Harrison, Barry; Vymyatnina, Yulia

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Currency substitution in a de-dollarizing economy: the case of Russia

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Bank of Finland, BOFIT
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Pekka.Sutela@bof.fi

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Russian economy and economic policy
Private sector development
Tuuli.Juurikkala@bof.fi

Mr Juuso Kaaresvirta, economist
Chinese economy and economic policy
Juuso.Kaaresvirta@bof.fi

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Chinese economy and economic policy
Editor-in-Chief of *BOFIT China Review*
Tuuli.Koivu@bof.fi

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Monetary policy in transition economies
Editor-in-Chief of *BOFIT Discussion Papers*
Iikka.Korhonen@bof.fi

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Chinese economy and economic policy
Monetary policy in transition economies
Aaron.Mehrotra@bof.fi

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bofit@bof.fi

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Russian regional issues
Merja.Tekoniemi@bof.fi

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Information services
Tiina.Saajasto@bof.fi

Contact us

Bank of Finland
BOFIT – Institute for Economies in Transition
PO Box 160

Phone: +358 10 831 2268
Fax: +358 10 831 2294
E-mail: bofit@bof.fi

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Contents

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Barry Harrison* and Yulia Vymyatnina**

Currency substitution in a de-dollarizing economy: The case of Russia

Abstract

Currency substitution, the use of foreign money to finance transactions between domestic residents, is a common feature of emerging market economies. Currency substitution reduces the stability of money demand functions in ways that can seriously undermine central bank credibility and its efforts to implement monetary policy. Most transition economies, including Russia, experienced widespread currency substitution in the early phase of transition. Following Russia's financial meltdown in 1998, its monetary authorities introduced a raft of changes that substantially improved the stability and performance of the macroeconomy and reduced currency substitution. This paper investigates currency substitution in the Russian economy in the post-crisis period of 1999–2005. Several measures of currency substitution and different modelling frameworks consistently suggest an on-going decline in currency substitution, a shift that has important implications for Russian monetary policy.

JEL Classification: E58, F31, F41

Key words: currency substitution, transition economies, de-dollarization

* Harrison,Nottingham Business School, Burton Street,Nottingham,United Kingdom, NG1 4BU, Tel: 00 44 115 848 5504, Fax: 0044 115 8486829, Email: Barry.Harrison@ntu.ac.uk
** VymyatinaThe author is grateful to INTAS for its support of this research through the INTAS Young Scientists Fellowship grant #03-55-2408.
Department of Economics, European University at St. Petersburg, #3, Gagarinskaya Str., St. Petersburg, 191002, Russia, Tel: 00 7 812 275 11 30, Fax: 00 7 812 275 11 30, Email: yv@eu.spb.ru

Barry Harrison and Yulia Vymyatnina

Currency substitution in a de-dollarizing economy: The case of Russia

Tiivistelmä

Ns. valuuttasubstituutio eli toisen maan valuutan käyttö maan sisäisissä taloudellisissa transaktioissa on varsin yleistä kehittyvissä talouksissa. Valuuttasubstituutio heikentää rahankysynnän vakautta, mikä puolestaan saattaa haitata keskuspankin uskottavuutta ja rahapolitiikan toteuttamista. Valuuttasubstituutio oli varsin yleistä useimmissa siirtymätalouksissa järjestelmämuutoksen alkuvuosina, ja näin oli myös Venäjällä. Vuoden 1998 talouskriisin jälkeen Venäjän talouskasvu on ollut nopeaa ja taloustilanne selvästi aiempaa vakaampi, osaksi talouspoliittisten toimien ansiosta. Tämä on vähentänyt valuuttasubstituutiota. Tässä tutkimuksessa tarkastellaan valuuttasubstituutiota Venäjällä talouskriisin jälkeisinä vuosina 1999–2005. Tutkimuksessa käytetään useita valuuttasubstituution määritelmiä ja empiirisiä menetelmiä. Tulokset osoittavat, että valuuttasubstituutio on jatkuvasti vähentynyt. Tämä on otettava huomioon Venäjän rahapolitiikassa.

Asiasanat: valuuttasubstituutio, siirtymätaloudet, dollarisaatio

1 Introduction

Currency substitution, the use of foreign money in financing transactions between domestic residents, is commonly found in emerging market economies. Transition economies often experience an initial period of hyperinflation and financial sector instability as once regulated prices become subject to market forces. Under such inflationary conditions, money loses its ability to perform some of its traditional functions, particularly its function as a store of value. Domestic residents respond by holding substitute currencies offering stable purchasing power; businesses write contracts in foreign currencies to ensure the amount they receive corresponds more or less to the value of the goods or services delivered. In many transition economies, the dollar has emerged as the choice of substitute currency and therefore a common phenomenon in economies at the early stages of transition is partial dollarization – the ubiquitous use of the US dollar in private transactions as a unit of account, a medium of exchange and store of value.

Currency substitution, whatever form it takes, has important implications for the conduct of monetary policy. When such substitution is *de facto*, the velocity of money becomes unstable as domestic residents switch between domestic and foreign currencies, and makes it impossible for the domestic monetary authority to implement their monetary targets effectively. Feige, Faulent, Šonje and Šošić (2000) suggest that the effective money supply can be much larger than the domestic money supply when currency substitution is taking place. Moreover, extensive and volatile dollarization impairs the central bank's ability to monitor and regulate the money supply. Indeed, currency substitution generally hampers the ability of the monetary authorities to implement stabilization programmes, because, as Balino et al. (1999) argue, the availability of foreign currency deposits limits the ability of the central bank to control interest rates. In the worst cases, an inability to stabilize the economy encourages further currency substitution and complicates challenges already facing a central bank struggling to establish some degree of credibility.

Currency substitution may threaten the ability of a government to finance its budget deficit since foreign currency holdings by the private sector provide no seignorage revenue. Bufman and Leiderman (1992), for example, demonstrate that small increases in dollarization resulted in large seigniorage losses for the state of Israel.

Currency substitution can also preclude a government from using an inflationary tax to finance its expenditure programmes as the spending power is limited by the willingness of domestic residents to hold domestic currency. Further, foreign currency cash transactions can encourage tax evasion and facilitate participation in the underground economy. Such behaviour weakens the government's budgetary position, leaving it to choose between larger budget deficits or spending cuts. Shifting economic activity to the underground economy may also seriously impair the quality of macroeconomic information available to policymakers.

Finally, inflation targeting regimes, like those commonly used in transition economies, depend on the monetary authority's ability to provide accurate forecasts to guide policy adjustments. Currency substitution adds unwelcome uncertainty to inflation measurement. Failure to forecast inflation accurately, in turn, reduces the likelihood the target will be hit. Again, the monetary authorities lose credibility, while the costs of fighting inflation are increased.

Several studies address the problem of currency substitution and dollarization in the Russian economy, most notably Brodsky (1997), Buchs (2000), Friedman and Verbetsky (2001), and Oomes and Ohnsorge (2005). Our study differs from these papers in that we look for both currency substitution *per se* and asset substitution. Moreover, we limit our analysis to the period following Russia's 1998 financial crisis, and consider several events in the post-crisis period that may have affected dollarization.

The rest of the paper is organized as follows. Section 2 discusses different concepts of currency substitution and the different ways in which it can be measured. Section 3 gives a brief survey of the existing literature in the field. Section 4 discusses contemporary approaches towards modelling currency substitution and outlines the approach we use in this paper. Section 5 gives a brief overview of developments in the financial sector in Russia during the period 1999–2005, as well as description of the data employed in this study. Section 6 presents a discussion of the results and section 7 concludes.

