WP 1471) version of this paper.

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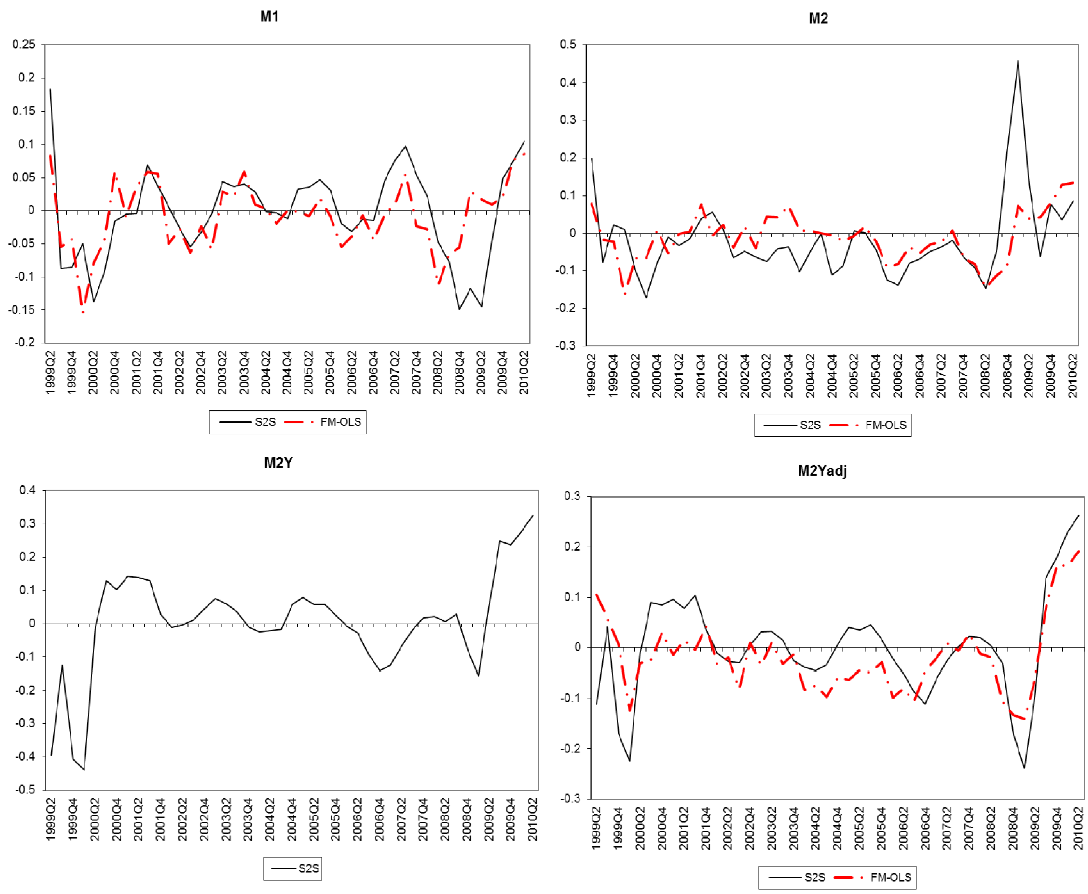
The parameters estimated with S2S method are statistically highly significant and economically meaningful. The growth of GDP and real wealth increases money demand. Interestingly, there are striking differences in income elasticities between the models. The M1 and M2 models retain the feature of high income elasticity, which was also reported in all the previous money demand studies for Russia. This peculiarity is usually associated with ongoing institutional changes such as financial deepening and the return of confidence in the national currency. In the cases of M2Y and $M2Y^{adj}$ however the income elasticities are lower, while the parameters for wealth are somewhat higher. The sum of the income and wealth parameters is only slightly higher than unity[27]. In fact these results are consistent with the parameters reported in Greiber and Setzer (2007) for the euro area and the US and in Seitz and von Landesberger (2010) for the euro area. These results seem to be thought-provoking as they show how differently monetary developments in Russia could be interpreted when different money stock measures are used. The opportunity-cost variables all have the expected signs. The increase of uncertainty has a positive effect on money demand. As could be expected it seems to be less evident in case of ruble aggregates.

These findings are generally confirmed by FM-OLS estimates for M1, M2 and $M2Y^{adj}$ models, although the uncertainty variable in the M1 model and OC variables in M2 and $M2Y^{adj}$ models are statistically insignificant. Nevertheless we proceed with further analysis of this cointegration vectors as they are economically meaningful. We exclude the FM-OLS cointegration vector for the M2Y model that displays the "wrong-signed" OC variable coefficient.

Figure 6
Monetary overhangs[28]



[27] The sum of coefficients equals 1.26 and 1.3. Interestingly, Oomes and Ohnsorge (2005) report an income elasticity of 1.2 for M2Y money demand function without wealth.

[28] The monetary overhangs were computed (using seasonally adjusted data) as demeaned error correction terms from the estimated cointegration relationships.

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In order to test the robustness of the results we estimate the cointegration vectors recursively to check if the point estimates remain stable as the post-crisis observations are added into the sample (Figures A3–A6 in Annex A). The recursive estimates of income and wealth elasticities are relatively stable in all models irrespectively of the estimation method (with the exception of income elasticity in S2S M2Y model which was insignificant if estimated using only pre-crisis sample). The OC and uncertainty recursive coefficients displayed considerable fluctuations but still seemed meaningful in the models for ruble M1 and M2 aggregates. The recursive estimates of OC variable coefficient in M2Y and M2Y^{adj} models reveal, however, that the OC variables only started to enter the cointegration relationship with the "right" sign after the large number of post-crisis observations had been added to the estimation sample. This result may indicate that the relationship between broader monetary aggregates and OCs is more complex than implied by this money demand relationship or that the financial returns indicators do not fully represent the OCs in the Russian economy. On the other hand, given the limited variation of OCs before the crisis and relatively short time sample we can not rule out the possibility that adding the observations characterizing the opposite phase of the economic cycle was just necessary to disentangle the true effect of OCs on money demand.

We may examine monetary overhangs derived from the cointegrating relationships as the measures of excess liquidity and as shown in Figure 6. The choice of cointegration vector's estimation method does not seriously change the outcome here. With the exception of fluctuations in the beginning of the sample and the hikes of S2S M2 overhang in early 1999 and 2009 (determined by the sharp exchange rate depreciation episodes) the dynamics of the overhangsseem meaningful. They fluctuate evenly around zero, pick up in 2006 before plummeting to some very low levels in 2008–2009. Then, as money growth picked up while money demand fundamentals' (particularly real asset prices) remained weak, the monetary overhangs climbed to unprecedentedly high levels, in particular for M2Y and adjusted M2Y.

4.3. Error correction models

The short-run money-demand models are formulated as conventional ECMs of the form:

$$\Delta(m-p)_t = \alpha_0 + \alpha_1 ec_{t-1} + \sum_{j=1}^{2} \alpha_{2j}\Delta(m-p)_{t-j} + \sum_{j=1}^{2} \alpha_{3j}\Delta y_{t-j} +$$

$$+ \sum_{j=1}^{2} \alpha_{4j}\Delta w_{t-j} + \sum_{j=1}^{2} \alpha_{5j}\Delta OC_{t-j} + \sum_{j=1}^{2} \alpha_{6j}\Delta unc_{t-1} + \sum_{i=1}^{3} \sigma_i D_{it} + \varepsilon_t$$

where ec is the error correction term and D_i are the seasonal dummy variables. The equations include two lags of real money growth. The short-run part of the equations also contains up to two lags of first differences of other explanatory variables (these are eliminated if the respective t-statistics are smaller than 1.67). Conventional tests do not find serial correlation or ARCH effect in the equations' residuals. The α_1 coefficients as given in Table 6 are of most interest as they show that real money growth adjusts in accordance with the cointegrating relationship.

