ВОПРОСЫ ТЕОРИИ

The demand for money and currency substitution in Russia during and after hyperinflation: 1992-1996

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This paper presents econometric evidence on the determinants of the demand for a number of rouble and US$ monetary aggregates in Russia and on the stability of these demand functions and of the estimated parameters. The aggregates considered are rouble banknotes, rouble M2, US$ banknotes and US$ deposits held at Russian banks. The data used is monthly and the sample period is May 1993 to January 1997. The econometric model used is the error correction model (EC-model) which distinguishes between the long run (cointegrating) relationship among the variables and the short run dynamics. Particular attention is devoted to measuring the effect of exchange rate changes or expectations thereof and of political risk on rouble and dollar asset demands.

Introduction[1)]

This paper presents econometric evidence on the determinants of the demand for a number of rouble and US$ monetary aggregates in Russia and on the stability of these demand functions and of the estimated parameters. The aggregates considered are:

-rouble banknotes in circulation outside banks,

-rouble M2 (the sum of rouble banknotes and rouble deposits),

-US$ banknotes in its narrow and broad estimate and

-US$ deposits held at Russian banks.

The data used is monthly and the sample period for the estimations is in general May 1993 to January 1997. Before May 1993 one important explanatory variable, the rouble interest rates is not available (because the Treasury bill market was not developed yet). The econometric model used is the error correction model (henceforth EC-model) which distinguishes between the long run (cointegrating) relationship among variables and the short run dynamics[2)]. The paper focuses also

[1)] The authors would like to thank Charles Wyplosz for very useful comments on an earlier draft.

[2)] See Engle and Granger, (1987).

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on dollarization and currency substitution; as a result particular attention will be devoted to measuring the effect of exchange rate changes or expectations thereof and of political risk on the rouble and the dollar asset demands.

The analysis of the demand for money is important for several reasons. First, it is crucial for decisions on the optimal conduct of monetary policy. For instance in the face of large capital inflows the Central Bank of Russia (CBR) has to decide by how much the money supply can grow without causing inflation. For this purpose knowledge about the determinants of real money demand is necessary. Furthermore it is likely that the need for exchange rate flexibility is going to increase in Russia in the coming years. In that case the CBR may consider moving from an exchange rate anchor (the corridor) to a monetary anchor by pursuing and announcing a target for a monetary aggregate. It is therefore important to test for the stability of the various monetary aggregates and check which one presents the most stable relationship with inflation and output.

Second, the knowledge about the determinants and stability of the real demand functions for money is important for the analysis of the determinants of inflation and of the most relevant monetary aggregate(s) in this context[3)]. For instance it is important to find out if non-rouble monetary aggregates add to the explanatory power of inflation equations for Russia.

Third, it is important to have precise knowledge of the determinants and stability of the money demand functions for the analysis of the causes of dollarization and de-dollarization of the Russian economy. It is well known that currency substitution can add to the instability of interest rates, exchange rates and ultimately of inflation and output. This is certainly undesirable. Although monetary authorities can in principle adjust rouble aggregates in such a way as to compensate for the effect of currency substitution on these variables, this is often difficult and at times impossible. In other words, in the presence of currency substitution the independence of domestic inflation (and of domestic monetary policy) from foreign influences under flexible exchange rates is lost and "the case for flexible exchange rates"[4)] to achieve inflation and monetary independence is weakened. The foreign shocks which under fixed exchange rates influence the domestic economy via changes in the money supply, will influence it via changes in the demand for money under flexible exchange rates. Changes in money demand caused by currency substitution will have to be compensated by equal changes in the rouble money supply to avoid instability and for this purpose the Central Bank needs to have an idea of the effect of exchange rate expectations and of political risk on the degree and speed of substitution between dollars and roubles. This study hopes to contribute to the understanding of these issues.

Fifth the degree of dollarization and the speed of de-dollarization have important consequences for government revenues from inflation and growth (the so-called seignorage). In turn they are influenced by tax evasion, the design of the fiscal system and the confidence of the public in current and future governments.

[3)] In the pocket-model of the Russian economy developed by Charles Wyplosz, Clemens Grafe and Tatiana Kirsanova (1996) Russian inflation is determined by the quantity theory and the relevant monetary aggregete is the monetary base in roubles.

[4)] Milton Friedman wrote his famous article in 1951, neglecting the possibility of currency substitution, which was probably correct for the USA in the early post-war period, when the international mobility of capital was very low. See Friedman (1951).

The structure of the paper is as follows. Section 1 is divided into two subsections. Section 1.1 contains a very brief overview of the history of inflation, and of exchange rate changes in Russia because they are crucial to the understanding of the dynamics of rouble monetary aggregates and of dollarization. Section 1.2 presents a very brief overview of the development of the main rouble and dollar aggregates and of the dollarization ratios for banknotes and bank deposits. Section 2 describes the demand functions chosen and explains the EC-model. Section 3 presents the econometric evidence for the four aggregates. Section 4 contains concluding comments. Four appendices are added to the paper. Appendix 1 describes the data used and their sources. Appendix 2 contains estimates of the demand function for the broader estimate of US$ banknotes and Appendix 3 discusses the increasing weight of Veksels[5)] in an extended definition of the rouble money stock, but does not present estimates since their role has remained small. Appendix 4 presents the estimations of the demand functions for the rouble and dollar aggregates with the alternative scale variables.