2 Definition and measurement of currency substitution

Students of currency substitution and dollarization apply a range of definitions to these terms. McKinnon (1985), for example, distinguishes between direct currency substitution, where a foreign currency acts as a means of payment, and indirect currency substitution, where investors switch between non-monetary financial assets denominated in different currencies. Cuddington (1989) and Calvo and Vegh (1992) restrict their definition of currency substitution to the use of foreign currency in the role of medium of exchange. When the foreign currency assumes other functions of money, i.e. store of value and unit of account, they apply the broader term dollarization. Calvo and Vegh (1992) and Sahay and Vegh (1995) draw a distinction between currency substitution and asset substitution, using the latter to describe substitution between interest-bearing assets denominated in foreign and domestic currencies. Asset substitution is therefore treated as part of the dollarization process.

Some authors consider both substituting and substituted currencies. A substituting currency is the stable currency replacing the unstable domestic currency, and the substituted currency is the domestic currency being replaced. Komarek and Melecky (2003) go so far as to distinguish between locally and globally substituting and substituted currencies. They identify the US dollar, the Deutschemark, the Swiss franc and the Japanese yen as global substituting currencies. Different estimates of the amount of cash dollars held outside the US range from 30% in 1996 (Doyle 2000) to 50% in 2001 (Feige, 2003), while for the Deutschemark, the cash circulation outside of Germany in 1996 was 69% of the total Deutschemark cash circulation (Doyle 2000). Examples of locally substituting currencies are the British pound and the French franc. Interestingly, some currencies of transition economies might also function as a substituting currency. Komarek and Melecky (2003) further suggest that this is the case with the Czech koruna for some of the post-socialist countries. The Russian ruble clearly played the same role in 1992–1993 for all countries emerging from the former Soviet Union with the exception of the Baltic States. The relatively stable Russian ruble continues to be the substituting currency for the Belarus ruble.

Most of the literature on currency substitution and dollarization deals with asset substitution rather than with currency substitution per se due to the lack of readily available data on cash holdings of foreign currencies for most economies (e.g. Us, 2003; Komarek and Melecky, 2003; Heimonen 2001; and Sarajevs, 2000.) Some authors (e.g. Feige, 2003;

Friedman and Verbetsky, 2001) construct their own estimates of cash holdings of substituting foreign currencies. Similarly, central banks of several transition economies now publish their own estimates of cash holdings of foreign currency along with transactions involving cash foreign currency conducted via the banking system. These changes have facilitated research on currency substitution per se (Mongardini and Mueller, 1999).

The current literature employs three major measures of currency substitution. The first is currency substitution measured as the ratio of residents' foreign currency deposits to deposits denominated in domestic currency (Vetlov, 2001; Komarek and Melecky, 2003). The second considers currency substitution as the ratio of residents' foreign deposits to the M2 monetary aggregate representing the domestic broad money supply (Mongardini and Mueller, 1999; Sarajevs 2000; Vetlov, 2001, Us, 2003). The third is a measure of currency substitution as the ratio of residents' foreign deposits to the sum of residents' foreign deposits and deposits denominated in domestic currency (Us, 2003; Mongardini and Mueller, 1999). Not surprisingly, most measures are defined for asset substitution rather than currency substitution per se due to the above-mentioned data availability problem. Similar approaches can, however, be employed for measuring the scale of currency substitution. Dollarization can also be measured in a similar way provided data on both currency substitution and asset substitution are available. In this study, data availability enables us to use two measures of currency substitution, two measures of asset substitution and two measures of dollarization (see section 5).

3 Literature review

Recent literature in the field of currency substitution addresses the issue for both developed economies (e.g. Mizen and Pentecost 1994; de Vrie, 1988) and emerging economies, including a vast body of work on literature on Latin American countries (e.g. Rodriguez and Turner, 2003; Savastano, 1996; Gruben and Welch, 1996; Marquez, 1987; Melvin, 1988, 1989). The introduction of the euro also prompted a revival of interest in currency substitution in developed economies. Yildirim (2003) studies currency substitution defined as cross-border deposits between five EU member states (France, Germany, Italy, the Netherlands and the UK) and finds that the degree of currency substitution based on this definition is relatively high, while the joint money demand function is relatively stable compared

with individual country money demand functions. Work by de Freitas (2003, 2004) suggests that US long-term interest rates play a significant role in the European money demand relationship. This result holds for different combinations of variables forming the vector auto-regressive system and suggests that currency substitution vis-à-vis the US dollar may be an important factor influencing ECB monetary policy.

A number of studies address currency substitution in Turkey, an EU candidate country with relatively high inflation. Selçuk (1997) finds a relatively substantial and persistent degree of substitution of the Turkish lira by both the US dollar and the Deutschmark. Us (2003) also finds strong evidence of substitution of the Turkish lira by the US dollar – a rational response of asset-holders to Turkish inflation.

The literature also treats currency substitution and its consequences for the EU accession countries. Melecky (2002) and Komarek and Melecky (2003) conclude that the presence of asset substitution in the Czech banking system and the presence of capital mobility in the Czech Republic indicate substitution of the Czech koruna for both the US dollar and the Deutschmark.

As longer and more accurate time-series data have become available, more thorough analyses of currency substitution in the transition economies have become possible. Aarle and Budina (1995) found evidence of currency substitution during transition in Hungary, Poland, the Czech Republic, Bulgaria and Romania. In most cases, currency substitution caused a permanent shift in the demand for real money balances during the reform process. Sahay and Vegh (1995) perform a wider study of dollarization in 15 transition economies during the period 1990–1994. Korhonen (1996) investigates currency substitution in Lithuania in the early 1990s, while Mongardini and Mueller (1999) report on currency substitution in the Kyrgyz Republic in the period 1993–1998. In 2000–2001, works addressing the issue of currency substitution for the three Baltic states were conducted under the aegis of BOFIT. They include the study of Sarajevs (2000) on the short-run and long-run dynamics of currency substitution in Latvia, a discussion by Heimonen (2001) on the situation in Estonia, and Vetlov's (2001) investigation of dollarization in Lithuania during the period 1992–2000. These studies all confirm the presence of currency substitution during the transition process.

Russia, the largest transition economy, has been the subject of extensive research on currency substitution and dollarization. Brodsky (1997) was the first to report results on currency substitution in Russia. He identified a relationship between the degree of dollari-

zation and the difference between the growth rate of the exchange rate and the inflation rate for the period 1994–1996. However, these results can only be regarded as tentative since the period investigated was relatively short and the quality of data available for the period not entirely reliable. Buchs (2000) looks at the period 1992–1997 and concludes that total internal dollarization reached 42% of broad money in 1997 (including foreign cash in circulation). An investigation by Friedman and Verbetsky (2001) tested currency substitution in Russia using Central Bank of Russia (CBR) estimates of actual cash foreign currency holdings for the period 1995–2000. They find that the elasticity of currency substitution in that time varied between 2 and 3, implying that the US dollar and the ruble were "good substitutes in Russia for providing liquidity services". Their results also bolster the hypothesis that foreign currency is a determinant of the representative consumer's utility function (and again implying strong substitution between the ruble and the US dollar). A more recent study of money demand and inflation in the dollarized Russian economy by Oomes and Ohnsorge (2005) concludes that the high level of foreign currency cash holdings in Russia is responsible for the instability of short-run and long-run money demand functions.

The overwhelming conclusion of investigations into currency substitution in Russia is that the phenomenon has been widespread, especially during periods of relatively high inflation. It appears to be a major factor in explaining instability in money demand functions. The present research, which focuses on Russia's post-crisis period (1999–2005), contributes to the ongoing debate on currency substitution by examining the issue with several measures of currency substitution.