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Table 6
ECMs' α_1 loading coefficients (t-statistics)

Estimation period	Cointegration vector	Model			
		M1	**M2**	**M2Y**	**M2Y^{adj}**
1999Q1–2008Q2	S2S	-0.39 (-3.84)	-0.05 (-0.88)	0.05 (1.59)	-0.03 (-0.44)
	FM-OLS	-0.47 (-3.61)	-0.23 (-2.11)	-	-0.4 (-4.00)
1999Q1–2010Q2	S2S	-0.24 (-2.82)	0.01 (0.11)	0.07 (2.25)	-0.02 (-0.56)
	FM-OLS	-0.28 (-2.37)	-0.03 (-0.35)	-	-0.24 (-3.17)
1999Q1–2010Q2 (with dummy variables)	S2S	-0.31 (-3.70)	-0.05 (-0.98)	0.06 (1.93)	-0.01 (-0.16)
	FM-OLS	-0.41 (-3.44)	-0.19 (-2.19)	-	-0.2 (-2.65)

At first we estimate the ECMs on the pre-crisis period prior to 2008Q3. The loading coefficient in the M1 and M2 models is large and statistically highly significant (although the FM-OLS cointegrating vector is clearly more relevant for short-run M2 developments than S2S estimates). Quandt-Andrews breakpoint tests indicate that the models are stable over this sample. When the post-crisis observations are added to the time sample, the loading coefficients deteriorate notably (although in case of M1 it is still significant). The recursive estimates of loading coefficients show that their instability coincided with crisis developments (Figure A7 in Annex A). We therefore also examine the ECMs' estimates with the period of 2008Q3–2009Q1 covered with dummy variables. Under this set-up the estimates of the loading coefficient do not change significantly in comparison with the pre-crisis sample estimates.

This result could be expected, given the drastic and unpredictable fluctuations of money stock during the most severe phase of the crisis. The rapid return of dollarization, for example, could not be captured by the exchange rate variable since ruble's depreciation expectations were much stronger than implied by the gradual CBR-controlled depreciation rates. If we assume that the model's error during the crisis was due to the error in measuring exchange-rate expectations we may illustrate this by solving the model for M2[29] back and finding the exchange-rate variable value that implied no error in the model's estimate of money stock. Over most of the sample this estimate would have no economic meaning. Yet, during the depreciation episode this estimated exchange rate variable's value could be used to assess these unobserved expectations.

[29] We used the FM-OLS model for M2 estimated over the 1999Q1–2008Q2 time sample.

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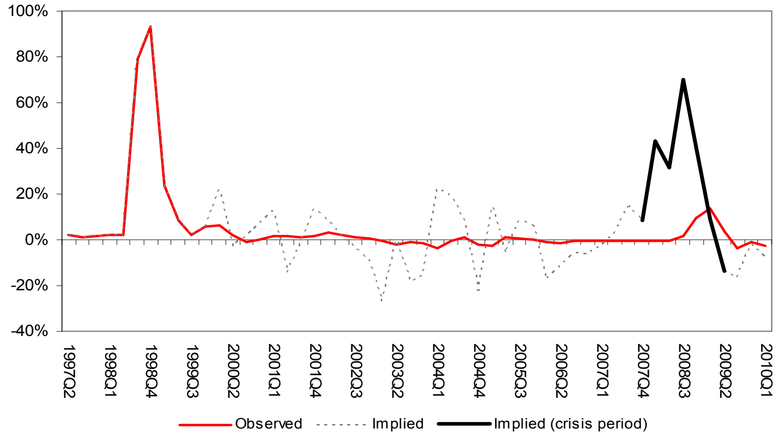
Figure 7
Exchange rate expectations: observed proxy (the average quarterly ruble's depreciation over the last two quarters) and the estimate implied by the model



Source: authors' calculations.

The results of this exercise, as shown in Figure 7, indicate that the expected ruble's depreciation which would be consistent with the intensity of dollarization was higher than the one actually realized. In fact the market participants seemed to expect a depreciation similar to the one that took place during the previous crisis of 1998.

The results of ECMs' estimation for broader aggregates are more ambiguous. In contrast to ruble aggregates the broader M2Y and $M2Y^{adj}$ seem to be unaffected by the cointegrating relationship (at least by those estimated with the S2S method). The α_1 estimates are statistically insignificant under any set-up and in the case of M2Y the loading coefficient is positive which is clearly implausible. We believe that this difference arises from the fact that the nominal volumes of ruble aggregates are quite sensitive to changes of transactional needs and opportunity-cost fluctuations (as households are eager to switch between currencies or between cash and bank deposits). There are however fewer means for nominal volumes of broad aggregates to adjust as their dynamics is only partially determined by demand-driven processes (i.e. financial intermediation) and there are virtually no assets outside M2Y aggregate that are widely used for savings purposes. There still is the chance that the real money stock would adjust due to the increase of the price level, but given the relatively short period under review and the scope of the nominal money-supply shocks whicht took place during this period, it is unsurprising that such adjustment could go unnoticed by the econometric model. Yet, we can not rule out the possibility that broad aggregates may be driven by money demand completely as the ECM based on FM-OLS cointegration vector estimate for $M2Y^{adj}$ performs satisfactorily and is not drastically affected by the crisis.

We can summarize our findings as follows. The long-run money demand relationship may be established for M1, M2, M2Y and $M2Y^{adj}$ aggregates. The parameterization of these relationships is notably different, although it is impossible to discriminate between them from a theoretical viewpoint since all sets of parameters might be plausible under certain assumptions. Contrarily to Oomes and Ohnsorge (2005), the narrowest M1 aggregate performs at least as good as the broader aggregates. In fact the recursive estimates of the cointegration vector of M1 money-demand relationship seems to be more stable than those estimated for broader monetary aggregates, in which cases the robustness is questionable. The short-run model of the demand for M1 is obviously the best performing, while M2Y developments seem to be ambiguously affected by the money-demand relationship. Although given the exogenous nature of the sources of nominal money growth in Russia and the underdevelopment of the alternative financial assets that could be used for savings purposes beyond those included into M2Y, this last finding seems plausible.

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5. THE INFORMATION CONTENT OF MONEY FOR INFLATION AND FOR REAL ECONOMIC DEVELOPMENTS

As described in Papademos and Stark (2010), chapter 4, extracting the signals in monetary developments is an essential piece of information for policy-makers, though it may be difficult at times because of the short-term volatility of monetary aggregates. A key issue for central banks aiming to maintain price stability is the information content of money for future inflation. Understanding the behaviour of loans and monetary aggregates during the business cycles, however, can add useful insights for analyzing the driving forces of real economic activity. In this part we present two models that shed some light on these questions in the case of Russia.

5.1. Money-based inflation risk indicators

We use money-based inflation-risk indicators in order to assess the long-run link between monetary growth and inflation. Thus, the assessment of risks to price stability should rather focus on the persistent or lower frequency movements of the monetary developments, or – to repeat the wording of the ECB here – on the "underlying monetary growth". As outlined in Papademos and Stark (2010, p. 209) and as recognized by the ECB's two-pillar strategy, it is important to stress that money alone is insufficient for collecting information on future price developments. Money, nevertheless, is a necessary component and a starting point is to use a reduced-form inflation-forecast equation in the spirit of Stock and Watson (1999). As applied by Nicoletti-Altimari, 2001 or Hofmann, 2008 and described in Fischer et al.(2008) we use an augmented autoregressive equation for forecasting consumer price inflation, π, at time t+h with the information embodied in monetary indicators x at point t:

$$\pi^k_{t+h} = \beta_0 + \beta_1(L)\pi_t + \beta_2(L)x_t + \varepsilon_{t+h} \quad (5)$$

In the case of Russia and similarly to Papademos and Stark (2010, p. 220, 221), we use quarterly data and capture the idea of "underlying money growth" with two smoothing measures.

Firstly, the key explanatory variable is the (weighted) average of monetary developments over several periods as implied by β_2(L). The number of lags, just as in the case of β_1(L), are selected using the Schwartz information criterion (with a maximum of 3).[30]

Secondly, k denotes the number of quarters over which the inflation term is calculated in annualised terms. A specification with k = 4 would generate point forecasts for annual CPI inflation at any specific horizon chosen for h, while k > 4 represents annualised inflation over a period longer than one year, and thus, can be seen as a smoothing measure. In this study k ranges between 4 and 6 for the chosen six-quarter-ahead forecasts in order to produce indicators that are informative about the medium-term trends in inflation.

These trends will influence developments at horizons well beyond 12 quarters ahead, thus indicating a time horizon, at which inflation ultimately becomes a monetary phenomenon according to the ECB's monetary analysis.