4 Approaches to studying currency substitution

Two approaches dominate the modelling of currency substitution and its empirical estimation. While both adopt the methodology of portfolio balance models, the first approach sequences the actions of economic agents into two stages. In stage 1, agents choose an optimal allocation of their resources between monetary and non-monetary assets. In stage 2, agents select the optimal distribution of monetary assets in their portfolio between different currencies. This approach was first suggested by Miles (1978), who showed that if the money service function of economic agents has constant elasticity of substitution, then the re-

lative demand for domestic currency (M) and foreign currency (M^f) is described by the following equation:

$$\log\left(\frac{M}{eM^f}\right) = \alpha_0 + \alpha_1(\log(1+i^f) - \log(1+i)), \quad (1)$$

where e is the nominal exchange rate, and the coefficient α_1 is the elasticity of currency substitution.

A subsequent modification of this approach, suggested by Bordo and Choudri (1982), included the level of output in the maximization problem of a representative agent. The approach was further developed to account for dynamic settings. Imrohoroglu (1994) proposed a stochastic inter-temporal currency substitution model and estimated consumer preferences using the Generalized Method of Moments approach. A similar method with modifications in the formulation of the theoretical model was used by de Vries (1988), Selçuk (1997) and Friedman and Verbetsky (2001). An attractive feature of this approach is that it allows for the estimation of other effects besides currency substitution per se. For example, Friedman and Verbetsky (2001) use this approach to estimate the effects of currency substitution, seigniorage levels and welfare.

The second approach is a static two-period portfolio balance model. This type of model assumes that a representative agent allocates resources between four types of asset: domestic currency, foreign currency, domestic government bonds and foreign government bonds. In this approach, the demand functions for domestic and foreign real money balances, and for domestic and foreign bonds, usually take the following form:

$$\frac{M}{P} = f_1(\overset{+}{Y}, \overset{-}{i}, (i^f + \overset{-}{\Delta e^e}), \overset{-}{\Delta e^e}, \overset{-}{\pi}) \quad (2)$$

$$\frac{eM^f}{P} = f_2(\overset{+}{Y}, \overset{-}{i}, (i^f + \overset{-}{\Delta e^e}), \overset{+}{\Delta e^e}, \overset{+}{\pi}) \quad (3)$$

$$\frac{B}{P} = f_3(\overset{-}{Y}, \overset{+}{i}, (i^f + \overset{-}{\Delta e^e}), \overset{-}{\Delta e^e}, \overset{-}{\pi}) \quad (4)$$

$$\frac{eB^f}{P} = f_4(\overset{-}{Y}, \overset{-}{i}, (i^f + \overset{+}{\Delta e^e}), \overset{-}{\Delta e^e}, \overset{-}{\pi}), \quad (5)$$

where Δe^e is expected depreciation of local currency, π is domestic inflation, B is the nominal value of domestic bonds and B^f is the nominal value of foreign bonds. This approach is sometimes modified to estimate currency substitution as a function of the underlying variables. In this case, currency substitution (CS) is modelled as:

$$CS = f(\overset{-}{Y}, \overset{-}{i}, (i^f + \overset{+}{\Delta e^e}), \overset{+}{\Delta e^e}, \overset{+}{\pi}) \quad (6)$$

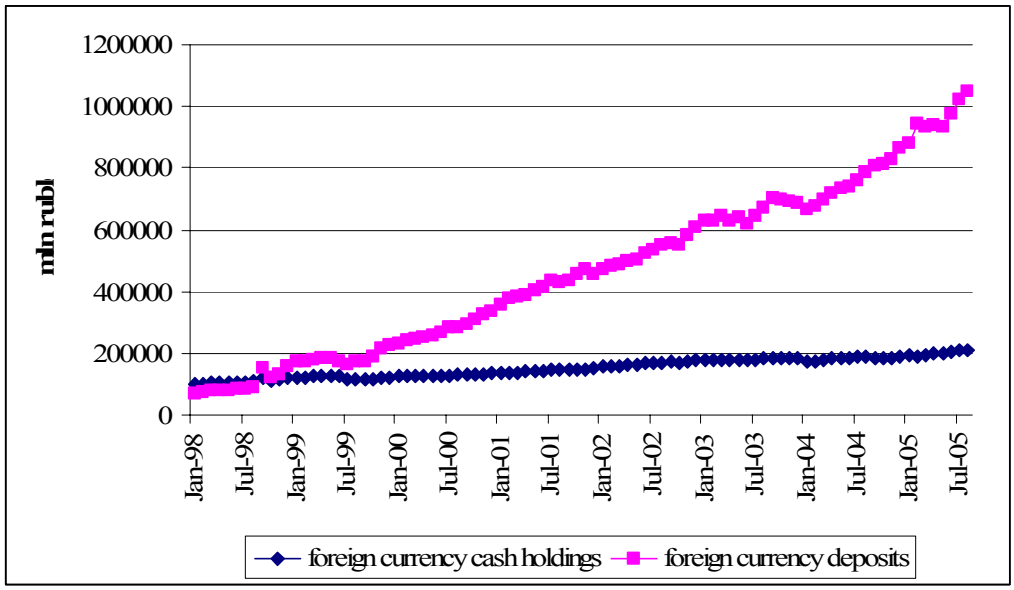
This is the approach used by Mongardini and Mueller (1999), Us (2003), Komarek and Melecky (2003), and Rodriguez and Turner (2003). It is also the approach adopted here as it offers several advantages. First, it imposes general assumptions on the behaviour of representative economic agents and allows for a straightforward interpretation of the results. Second, the model specification omits bonds, which is appropriate for our analysis of Russia. Following the default on government bonds in August 1998, economic agents were much less inclined to buy domestic government bonds and currency controls made it difficult to buy foreign government bonds.

5 Stylized facts about the Russian economy and data description[1]

In the early stages of transition, Russia experienced chronic inflation along with an unstable and undeveloped financial system. This gave domestic economic agents an incentive to hold foreign currency in preference to rubles. The US dollar became a unit of account and a widespread means of payment, especially in the underground economy. It was also the most readily available and reliable asset serving as a store of value. The 1995 Law on National Currency prohibited the use of any foreign currency as a unit of account or means of payment. However, in practice this did not prevent the US dollar serving as a unit of account, since an artificial unit of account, called a 'conditional unit', had been created. This conditional unit, which can be declared by sellers equal to a certain amount of rubles, tracks the ruble/US dollar nominal exchange rate. Indeed, the conditional unit of account is still in use today with approximately equal shares of US dollar and euro serving as the underlying currency.

[1] The data used in the study are posted at http://www.cbr.ru and http://www.gks.ru. The authors will also provide them upon request.

Figure 1 Dynamics of foreign currency cash holdings and foreign currency deposits in 1998–2005



Source: Central Bank of Russia monthly bulletin of banking statistics (1998–2005)

In August 1998, the Russian economy suffered a large-scale financial crisis involving default on government bonds, depreciation of the ruble on the foreign exchanges by at least 70%, an increase in the rate of inflation and serious liquidity problems in the commercial banking system. These events impaired the ability of the authorities to implement a credible monetary policy and establish confidence in the domestic currency. These developments did nothing to lessen the preference of domestic residents for foreign currency. Only the CBR's introduction of temporary measures aimed at constraining foreign currency operations by the commercial banks prevented a sharp increase in foreign currency holdings by Russian residents (see Fig. 1). On the other hand, growth in foreign currency deposits took off, well outpacing the relatively slow and steady growth of foreign currency cash holdings.