We also test the performance of alternative explanatory variables under the same model set-up. We use a number of readily available variables from the categories of economic indicators that are often regarded as important inflation determinants in Russia (see e.g. Oomes and Dynnikova (2006)): quarterly GDP growth, GDP gap (recursively calculated with Hodrick-Prescott filter, λ = 1600), quarterly growth of nominal effective exchange rate (NEER) and quarterly growth of ruble oil prices. Additionally we test the performance of tri-variate economic indicators model

[30] The selection of the lags in a purely data-dependent manner implies that the precise specification of a model can change from one forecast to the next. The disadvantage of more difficult comparability between forecasts is accepted in order to have a less complex model.

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including both GDP and NEER growth as regressors that may be regarded as a proxy for a Phillips curve relationship.

Table 7 presents the results of the accuracy of the forecasts for the model based on different monetary aggregates, their median forecast, economic indicators models and the pure autoregressive model for inflation (AR). It is expressed as the ratio between the Root Mean Squared Error for the money-based forecasting model (RMSE) and the Root Mean Squared Error of the Random Walk (RMSE_RW) for different monetary aggregates in Russia. As suggested in Hofmann, 2008 we also report the results of Diebold and Mariano (1995) test (with HAC correction) on the equality of the forecast errors.

Table 7
RMSE/ RMSE_RW (p-values of the tests of the hypotheses that RMSE = RMSE_RW in parentheses)

	k = 4	k = 5	k = 6
M1	**0.51**	**0.42**	**0.3**
	-0.1	*-0.04*	*-0.01*
M2	**0.88**	**0.59**	**0.45**
	-0.62	*-0.02*	*-0.01*
M2X	**0.37**	**0.36**	**0.51**
	-0.03	*-0.02*	-0.01
M2X adjusted	**0.59**	**0.44**	**0.38**
	-0.06	*-0.02*	*-0.01*
M2Y	**0.96**	**0.84**	**0.67**
	-0.3	*-0.01*	*-0.05*
M2Y adjusted	**0.84**	**0.89**	**0.77**
	-0.03	*-0.39*	*-0.02*
Median forecast of monetary models	**0.4**	**0.4**	**0.44**
	-0.01	*-0.02*	*-0.01*
Δ GDP	**1.17**	**0.83**	**0.69**
	-0.57	*-0.05*	-0.05
GDP gap	**1.04**	**1.05**	**0.87**
	-0.59	*-0.6*	*0*
Δ NEER	**0.79**	**0.82**	**0.74**
	-0.23	*-0.09*	*-0.02*
Δ GDP, Δ NEER	**0.83**	**0.67**	**0.72**
	-0.2	*-0.1*	*-0.05*
Δ Oil prices	**0.98**	**0.89**	**0.92**
	-0.62	*-0.01*	*-0.27*
AR	**0.82**	**0.69**	**0.62**
	-0.07	*-0.02*	*-0.02*

Based on this measure most of the money-augmented inflation forecasts improve the accuracy compared to the Random Walk and autoregressive model and also outperform the economic indicators. The most informative monetary aggregates are M1 and M2X (both adjusted and

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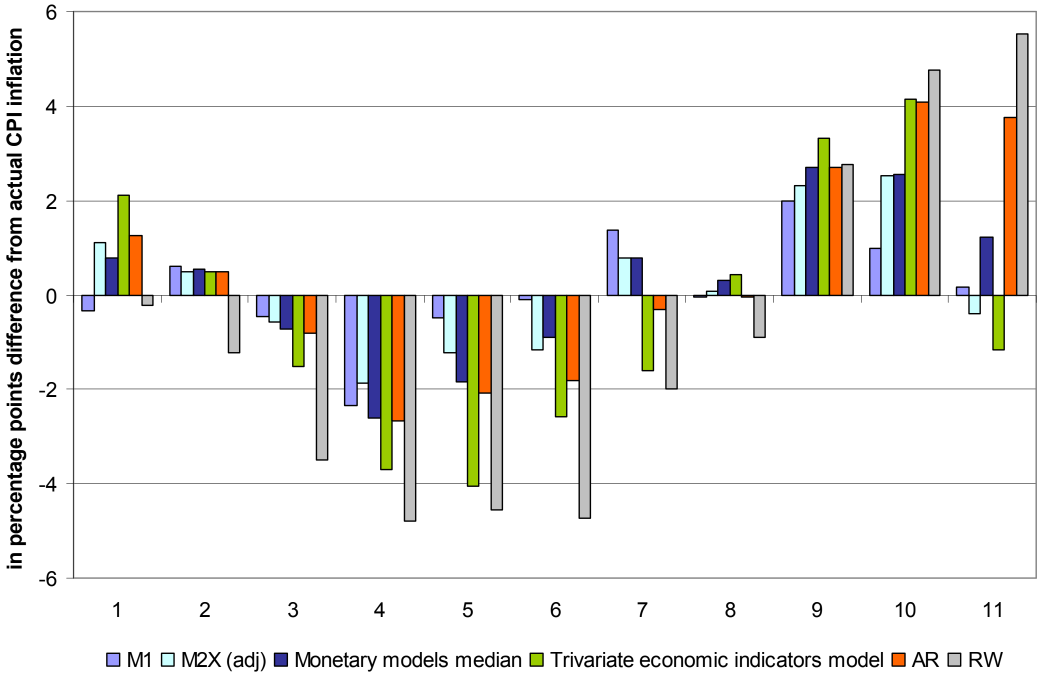
unadjusted). In general, monetary models seem to perform better when forecasting on longer horizons.

Figure 8 shows the errors of the six-quarter-ahead forecast for k = 6 compared with the actual CPI inflation outcomes for selected approaches.

Figure 8

Forecast Errors of Inflation Indicators for Russia (2007Q4–2010Q2)



1 – 2006Q2–2007Q4
2 – 2006Q3–2008Q1
3 – 2006Q4–2008Q2
4 – 2007Q1–2008Q3
5 – 2007Q2–2008Q4
6 – 2007Q3–2009Q1
7 – 2007Q4–2009Q2
8 – 2008Q1–2009Q3
9 – 2008Q2–2009Q4
10 – 2008Q3–2010Q1
11 – 2008Q4–2010Q2

Source: authors' calculations.

The forecast errors of the money-augmented models are relatively small compared to the alternative models for most periods. The fact that monetary models performed relatively well may reflect certain complications in forecasting inflation in Russia with traditional economic variables. For instance while oil-price growth is cost increasing factor[31] it is also an important income factor and is usually associated with reduced inflation due to ruble's appreciation. Extracting relevant information from (quite volatile) output growth rates in conditions of ongoing transformation of the economy (due to both the emerging market nature of the Russian economy and its susceptibility to external shocks) may also be challenging. In this context, money-based inflation-risks indicators may prove particularly useful. It should, however, be kept in mind that the forecasting exercise is restricted to a fairly short and special time window due to the availability of data.

5.2. The informational content of money for real economic developments

Using money as an information variable for real sector developments is another important aspect of analyzing monetary aggregates. In Brand et al. (2003) narrow money, here M1, seems crucial for cyclical developments in the euro area compared to other macroeconomic and financial

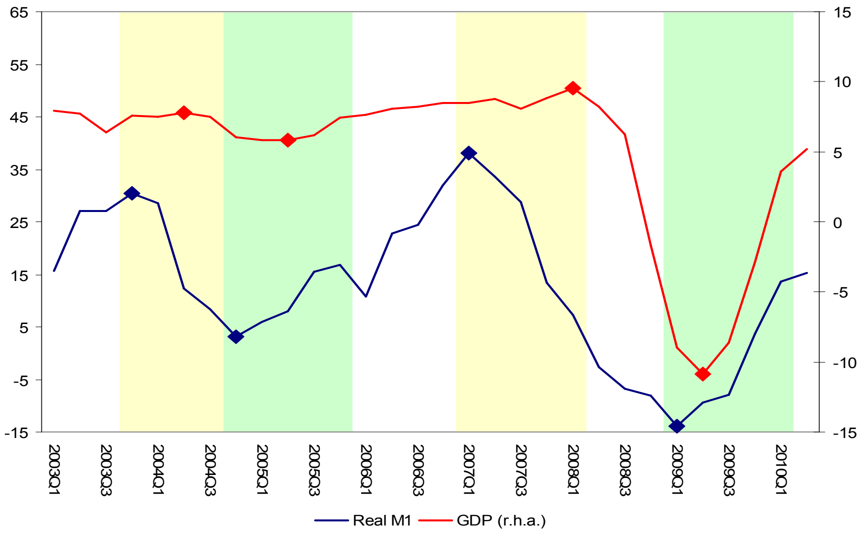
[31] Interestingly, the link between world oil prices and (monopolized and regulated) domestic fuel market's prices may be less evident in Russia.