Following the 1998 crisis, the CBR adopted an explicit inflation target as an anchor for monetary policy. This move initiated a 'dirty float' regime for the exchange rate and attempts to institute predictable monetary policy, including the publication of a policy paper, 'General directions of a unified state monetary policy' in 1999. Russia subsequently saw the return of a somewhat stable nominal exchange rate; inflation fell and ruble depreciation was modest during 1999–2002. Since 2002, rising oil prices have contributed to an increase in the central bank's holdings of net foreign assets, causing a nominal appreciation of the ruble against the US dollar. The rate of inflation also continued to fall and this, along with improved stability of the banking system, resulted in a shift in consumer preferences

from foreign currency cash and deposit holding in favour of domestic currency. As a consequence, there was a decrease in currency substitution ratios (see Figures 2-4).

We have chosen January 1999–August 2005 as our period of investigation. We start with January 1999 as the immediate consequences of the financial crisis had passed and we escape the problem of outliers.[2] The end of the period reflects the most recent data available.

We use the following monthly data for the period January 1999–August 2005:

- flow of foreign currency in the banking system (CBR), including net purchases of foreign currency, demand and long-term deposits and cash withdrawals from currency accounts;
- M0 (M_0^R) and M2 (M_2^R) monetary aggregates in domestic currency;
- weighted average interest rates on deposits in domestic (i) and foreign (i^f) deposits;
- average monthly nominal exchange rate between ruble and US dollar;[3]
- nominal total trade (Y) as approximation for the monthly output level; and
- rate of inflation measured as the monthly change in the CPI.

Using the data above, we calculate the following:

- M_0^F, the sum of net foreign currency purchases, demand deposits denominated in foreign currency, cash withdrawal from deposits denominated in foreign currency and the initial estimate of the foreign currency cash holdings as of December 1998;
- M_2^F, all deposits denominated in foreign currency with the exception of demand deposits; and
- Δe^e, the log-difference of the average monthly nominal exchange rate between the ruble and the US dollar.

We only consider the exchange rate between the ruble and the US dollar as there are no data available on the allocation of different foreign currency holdings and deposits. Moreover, we see no reasonable way to estimate weights for the possible weighted average nominal exchange rate of the ruble. In any case, the US dollar has remained the major reference foreign currency in Russia. This is corroborated by e.g. Dorbec (2005). Although the gradual ascendance of the euro is not in dispute, we should remember that the cash euro had yet to be introduced for about half of the examined period, and therefore unavailable to economic agents in Russia for currency substitution purposes.

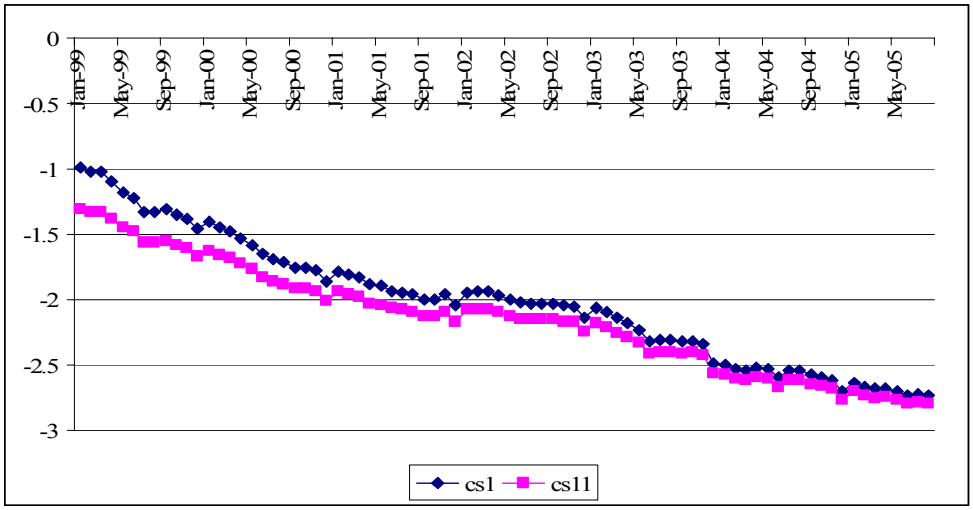
We construct the following measures for currency substitution, asset substitution and dollarization:

[2] The initial ambition to start in 1994 or 1995 and to compare results for the pre-crisis and post-crisis periods was abandoned due to absence of coherent data set.
[3] Authors' calculations based on daily CBR data.

- $CS1 = \frac{M_0^F}{M_0^R}$ and $CS11 = \frac{M_0^F}{M_0^R + M_0^F}$, alternative measures of currency substitution for comparing the relative importance of the aggregates that can be termed as true money, i.e. readily available for transaction purposes, in both domestic and foreign currencies;
- $CS2 = \frac{M_2^F}{M_2^R}$ and $CS22 = \frac{M_2^F}{M_2^R + M_2^F}$, alternative measures of asset substitution for comparing the substitution between the monetary assets denominated in both domestic and foreign currencies;
- $CS3 = \frac{M_0^F + M_2^F}{M_0^R + M_2^R}$ and $CS3 = \frac{M_0^F + M_2^F}{M_0^R + M_2^R + M_0^F + M_2^F}$, alternative measures of dollarization, referring to the ratios of money in all its functions.

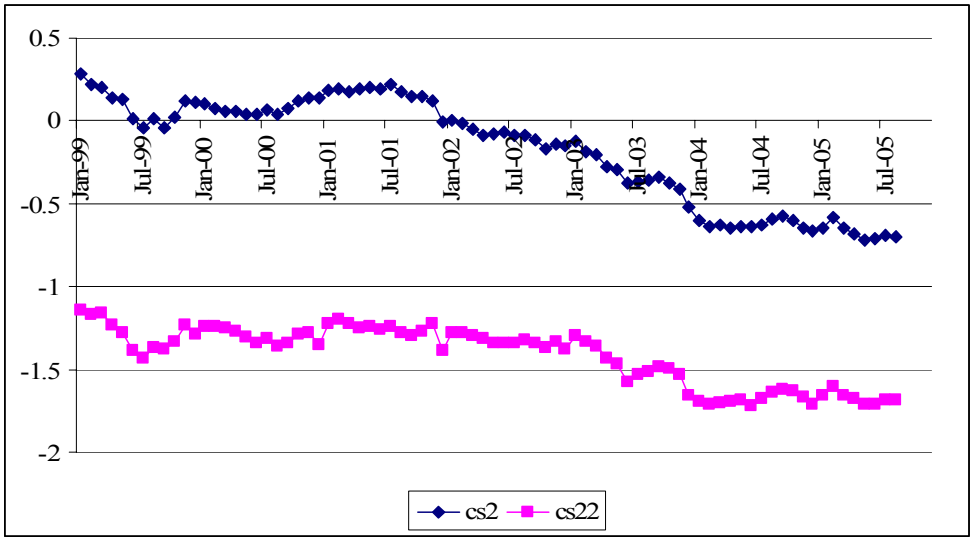
To make the estimation of the model of the type represented by equation (6) workable, we take logarithms of our currency substitution, asset substitution, and dollarization measures and of nominal total trade. Variables in logarithms are denoted by lower case symbols. The dynamics of the alternative measures of currency substitution, asset substitution and dollarization in logarithms are presented in Figures 2-4.