DOI: 10.7172/2353-6845.jbfe.2014.2.5

variables commonly used for forecasting real economic activity. Interestingly, this is in contrast to most studies conducted for the U.S. Thus, we investigate this question for Russia. The robust relationship between money and real growth may prove valuable for the purposes of assessing the general trends of the real sector developments as well as for more specific short-term forecasting. Indeed, some central banks underscore the importance of the close link between money and actual spending in their routine analytical work (see e.g. Bank of England, 2008 or ECB, 2008).

The exploration of the link between money and credit aggregates and economic activity has also intensified when attempting to explain drastic GDP fluctuations in Russia. In fact the analysis of the linkage between the turning points in output and real money stock dynamics conducted at the ECB in 2008 seems to be perfectly applicable for Russia. As shown on Figure 9, over the last decade every turning point in the annual growth rates of real M1 was followed by the turning point in the annual growth rates of real GDP within the next 4 quarters.

Figure 9
Real M1 and real GDP annual growth rates (%) and turning points[32]



Source: CBR, Rosstat.

This type of analysis however makes use of only several observed episodes. We will also examine to what extent the monetary aggregates can be used to forecast the real sector developments in a more linear fashion.

5.2.1. Model specification and data issues

Our empirical approach is closely related to Brand et al. (2003). We formulate the regression of the form:

$$\Delta y_t = \alpha_0 + \alpha_1 \Delta_4 m_{t-1} + \alpha_2 oil_t + \alpha_3 \Delta_4 reer_t + \alpha_4 \Delta y_{t-1} + \alpha_5 \Delta y_{t-2} + \varepsilon_t, \quad (6)$$

where Δy is the change of seasonally adjusted GDP and $\Delta_4 m$ is the 4-quarters change of the real monetary aggregate (deflated with GDP deflator). As the model with M2Y has a "wrong" (negative) α_1 coefficient we exclude it from further analysis. We add real ruble oil prices (*oil*) and the 4 quarters changes of the real effective exchange rate (*reer*) as control variables[33] that

[32] The turning points were identified as local maxima/minima on the rolling-window periods of 9 quarters.

[33] The conventional choice of the control variable for this regression are yield spreads. Adding the spread between interest rates on loans and deposits and real interest rate on loans produces counterintuitive results (positive coefficients) and we therefore removed them.

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are commonly used to explain GDP fluctuations in Russia (see e.g. Rautava, 2009). The lagged changes of GDP prevent the autocorrelation in the residuals. All variables are in logs. The time sample was set to 1999Q1–2006Q4. The Phillips-Perron and KPSS unit root tests yield conflicting results, as the Phillips-Perron test suggests that annual changes of monetary aggregates may have unit roots (Table B1 in Annex B). However, based on the visual observation of the time series and given that there is no possibility of spurious regression since the left-hand-side variable is clearly stationary, we proceed by estimating the regression.

5.2.2. Results

Firstly we examine the in-sample performance of the models. For this purpose we compute one-step-ahead static forecasts. Following Fischer et al. (2008) we use the mean squared forecast error (MSFE) as the criteria. We also formulate the benchmark models to assess the usefulness of taking into account the monetary aggregates. As in Fischer et al. (2008) these are the simple autoregressive models (AR) and the naïve random walk forecast (RW). The third benchmark model (X) equals the model as stated in equation (3), but excludes the monetary indicator.

Table 8
In-sample forecasting performance

	MSFE	$MSFE/MSFE^{AR}$
AR	0.00007713	1.00
RW	0.00010732	1.39
X	0.00003282	0.43
M1	0.00003143	0.41
M2	0.00002816	0.37
M2X	0.00003210	0.42
M2X_adj	0.00003103	0.40
M2Y_adj	0.00003190	0.41

On the in-sample period the models with money are performing better than naïve models, although their MSFE is only marginally smaller than MSFE of the X-model that does not include money as shown in Table 8. In fact the statistical significance of money in these equations is rather low, with only M2 being significant at the 5% level. We then proceed by making the out-of-sample static forecasts over the period of 2007Q1-2010Q2. As in Fischer et al. (2008) we report both components that determine the MSFE, the standard deviation of the forecast and the forecast bias.

Table 9
Out-of-sample forecasting performance

	MSFE	$MSFE/ MSFE^{AR}$	Bias	Standard deviation
AR	0.00057	**1.00**	-0.011	0.005
RW	0.00064	**1.11**	0.005	0.020
X	0.00072	**1.26**	-0.016	0.009
M1	0.00054	**0.95**	-0.014	0.010
M2	0.00050	**0.88**	-0.015	0.012
M2X	0.00066	**1.16**	-0.016	0.010
M2X_adj	0.00076	**1.33**	-0.017	0.012
M2Y_adj	0.00082	**1.44**	-0.018	0.011

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Over the out-of-sample period, only M1 and M2 models are performing better than naïve benchmarks. Yet, the models that include M1, M2 and M2X perform notably better than the X model which does not include money. These results should be interpreted with caution as the time sample analyzed includes the crisis developments and may therefore not be fully representative. Table 10 shows the results when excluding the period of 2008Q3–2009Q2 (i.e. the period of recession) from the sample.

Table 10
Out-of-sample forecasting performance (excluding recession)

	MSFE	MSFE/ $MSFE^{AR}$	Bias	Standard deviation
AR	0.00005	**1.00**	-0.001	0.002
RW	0.00038	**7.21**	0.016	0.012
X	0.00009	**1.75**	-0.004	0.006
M1	0.00007	**1.34**	-0.004	0.006
M2	0.00010	**1.92**	-0.006	0.006
M2X	0.00009	**1.66**	-0.005	0.006
M2X_adj	0.00012	**2.28**	-0.006	0.008
M2Y_adj	0.00013	**2.49**	-0.006	0.008

The results of the out-of-sample forecast over the relatively calmer periods indicate that the models' performance are not impressive as none of them was able to outperform the autoregressive model. The M1 and M2X models are still forecasting better than the X model, meaning that money developments contain some useful information beyond that contained in the control variables.

Summarizing, we find only limited usefulness of using monetary aggregates to forecast GDP growth over the pre-crisis period in the linear model framework. The performance of the estimated models generally deteriorates during the crisis and post-crisis periods and is worse compared to naive models. Yet, the models which contain money seem to perform better than the one that does not. This is particularly so when the periods of recession are included, although to what extent this finding is representative remains unclear. As could be expected, the best-performing monetary aggregate appears to be M1.

6. CONCLUSIONS

Tools and techniques of the ECB's monetary analysis can give valuable input to the conduct of monetary policy at other central banks, if institutional, economic and financial differences are taken into account. We take the case of the Bank of Russia and analyze the changing role of money in its monetary policy.

In the core part of our paper we derive stable money demand functions that are related to income and wealth and to a lesser extent to opportunity costs and uncertainty. Estimations of narrower aggregates that only include components denominated in national currency seem to be more stable than broader aggregates. It signals that monetary developments are influenced by factors that go beyond the usual money-demand factors, such as the buffering function of the sovereign wealth fund in case of Russia. This makes the interpretation of monetary overhangs and the policy implications that can be drawn from them more complex since the impact of the sovereign wealth fund on monetary development is already a policy reaction. Eventually, it should be kept in mind that the concept of monetary overhangs are a starting point for an analysis that also focuses on changes in the stocks rather than analyses that solely focus on changes in

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the flows. Additionally, we show how money demand functions can be used to derive implied exchange-rate depreciation expectations as compared to actual exchange-rate depreciation.

In the last section, we present results that deliver some information content of money for inflation and real economic development. As in case of the ECB's regular monetary assessment we measure money-based inflation risk indicators and compare the performance of different monetary aggregates with naïve and univariate inflation models as well as inflation models with alternative economic variables. The results are promising, though we leave it for future analysis to assess their performance over time. The results of the information content of money for real economic developments is fairly limited, however, in line with results for the euro area, the narrow monetary aggregate seem to perform relatively better compared to broader aggregates. This, however, should not be seen as a negative feedback to the ECB style monetary analysis since monetary aggregates are rather used as an indicator for the turning points in real GDP at the ECB. During our sample period this purposes is actually served fairly well for Russia.

We conclude that the ECB style monetary analysis gives valuable input to the analysis at the CBR. Monetary analysis, however, is an evolutionary process, so within an economy over time as well as across economies changes of the economic and financial environment have an impact on the analysis and on the policy conclusions that can be drawn from it. The case of Russia furthermore highlights that monetary analysis should not be minimized to a purely technical exercise, but that it needs and enforces institutional knowledge of the financial sector.

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ANNEX A

Figure A1
Variables used in the model

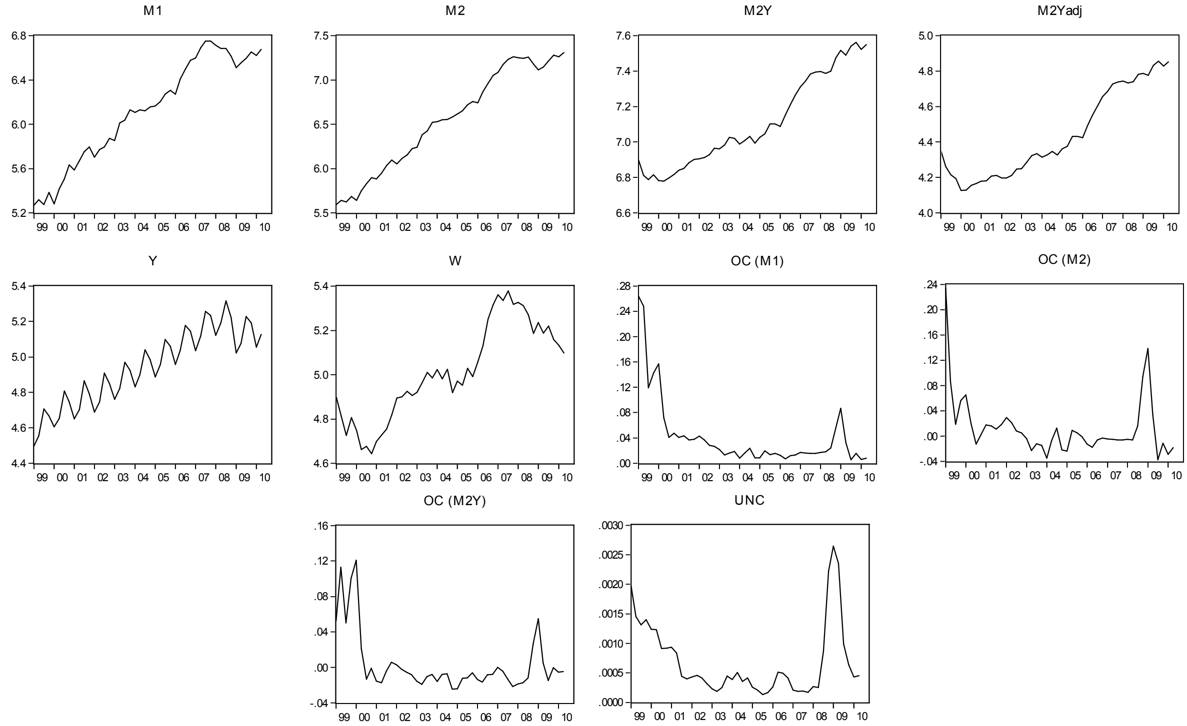

Table A1
Results of the unit root tests (for PP and KPSS tests the bandwidth is determined by automatic Andrews, 1991 procedure; the unit root test with structural break is conducted in the presence of seasonal time dummy variables and the shift type dummy variable in 2008Q4 (the impulse type dummy variable when the variables are in differences) with lag length set to 4)

Variable	**Test specification**	**PP test statistic (p-value)** Null hypothesis: variable has unit root	**KPSS test statistic** Null hypothesis: variable is stationary	**ADF type unit root test with structural break (Lanne et al. (2002)) test statistic** Null hypothesis: variable has unit root
M1	Levels (constant)	-0.68 (0.84)	0.45*	-1.78
	Levels (constant and trend)	-1.80 (0.69)	0.16**	-2.73
	1st differences (constant)	-7.47 (0.00)	0.14	-3.64**
M2	Levels (constant)	-0.49 (0.88)	0.66**	-1.4
	Levels (constant and trend)	-1.78 (0.70)	0.17**	-2.15
	1st differences (constant)	-5.88 (0.00)	0.14	-3.06**
M2Y	Levels (constant)	1.00 (0.99)	0.67**	-0.22
	Levels (constant and trend)	-3.95 (0.02)	0.15**	-0.77
	1st differences (constant)	-5.16 (0.00)	0.49**	-2.9**

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Variable	Test specification	PP test statistic (p-value) Null hypothesis: variable has unit root	KPSS test statistic Null hypothesis: variable is stationary	ADF type unit root test with structural break (Lanne et al. (2002)) test statistic Null hypothesis: variable has unit root
$M2Y^{adj}$	Levels (constant)	-0.00 (0.95)	0.58**	-0.13
	Levels (constant and trend)	-6.78 (0.00)	0.14*	-0.29
	1st differences (constant)	-5.30 (0.00)	0.48**	-3.42**
Y	Levels (constant)	-2.00 (0.29)	0.44*	-1.26
	Levels (constant and trend)	-4.82 (0.00)	0.18**	-2.9*
	1st differences (constant)	-6.63 (0.00)	0.04	-3.24**
W	Levels (constant)	-0.99 (0.75)	0.42*	-2.2
	Levels (constant and trend)	-1.41 (0.85)	0.14*	-2.29*
	1st differences (constant)	-6.84 (0.00)	0.18	-3.14**
OC^{M1}	Levels (constant)	-7.06 (0.00)	0.41*	-3.56**
	Levels (constant and trend)	-5.49 (0.00)	0.16**	-0.2
	1st differences (constant)	-6.56 (0.00)	0.42*	-4.13**
OC^{M2}	Levels (constant)	-21.3 (0.00)	0.31	-1.65**
	Levels (constant and trend)	-20.0 (0.00)	0.16**	-0.81
	1st differences (constant)	-6.82 (0.00)	0.37	-4.75**
OC^{M2Y}	Levels (constant)	-2.83 (0.06)	0.31	-3.94**
	Levels (constant and trend)	-2.97 (0.15)	0.16**	-0.36
	1st differences (constant)	-8.15 (0.00)	0.06	-5.28**
UNC	Levels (constant)	-2.67 (0.09)	0.15	-3.09**
	Levels (constant and trend)	-2.56 (0.30)	0.15*	-1.29
	1st differences (constant)	-4.35 (0.00)	0.13	-2.58

** – rejection of the null at 5%-level, * – rejection of the null at 10%-level.

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Figure A2
Recursively estimated eigenvalues with 95% confidence bands (for fixed short run dynamics)