Figure 2 Dynamics of the two measures of currency substitution



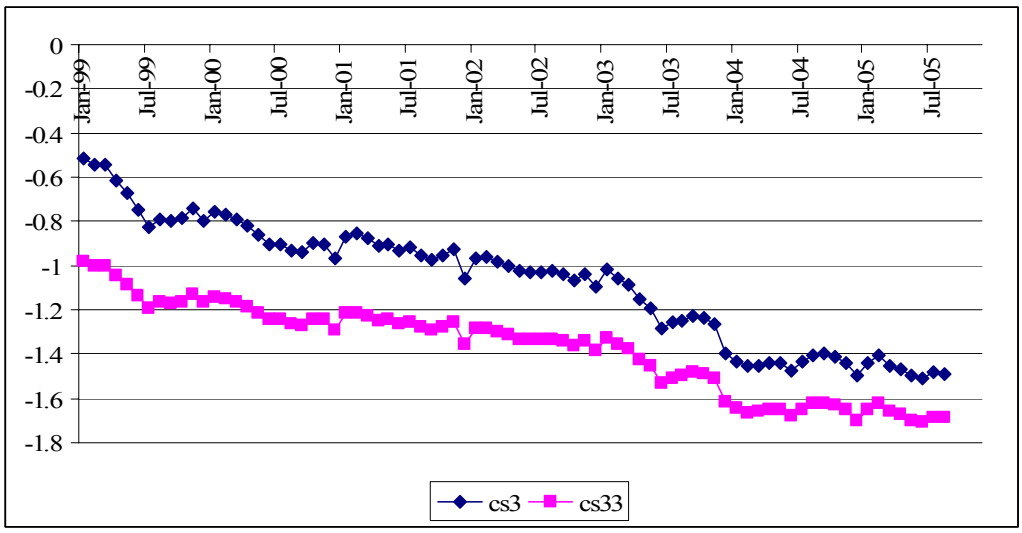
Source: Authors' calculation on the basis of the Central Bank of Russia monthly bulletin of banking statistics (1998–2005)

Figure 3 Dynamics of the two measures of asset substitution



Source: Authors' calculation on the basis of the Central Bank of Russia monthly bulletin of banking statistics (1998–2005)

Figure 4 Dynamics of the two measures of dollarization



Source: Authors' calculation on the basis of the Central Bank of Russia monthly bulletin of banking statistics (1998–2005)

As can be seen from the above figures, all measures of currency substitution, asset substitution and dollarization exhibit a decreasing trend indicating the process of de-dollarization of the Russian economy. The alternative measures have very similar dynamics and might be expected to produce similar estimation results for the econometric models. as a unit of account.

6 Results and discussion

Our preliminary analysis demonstrates all variables are subject to a seasonality pattern, so following the approach adopted in Mongardini and Mueller (1999) and Us (2003), all data are seasonally adjusted at the first stage by regressing variables on the twelve monthly dummy variables and taking residuals from the corresponding regressions. Before estimating the underlying model (6) for different measures of currency substitution, all variables are checked for the order of integration with ADF tests. The results are summarized in Table 1. Variables *cs2*, *cs22*, *cs3*, *cs33* and *y* are found to be integrated of order 1, *cs1* and *s11* were found to be trend-stationary, and i^f, i, Δe^e, π are found to be stationary.

Table 1 Results of ADF tests

Variable	t-stat	Crit. value 1%	Crit. value 5%	Crit. value 10%	Lags, c, t
i^f	-2.108623	-2.5950	-1.9448	-1.6181	7
i	-3.240096	-3.5297	-2.9048	-2.5896	12, c
Δe^e	-3.067063	-2.5973	-1.9452	-1.6183	12
π	-3.625235	-2.5950	-1.9448	-1.6181	6
y, level	-1.236650	-4.0990	-3.4769	-3.1657	12, c, t
y, 1 dif.	-3.249154	-3.5297	-2.9048	-2.5896	11, c
cs1, level	-3.774314	-4.0990	-3.4769	-3.1657	12, c, t
cs11, level	-3.892827	-4.0990	-3.4769	-3.1657	12, c, t
cs2, level	-1.936758	-4.0819	-3.4688	-3.1610	3, c, t
cs2, 1 dif.	-4.068672	-3.5188	-2.9001	-2.5871	3, c
cs22, level	-2.641398	-4.0990	-3.4769	-3.1657	12, c, t
cs22, 1 dif.	-3.086714	-3.5226	-2.9017	-2.5879	6, c
cs3, level	-2.403768	-4.0990	-3.4769	-3.1657	12, c, t
cs3, 1 dif.	-4.079642	-3.5226	-2.9017	-2.5879	6, c
cs33, level	-2.422842	-4.0990	-3.4769	-3.1657	12, c, t
cs33, 1 dif.	-3.935685	-3.5226	-2.9017	-2.5879	6, c

We next check for cointegration between the measures of asset substitution and nominal total trade and measures of dollarization and nominal total trade using the Johansen reduced rank cointegration test. All relevant pairs are found to be cointegrated. The results are summarized in Table 2.

When estimating models of the type suggested by equation (6), the ARDL approach is used. The estimated model has the following form:

$$csj_t = \alpha + \beta cs_{t-1-L} + \gamma i_{t-L} + \delta i^f_{t-L} + \lambda \Delta e^e_{t-L} + \nu \pi_{t-L} + \varphi y_{t-L} + \varepsilon \,, \qquad (7)$$

where L is the maximum lag identified by the Akaike information criterion. We initially use six lags, since a larger number of lags results in parameter estimates that are imprecise and less robust. Insignificant lags were further excluded if this did not result in autocorrelation of the residuals and an increase in the Akaike information criterion. Generally, we expect negative signs for the interest rate on domestic deposits and nominal total trade indicating increasing opportunity costs when i increases and increasing welfare and stability of the domestic economy when y increases. We expect positive signs for the interest rate on foreign deposits, expected depreciation (approximated by last period's actual depreciation). A positive sign for inflation indicates increased currency substitution when i^f increases and increasing opportunity costs of holding domestic money when Δe^e or π increases. The use of last period's change in the exchange rate and last period's inflation rate as proxies for Δe^e and π^e is justified by the usual assumption of rational expectations.

Following Mongardini and Mueller (1999), we include in our check for the hysteresis effect a ratchet variable in all equations. The ratchet variable is defined as the maximum level of the corresponding currency substitution indicators from the beginning of the sample period until one period before the current observation. However, since all measures of currency substitution exhibit a declining trend, the ratchet effect variable (as well as the intercept term) is not significant in any of the equations. Accordingly, all results are given for specifications of our model without the ratchet effect variable.

Table 2 Results of cointegration Johansen reduced rank tests

Cointegration check for *cs2* and *y*				
Hypothesized No. of CE(s)	Eigenvalue	Trace statistics	Crit. value 5%	Crit. value 1%
None **	0.268514	28.15124	19.96	24.60
At most 1	0.051548	4.075143	9.24	12.97
**(**) denotes rejection of the hypothesis at the 5%(1%) level*				
Trace test indicates 1 cointegrating equation(s) at both 5% and 1% levels				
Cointegration check for *cs22* and *y*				
Hypothesized No. of CE(s)	Eigenvalue	Trace statistics	Crit. value 5%	Crit. value 1%
None **	0.313911	35.33978	19.96	24.60
At most 1	0.120240	8.967411	9.24	12.97
**(**) denotes rejection of the hypothesis at the 5%(1%) level*				
Trace test indicates 1 cointegrating equation(s) at both 5% and 1% levels				
Cointegration check for *cs3* and *y*				
Hypothesized No. of CE(s)	Eigenvalue	Trace statistics	Crit. value 5%	Crit. value 1%
None **	0.333443	31.52194	19.96	24.60
At most 1	0.062789	4.344755	9.24	12.97
**(**) denotes rejection of the hypothesis at the 5%(1%) level*				
Trace test indicates 1 cointegrating equation(s) at both 5% and 1% levels				
Cointegration check for *cs33* and *y*				
Hypothesized No. of CE(s)	Eigenvalue	Trace statistics	Crit. value 5%	Crit. value 1%
None **	0.319401	29.92966	19.96	24.60
At most 1	0.060051	4.149296	9.24	12.97
**(**) denotes rejection of the hypothesis at the 5%(1%) level*				
Trace test indicates 1 cointegrating equation(s) at both 5% and 1% levels				

The estimated results of our models for the two alternative measures of currency substitution are presented in Table 3. The estimation results for both measures of currency substitution are remarkably similar. After excluding the insignificant variables from the right-hand side, both models contain the same set of explanatory variables. All explanatory variables have similar significant coefficients. Both regressions resulted in high R^2 and adjusted R^2 values indicating a high goodness of fit for our models. There is no autocorrelation in the residuals and no heteroscedasticity is detected. Both models are parsimonious in terms of the number of parameters included.