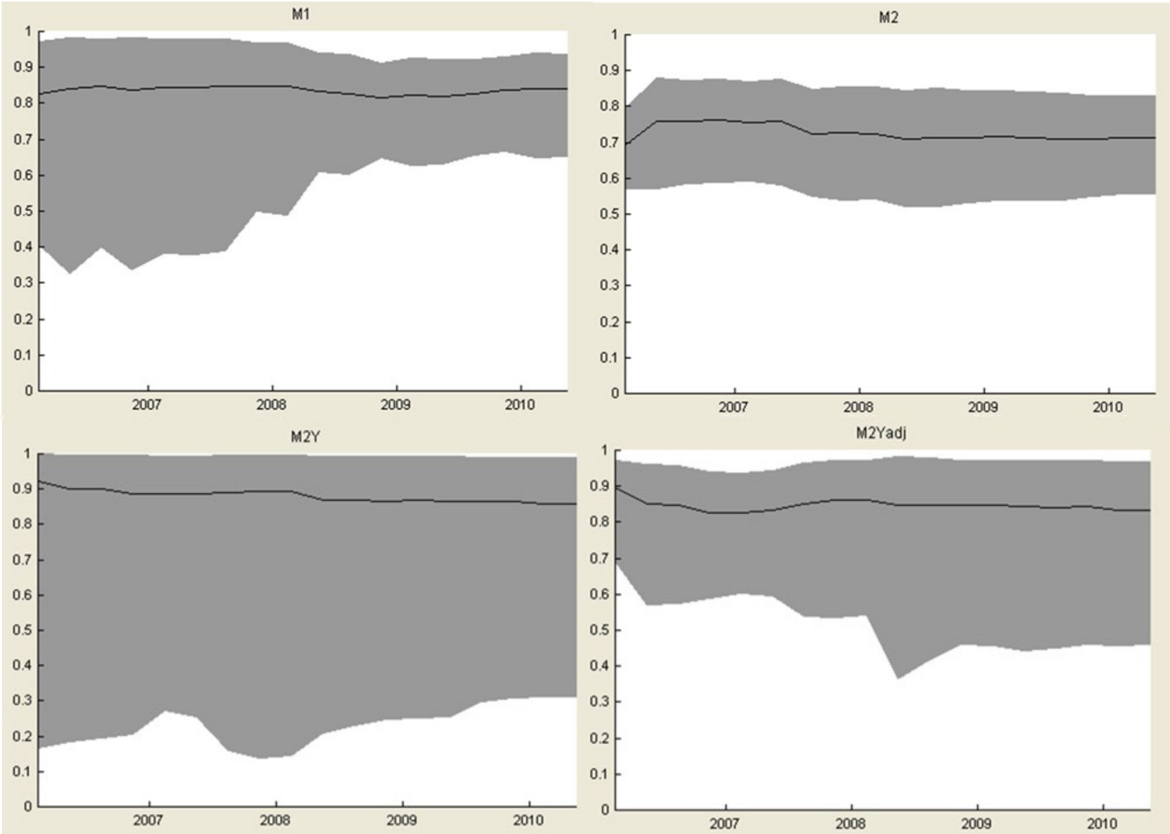

Figure A3
Recursively estimated statistic of Hansen and Johansen (1999) fluctuations test and 95% critical value (for fixed short run dynamics)

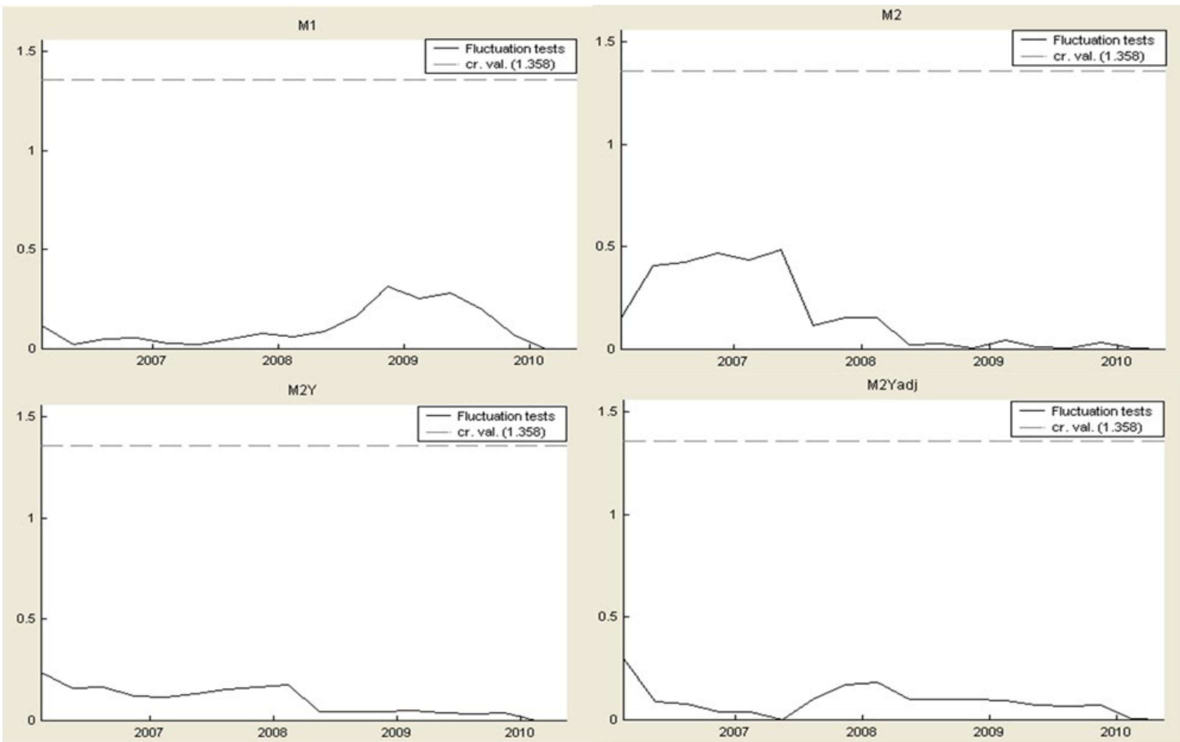

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Table A2
Test for stationarity of variables: F-statistics (p-value)

Variable	Model			
	M1	M2	M2Y	M2Y^{adj}
M	70.65 (0.00)	46.74 (0.00)	71.53 (0.00)	59.06 (0.00)
Y	71.25 (0.00)	46.55 (0.00)	70.06 (0.00)	60.13 (0.00)
W	67.71 (0.00)	44.33 (0.00)	69.03 (0.00)	53.54 (0.00)
OC	50.06 (0.00)	42.58 (0.00)	31.13 (0.00)	36.57 (0.00)
UNC	33.50 (0.00)	29.00 (0.00)	51.31 (0.00)	51.09 (0.00)

Figure A3
Recursive estimates of M1 money demand model's cointegration vector (±2 S.E.)

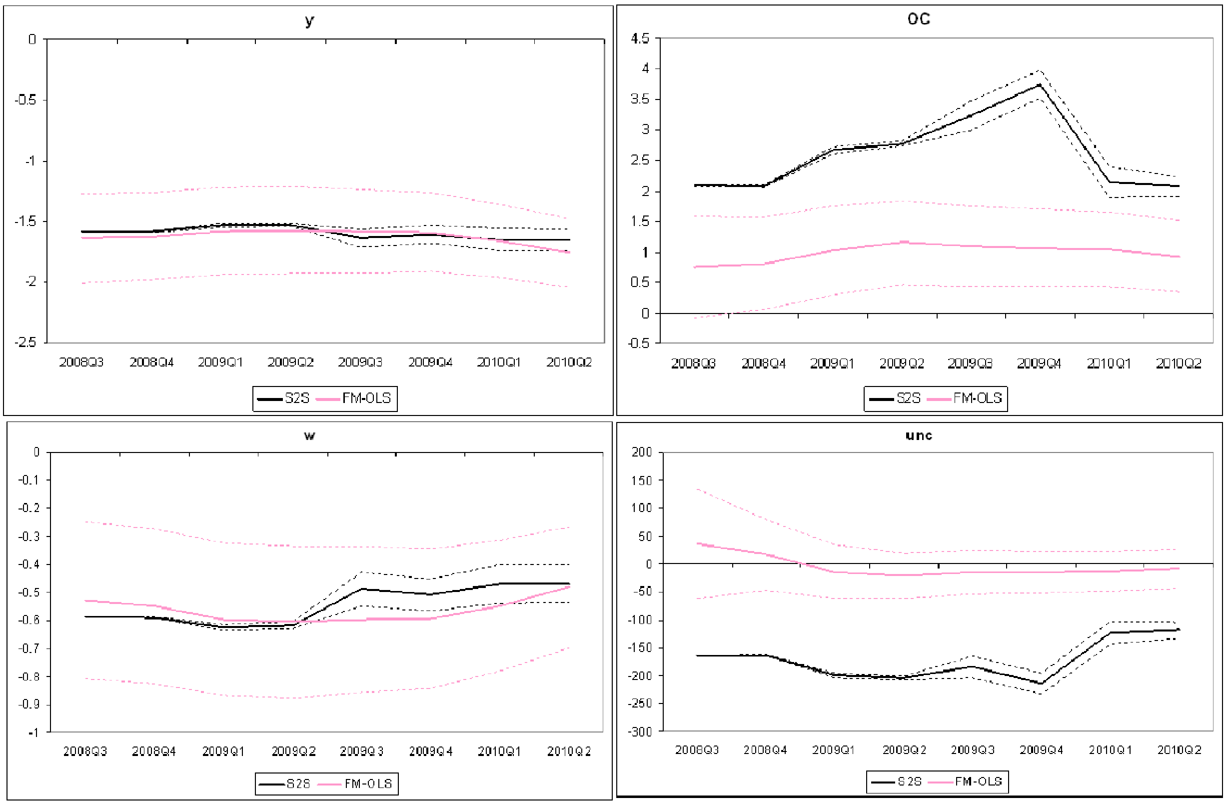

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Figure A4
Recursive estimates of M2 money demand model's cointegration vector (±2 S.E.)

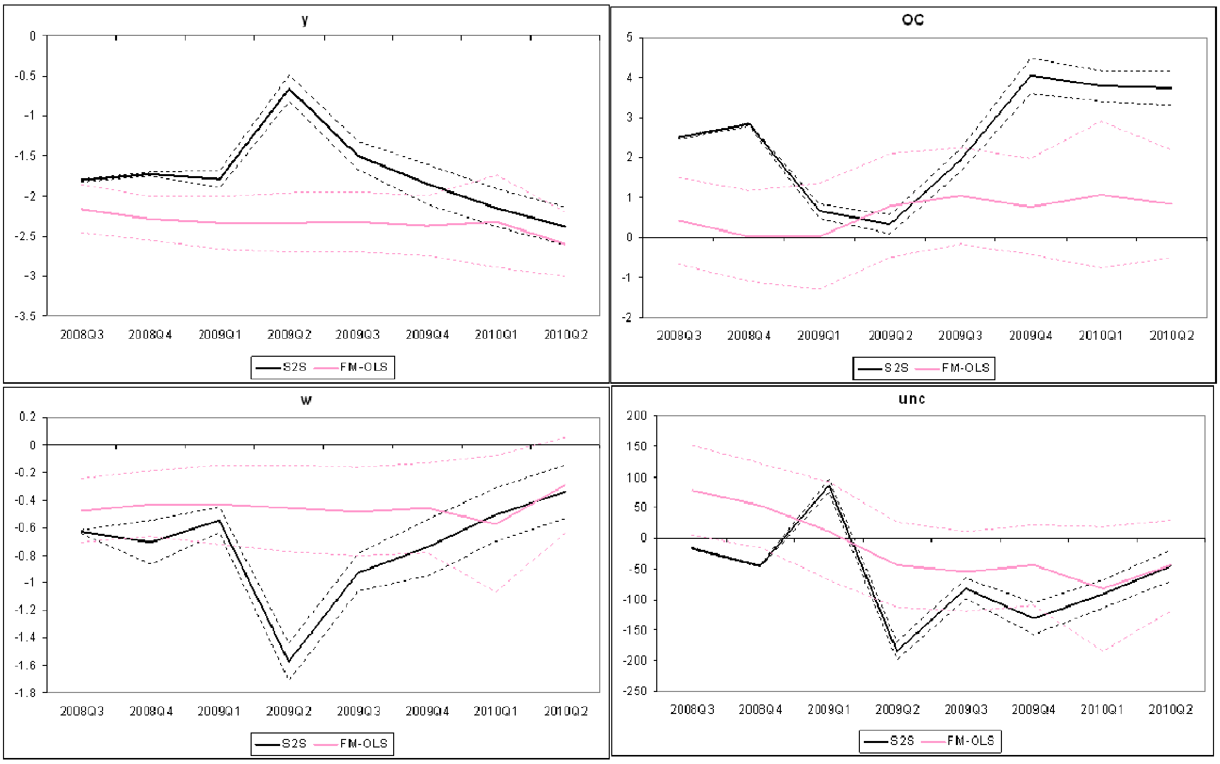

Figure A5
Recursive estimates of M2Y money demand model's cointegration vector (±2 S.E.)

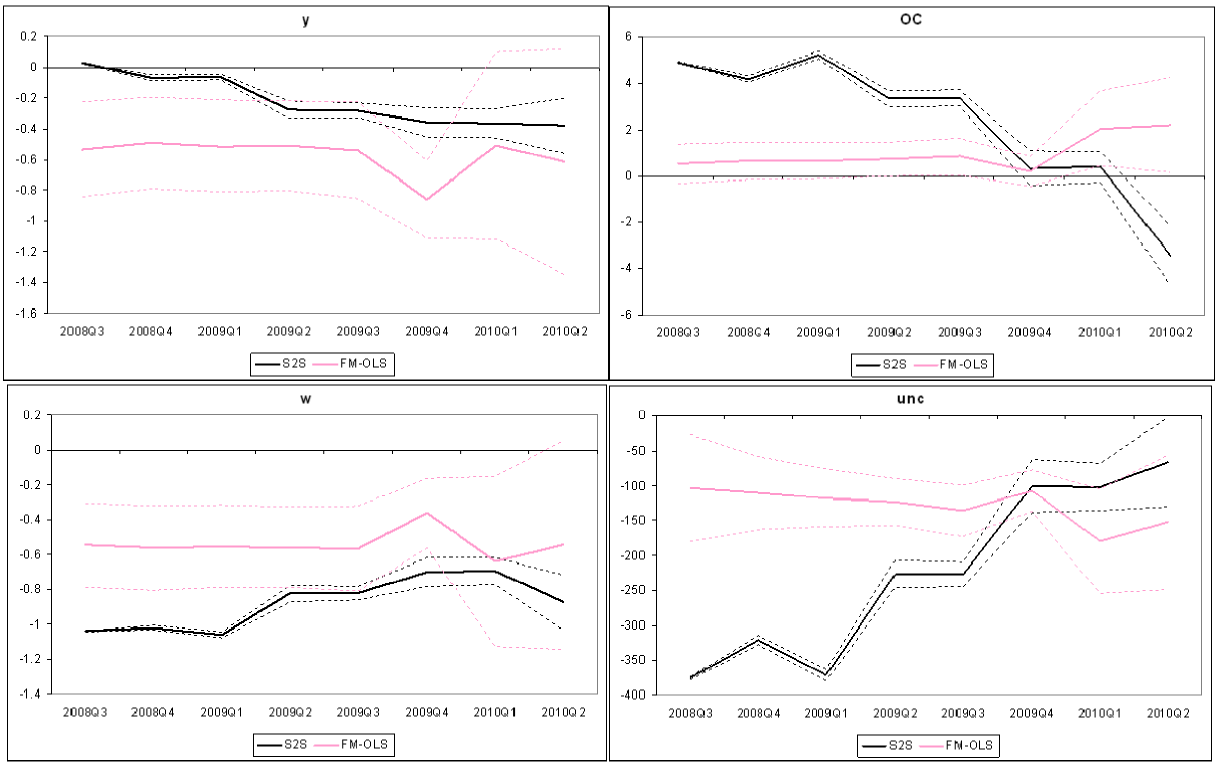

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Figure A6
Recursive estimates of M2Y[adj] money demand model's cointegration vector (±2 S.E.)