In both regressions, the coefficient of the lagged measure of currency substitution is about 0.97, reflecting the tendency for currency substitution to decline during the period investigated. Most coefficients for the explanatory variables have the expected signs. The coefficient for inflation is positive, indicating that rising inflation is associated with domestic economic agents switching assets into a more stable foreign currency. This finding is in line with the declining inflation and declining currency substitution that characterise the period under review. The a negative sign of the coefficient of the output proxy also makes sense intuitively; as the economy grows and output increases, we would expect confidence in the domestic currency to increase. The coefficient of the first lag of the expected proxy for currency depreciation is, as expected, positive indicating that the higher the expected depreciation of the domestic currency, the higher the degree of currency substitution. However, the coefficient of the second lag of the expected proxy for currency depreciation has an unexpected negative sign. This might be indicative of agents paying attention not only to a change in the exchange rate during the last period, but also to the speed of such change. Therefore, we also test separately for the rate of change of the exchange rate. Our results are presented in Table 4.

Table 3 Estimation results for the models of currency substitution alternative measures

	Model for cs1	Model for cs11
csj(-1)	0.972873 (0.0000)	0.977473 (0.0000)
π	1.628475 (0.0363)	1.309993 (0.0475)
Δe^e (-1)	0.956671 (0.0021)	0.790282 (0.0029)
Δe^e (-2)	-0.490699 (0.0135)	-0.402048 (0.0179)
d*y*	-0.985113 (0.0000)	-0.846350 (0.0000)
R-squared	0.996251	0.996397
Adjusted R-squared	0.996045	0.996199
Included observations	78	78
LM test for residual autocorrelation (12 lags)	0.933535 (0.520299)	0.904296 (0.547825)
White heteroscedasticity test	1.739476 (0.085736)	1.520142 (0.110129)

P-value given in parentheses

Testing our alternative models of currency substitution yields remarkably similar results and all coefficients show the expected signs. In both models, the coefficient of the previous value of our measure of currency substitution is quite close to unity, confirming that the process of change is largely inert. All measures of currency substitution are also found to depend heavily on inflation in the previous period (with an elasticity of 1.3) and on the proxy for the monthly output level (with an elasticity of about -1). This implies that a continuation of the declining trend in currency substitution depends heavily on continuous disinflation and/or continuing economic growth. The dependency of currency substitution on the rate of change of the exchange rate is not as impressive (about 0.4). Both models omit interest rates on deposits denominated in domestic or foreign currency, reflecting the view that cash foreign currency is kept mostly for transaction purposes (and in line with our definition of currency substitution in section 2).

Table 4 Estimation results of alternative model specification for the models of currency substitution alternative measures

	Model for cs1	Model for cs11
csj(-1)	0.982886 (0.0000)	0.986704 (0.0000)
π	1.365905 (0.0825)	1.108074 (0.0977)
$\Delta\Delta e^{e}$ (-1)	0.433795 (0.0312)	0.352448 (0.0403)
D*y*	-1.001195 (0.0000)	-0.859083 (0.0000)
R-squared	0.995984	0.996397
Adjusted R-squared	0.995821	0.996199
Included observations	78	78
LM test for residual autocorrelation (12 lags)	0.956693 (0.498736)	0.898597 (0.553161)
White heteroscedasticity test	1.851476 (0.068734)	2.176853 (0.043749)

P-value given in parentheses

Since both models are very similar, it is not surprising that they have similar predictive powers (see Fig. 5). Hence, we cannot discriminate between the two measures of currency substitution.

Figure 5 Actual, fitted and residual values for the estimated models of currency substitution

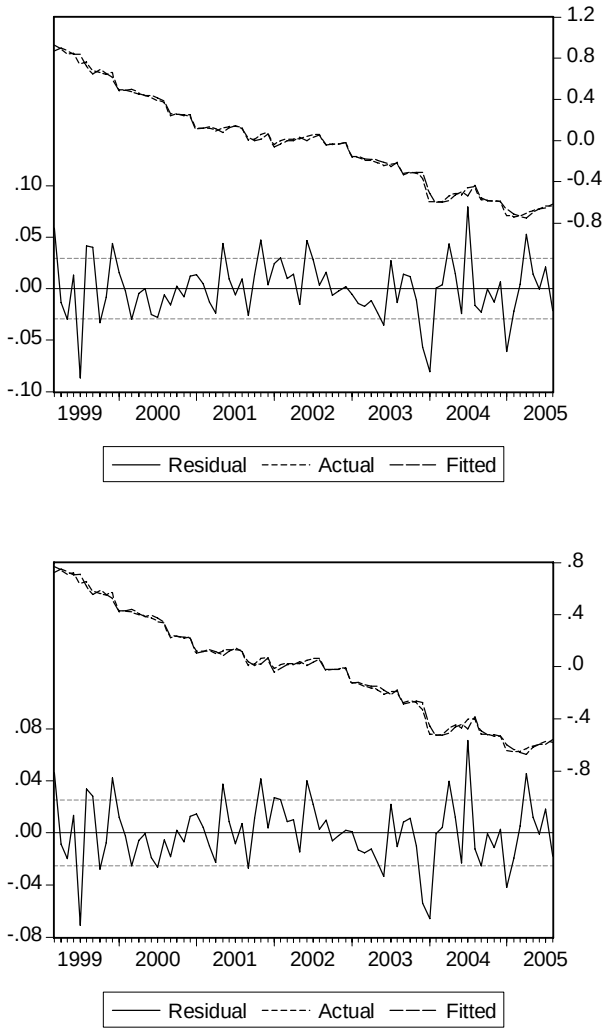


Table 5 gives the estimated results for our two alternative measures of asset substitution. Again, our models are similar, but the degree of similarity is not so marked as that between our alternative models of currency substitution. Both models of asset substitution have relatively high values for R^2 and adjusted R^2. In both cases, no sign of heteroscedasticity and residual autocorrelation is found. Since the measures of asset substitution and nominal total trade are found to be integrated of order 1 and cointegration exists between our measures of asset substitution and nominal total trade, we take absolute levels for our data and check for stationarity to avoid spurious regressions. The models tested are less parsimonious in terms of the number of parameters as compared to our models of currency substitution (11 and 12 against 5 and 5 for our currency substitution regressions).

The coefficient of the lagged dependent variable differs slightly in the two cases; it is larger for the model for our *cs*2 measure (0.93 compared to 0.85). The value of both coefficients reflects the tendency for asset substitution to decline throughout the period studied. Most variables in the two regressions have the expected signs. However, for our *cs*2 model, the signs of the coefficients of the third lag of the interest rate on foreign currency deposits, the fourth lag of the proxy for expected currency depreciation and the fourth lag of the proxy for output differ from the expected sign. These theoretically incorrect signs could reflect portfolio readjustments due to expected volatility in the behaviour of these explanatory variables.