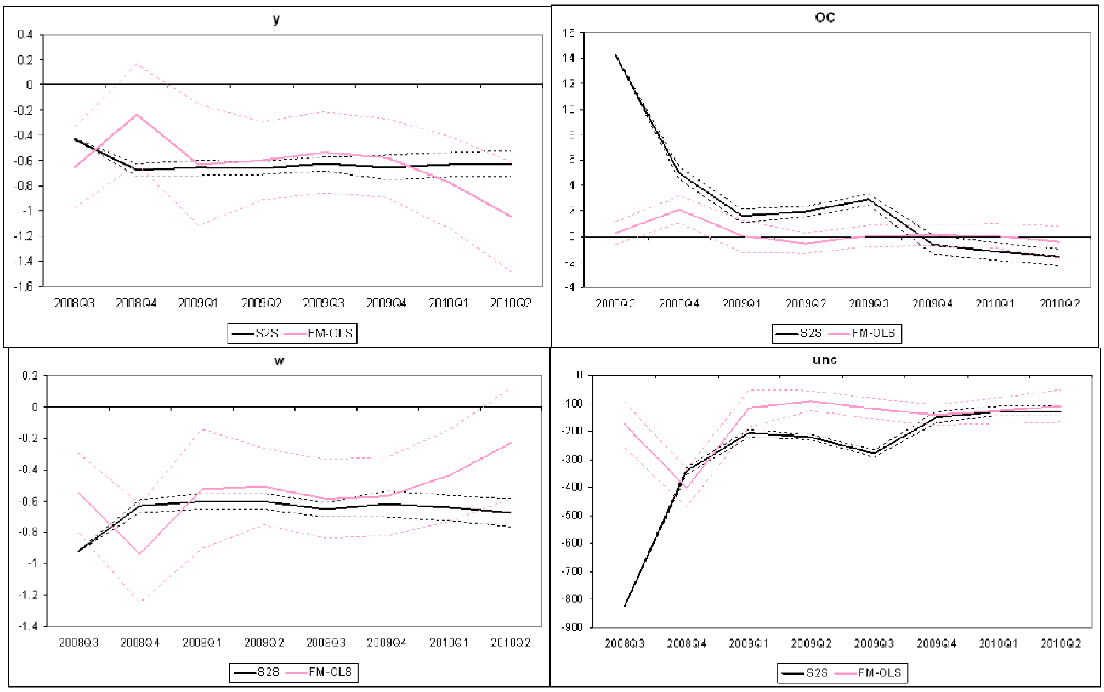
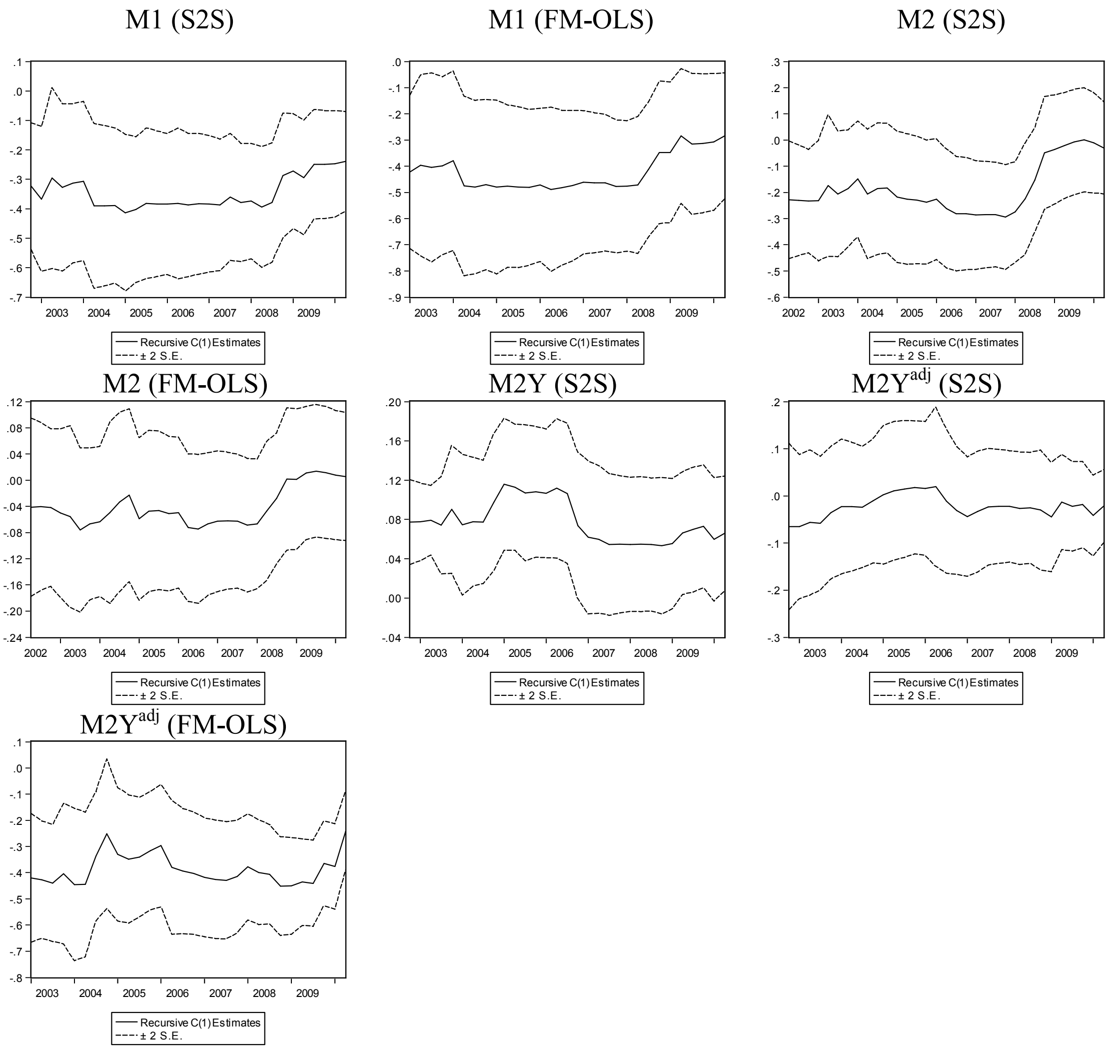


Figure A7
Recursive estimates of ECMs' loading coefficients



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ANNEX B

Figure B1
Variables used in equitation (5) (shaded area = period used for out-of sample forecasts)

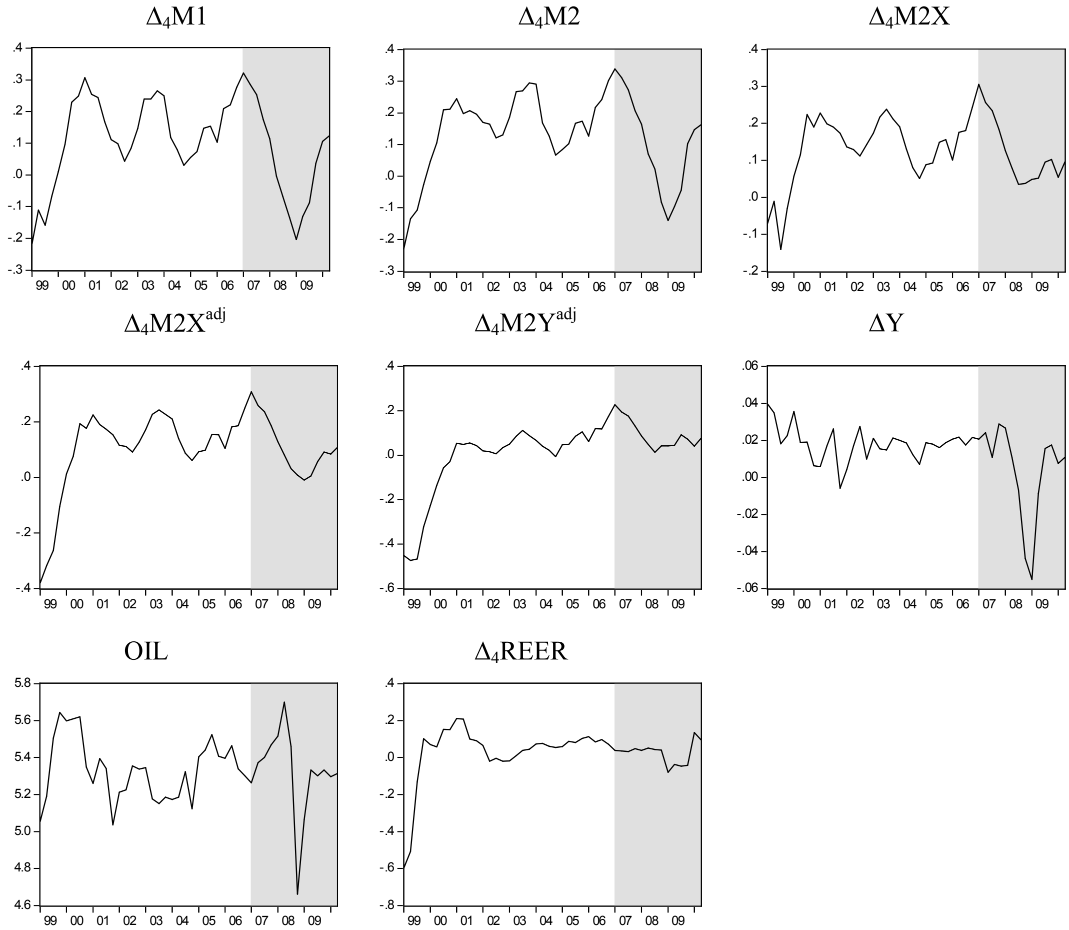

Table B1
Results of the unit root tests (variables in levels, bandwidth determined by automatic Andrews (1991) procedure)

Variable	PP test statistic (p-value) Null hypothesis: variable has unit root	KPSS test statistic Null hypothesis: variable is stationary
Δ_4M1	-1.99 (0.29)	0.31
Δ_4M2	-1.84 (0.36)	0.34
Δ_4M2X	-1.75 (0.4)	0.28
Δ_4M2X^{adj}	-3.55 (0.01)	0.35*
Δ_4M2Y^{adj}	-2.6 (0.1)	0.38*
ΔY	-4.55 (0.00)	0.23
OIL	-3.0 (0.05)	0.12
Δ_4REER	-5.48 (0.00)	0.24

* rejection of the null of stationarity at 10%-level.

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