For our *cs*22 model, the coefficients with theoretically incorrect signs are largely the same as for our *cs*2 model, i.e. the third lag of the interest rate on foreign currency deposits, the fourth lag of the proxy for the expected ruble depreciation on the foreign exchanges and the first lag of the proxy for output. As in the previous case we can assume that agents are either influenced by changes in the relevant variables or, with respect to interest rates, the dependency can be on the interest rate differential between interest rates on domestic and foreign currency deposits.

Table 5 Estimation results for the models of asset substitution alternative measures

	Model for cs2	Model for cs22
csj(-1)	0.932872 (0.0000)	0.849071 (0.0000)
i^f (-1)	3.603382 (0.0016)	1.218352 (0.0453)
i^f (-3)	-3.685475 (0.0019)	-2.107590 (0.0010)
I	-0.850605 (0.0006)	-0.516267 (0.0005)
i (-4)	--	-0.331132 (0.0292)
π (-1)	2.619744 (0.0010)	1.160844 (0.0101)
π (-4)	2.204443 (0.0015)	1.155717 (0.0043)
Δe^e	1.398343 (0.0000)	0.606565 (0.0003)
Δe^e (-3)	--	0.330461 (0.0390)
Δe^e (-4)	-1.052854 (0.0000)	-0.354923 (0.0033)
Y	-0.253999 (0.0005)	-0.407623 (0.0000)
y(-1)	--	0.311243 (0.0000)
y(-3)	-0.204075 (0.0133)	--
y(-4)	0.386588 (0.0000)	--
R-squared	0.993294	0.993952
Adjusted R-squared	0.992262	0.992913
Included observations	76	76
LM test for residual autocorrelation (12 lags)	0.820835 (0.628473)	0.851095 (0.599332)
White heteroscedasticity test	0.960471 (0.524596)	0.715033 (0.812923)
Residuals unit root test	-3.042564 1% critical value (-2.5994)	-2.804198 1% critical value (-2.5994)

P-value given in parentheses.

Accordingly, we test several modifications of the model for asset substitution. The results of the specification providing the most reliable results are reported in Table 6. Because the interest rate differential as an explanatory variable proved to be an unsatisfactory choice, we include the change in the interest rate on foreign deposits over two months as a new

explanatory variable. Furthermore, the rate of change of the exchange rate and the proxy for monthly output appear to be important in decisions about asset substitution by economic agents.

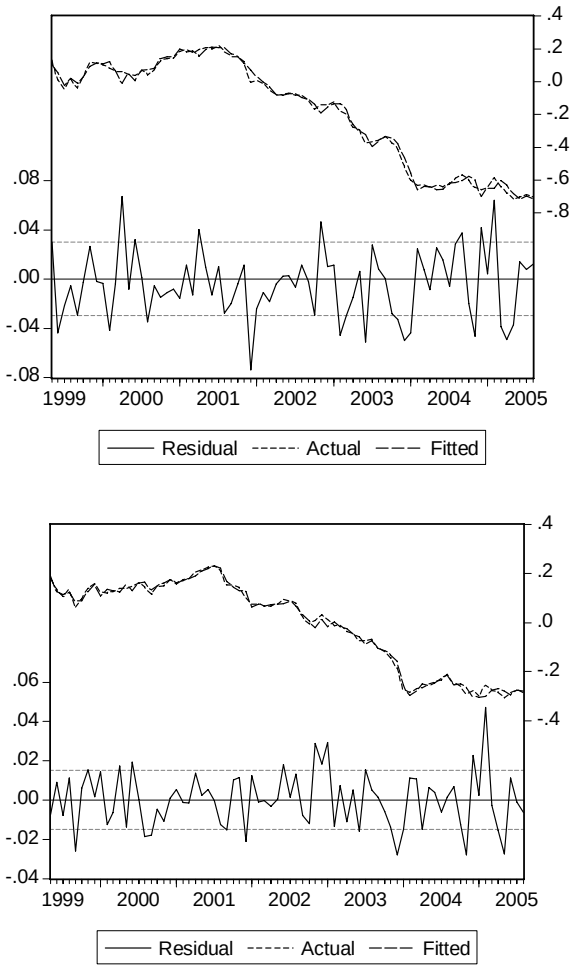
Comparing the models with the new specifications for asset substitution, we see that both models have almost the same number of explanatory variables (11 and 10), and again both demonstrate high dependency on the previous value of our measure of asset substitution (although the degree dependency is much higher for the *cs*2 measure than the *cs*22 measure). This, as in the case for currency substitution, is a sign of serious inertia in this process. In our model of the *cs*2 measure, the dependency on the two-month rate of change in the interest rate on foreign currency deposits is more than twice as high as the *cs22* measure. Given the way the two measures were constructed, this is hardly surprising. Moreover, the magnitude of this coefficient in both models stresses the importance of this factor in the dynamics of asset substitution. The dependency of the interest rate on domestic deposits is not so large in absolute terms in magnitude in both models, and dependency of asset substitution on inflation and exchange rate changes is higher for the *cs*2 model. Our results also show that the proxy for output and its rate of change have a substantially smaller impact on asset substitution as compared with currency substitution.

Table 6 Estimation results for the models of asset substitution alternative measures

	Model for cs2	Model for cs22
csj(-1)	0.964922 (0.0000)	0.861769 (0.0000)
$(i^f - i^f_{-2})$(-1)	4.303759 (0.0001)	1.915360 (0.0007)
I	-0.445961 (0.0382)	--
i (-1)	--	-0.443904 (0.0020)
i (-4)	--	-0.312966 (0.0232)
π (-1)	2.770570 (0.0011)	1.292063 (0.0062)
π (-4)	1.660858 (0.0109)	0.929896 (0.0159)
Δe^e	--	0.688793 (0.0000)
$\Delta\Delta e^e$	1.065979 (0.0006)	--
$\Delta\Delta e^e$ (-1)	0.923214 (0.0040)	--
Δe^e (-2)	0.863638 (0.0018)	--
Δe^e (-3)	1.124788 (0.0000)	0.356611 (0.0027)
Y	-0.039001 (0.0507)	-0.079785 (0.0001)
Δy	--	-0.267630 (0.0000)
Δy(-3)	-0.324292 (0.0002)	--
R-squared	0.992191	0.993634
Adjusted R-squared	0.990990	0.992766
Included observations	76	76
LM test for residual autocorrelation (12 lags)	0.320383 (0.982469)	0.657765 (0.782949)
White heteroscedasticity test	1.044742 (0.432056)	0.722310 (0.786344)
Residuals unit root test	-5.265459 1% critical value (-2.5994)	-6.297811 1% critical value (-2.5994)

P-value given in parentheses.

Figure 6 Actual, fitted and residual values for the estimated models of asset substitution



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Both models have virtually the same goodness of fit and are very close in their forecasting abilities (see Fig. 6). Thus, there is no reason to prefer one model over the other. We note in passing that our models of asset substitution include interest rates on deposits denominated in foreign and domestic currencies as explanatory variables, reflecting their importance in asset substitution.

Table 7 Estimation results for the models of dollarization alternative measures

	Model for cs3	Model for cs33
csj(-1)	0.801928 (0.0000)	0.868667 (0.0000)
i^f (-1)	--	1.523232 (0.0289)
i^f (-3)	-2.393274 (0.0031)	-2.969731 (0.0001)
i (-1)	--	-0.403947 (0.0028)
i (-4)	-0.516515 (0.0000)	--
π (-1)	1.789484 (0.0067)	1.710038 (0.0007)
Δe^e	0.781660 (0.0034)	0.844387 (0.0000)
Δe^e (-1)	0.561151 (0.0430)	--
Δe^e (-4)	--	-0.193659 (0.0384)
Y	-0.615403 (0.0000)	-0.448513 (0.0000)
y(-1)	0.466956 (0.0000)	0.369756 (0.0000)
R-squared	0.991674	0.992455
Adjusted R-squared	0.990817	0.991555
Included observations	76	76
LM test for residual autocorrelation (12 lags)	1.091954 (0.384720)	1.067894 (0.404252)
White heteroscedasticity test	1.706421 (0.070597)	1.764748 (0.064283)
Residuals unit root test	-2.613057 1% critical value (-2.5994)	-3.088470 1% critical value (-2.5994)

P-value given in parentheses.

The results of the models estimated for the alternative measures of dollarization are presented in Table 7. Again the models are quite similar, although not to the same extent as the alternative models for currency substitution. Both models estimated are parsimonious in terms of the number of parameters (8 and 9). In both cases, the goodness of fit is very high with an R^2 of over 0.99 and the residuals demonstrate no signs of autocorrelation or heteroscedasticity. Since cointegration was established for our measures of dollarisation

and nominal total trade, these variables were included as absolute levels into the estimated models and the residuals were checked for stationarity to avoid problems of spurious regression.

The coefficients of the lagged independent variables have values of 0.80 and 0.87, respectively. While the values are less than the R^2 values for our models of currency and asset substitution, the declining trend for dollarisation over the period is clear – de-dollarization occurred at a greater rate than the trend decline for both currency substitution per se and asset substitution. Again, most coefficients have the theoretically predicted signs. The exceptions are the third lag of the interest rate on foreign currency deposits, the fourth lag of the proxy for expected currency depreciation (for *cs*33 model) and the first lag of the proxy for output. Although the explanations for these theoretically incorrect signs are the same as those offered for our previous cases, we nevertheless also perform an alternative specification of our model. The results are reported in Table 8.

The alternative model specification for measures of dollarization proves to be slightly more economical in terms of parameters (7 and 8 versus 8 and 9), and all coefficients have the expected signs. The relatively high value of the lagged coefficient of the dependent variable confirms the high degree of inertia in the process, although it is significantly lower than for the case of asset substitution or currency substitution. As in the case of asset substitution, the highest degree of dependency, shown by the magnitude of coefficients is the two-month rate of change in interest rates on foreign currency deposits. The rate of inflation and the rate of change of the exchange rate also have a significant influence on the measures of dollarization.

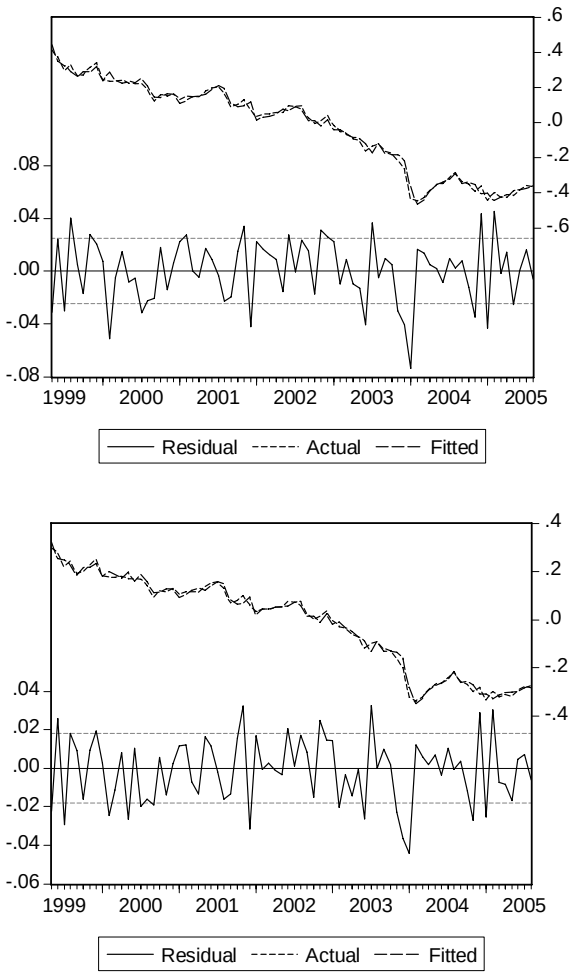
Table 8 Estimation results for the models of dollarization alternative measures

	Model for cs3	Model for cs33
csj(-1)	0.858622 (0.0000)	0.894790 (0.0000)
$(i^f - i^f_{-2})$(-1)	2.589507 (0.0039)	2.075397 (0.0019)
i (-1)	--	-0.373135 (0.0039)
i (-4)	-0.445909 (0.0002)	--
π (-1)	1.248006 (0.0529)	1.544838 (0.0025)
Δe^e	1.043915 (0.0001)	0.816867 (0.0000)
$\Delta\Delta e^e$ (-3)	--	0.293793 (0.0208)
Y	-0.093970 (0.0025)	-0.048631 (0.0188)
Δy	-0.522081 (0.0000)	-0.387345 (0.0000)
R-squared	0.991132	0.991860
Adjusted R-squared	0.990361	0.991022
Included observations	76	76
LM test for residual autocorrelation (12 lags)	0.971125 (0.486510)	0.933053 (0.521456)
White heteroscedasticity test	1.974263 (0.040283)	1.802648 (0.052463)
Residuals unit root test	-5.476338 1% critical value (-2.5994)	-5.470516 1% critical value (-2.5994)

P-value given in parentheses.

As Figure 7 shows, both models have very similar forecasting powers. This, together with very similar measures of R^2 and adjusted R^2 and largely the same coefficients, does not allow us to discriminate between the two models.

Figure 7. Actual, fitted and residual values for the estimated models of dollarization.



Indeed, the general conclusion must be that we cannot discriminate between the alternative measures of currency substitution, asset substitution and dollarization on the basis of the models estimated. Basically, both alternatives for each phenomenon can be used.

7 Conclusions

This paper investigated currency substitution in Russia. Two features of this study should be stressed before comparing our results with those reported in earlier studies of Russia. First, we address the issue of currency substitution in very broad terms, modelling currency substitution *per se*, asset substitution and dollarization. Secondly, the period under study is

the post-crisis period 1999–2005, a time when de-dollarization of the Russian economy began. Our results confirm declining measures of currency substitution per se, asset substitution and dollarization throughout the period.

At the beginning of the period, administrative measures were used to prevent massive currency substitution in the economy with the temporary suspension of operations in foreign currencies by commercial banks. These were imposed as part of a raft of measures designed to stabilize the economy in the aftermath of the currency crisis. As inflation subsided and the ruble stabilized on foreign exchanges, there was less incentive for domestic economic agents to hold foreign currency cash or deposits. The Russian ruble even made nominal gains against the US dollar at the end of 2002.

We calculated six different measures of currency substitution in the broad meaning of the term: currency substitution per se, asset substitution and dollarization. We used two alternative measures of each phenomenon and compared the results. In each case, our results for the two alternatives were remarkably similar, with our models of currency substitution per se showing the highest degree of similarity in their estimated results. All models recorded high R^2 values, revealed no residual autocorrelation or heteroscedasticity, and demonstrated good forecasting abilities. The major factors influencing currency substitution were found to be the rate of inflation and the rate of output change, while for our measures of asset substitution and dollarization the most significant factors were the two-month rate of change in the interest rate on foreign deposits, the rate of inflation and the rate of change of the exchange rate. Provided these factors continue to change so as to enhance macroeconomic stability (i.e. increasing output, decreasing inflation and stable exchange rate), the current trend in de-dollarization can be expected to continue and this is likely to enhance the credibility of CBR monetary policy.

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Bank of Finland
BOFIT – Institute for Economies in Transition
PO Box 160
FIN-00101 Helsinki

☎ + 358 10 831 2268
bofit@bof.fi
http://www.bof.fi/bofit