1. A brief overview of the dynamics of inflation, real money and dollarization in Russia: 1992-1996

1.1. Inflation and changes in the exchange rate regime

The history of inflation and exchange rate depreciation is crucial to understand the dynamics of real money and dollarization in Russia. This subsection gives therefore a very brief overview of the history of inflation and exchange rate depreciation in Russia from 1991 to 1996. This will allow us to proceed more speedily with the description of the behaviour or real money in subsection 1.2. Although the econometric evidence presented in Section 3 shows that the rate of inflation does not directly influence any of the aggregates estimated, its variability does influence the demand for rouble M2. In addition among the key determinants of one or the other demand function are the nominal interest rate (which incorporates inflation), the rate of change of the exchange rate and expectations thereof (which are both closely linked with inflation). Hence this brief history is presented mainly in terms of inflation.

In January 1992, soon after the breaking-up of the Soviet Union (November 1991), the reform-minded Russian government installed by President Yelstin and led by Gaidar carried through a widespread liberalization of prices and let the exchange rate go. Inflation accelerated sharply from a monthly average of 9,3% in 1991 to 245% in January 1992. The nominal exchange rate reacted less than prices and as a result the real exchange rate appreciated by a factor of about 2,6 in January alone. Immediately after the liberalization inflation was substantially higher than expected as the existing monetary overhang had been underestimated (Gros and Steinherr, 1996). This fact and the immense losses on monetary wealth which the Russian population had to bear slowed down considerably the stabilization process in the succeeding months and years. They made President Yelstin insecure about the next

[5)] Vecksels are promissory notes issued by firms and banks and frequently used as means of payments.

steps to take and led thereby to stop and go policies linked to the changing strength he was attributing to the group of young reformers and to the group of ministers representing the energy-military-industrial lobby within the government. Thus uncertainty remained very high and inflation was not subdued until well into 1995.

The main economic reasons for the slow stabilization of inflation after the unavoidable jump of the price level in the aftermath of the price and exchange rate liberalization of January 1992 were the sharp reduction in the real demand for roubles caused by ongoing inflation and the associated rapid dollarization of the economy which enhanced the inflationary potential of a given rouble nominal money stock, the initial incomplete adjustment of energy and administred prices and the high government budget deficits financed by monetary creation. Additional factors which played an important role were the initial lack of a Treasury bill and bond market, the monetary financing by the CBR of Russian imports by the former Soviet Republics[6)], especially in 1992 (Aslund, 1995) and the slow breaking up of the rouble zone which led to overissues of money and to free-rider problems between the republics[7)]. Finally, as the rouble zone started to break up in 1993, the roubles circulating in those Republics which created new currencies were dumped on the other leading to higher inflation there[8)].

A serious anti-inflationary monetary policy was finally started towards the end of 1994 and was reinforced on the one hand by the agreement with the International Monetary Fund on an Extended Fund Facility on March 10 1995 and on the other by the introduction on July 6th 1995 of the "exchange rate corridor", a daily crawling peg of the central rate of the rouble with the US dollar with wide fluctuation margins on both sides (+/- 600 roubles or about +/-5% in 1997). This restrictive monetary policy was consistently adhered to and it managed to bring about financial stabilization (but not the stabilization of the budget deficit) with about a two year delay (i.e. by the end of 1996).

This new course managed to withstand surprisingly well the shocks of the December 1995 Duma election, of the political uncertainties in the run-up to the June 1996 Presidential election, of Yelstin's heart problems in the second half of 1996 and of the renewed fiscal crisis started in the pre-presidential election period (early 1996) and which is continuing to this day. As a result monthly inflation, which had remained at high levels well into 1995 (39% on average in 1992, 20,5% in 1993 and 10% in 1994), fell to 7,3% in 1995, 1,7% in 1996 and 1,3% in the first 7 months of 1997[9)].

Nevertheless, the de-dollarization for banknotes was very slow in Russia during and after the stabilization of inflation, supporting the evidence of inertia and asymmetry[10)] found for other countries as well[11)]. It was somewhat faster for

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[6)] Associated since December 1991 into the Community of Independent States (CIS).

[7)] The overissue was in terms of bank deposits rater than currency as the production of rouble banknotes was centralized in Russia.

[8)] This was the main reason for the July 1993 monetary reform in Russia.

[9)] In July 1997 consumer price inflation stood at 0,9% or 14,7% with respect to July 1996.

[10)] By asymmetry here we mean the fact that dollarization was extremely rapid to set in while it was very slow to be reversed after inflation started falling, in fact for currency there is practically no significant evidence of de-dollarization at least until the end of 1996.

deposits. The dynamics and the causes of the dollarization and the slow de-dollarization will be discussed in detail in Sections 1.2 and 3 below.

1.2. The behaviour of real money and dollarization in Russia: 1992-1996

The six aggregates we shall consider in this section are:
M0=rouble banknotes circulating outside banks;
M2=M0+rouble deposits at Russian banks;
DEP=rouble deposits at Russian banks;
M0$N=stock of US$ banknotes circulating in Russia;
M2$N=M0$N+US$ deposits at Russian banks;
DEP$= US$ dollar deposits at Russian banks.

Of these aggregates the one surrounded by the greatest uncertainties is the stock of US$ banknotes which for the period January 1992 to August 1993 has been estimated by cumulating the monthly net purchases of US$ banknotes by households from banks and from September 1993 onwards by cumulating the net inflows of foreign currencies into Russia through authorized banks. This cumulation leads to an estimate of the stock of US$ banknotes circulating in Russia of US$ 86 billion at the end of 1996, assuming that at the end of 1991 the stock was zero. The total amount of US$ banknotes circulating in the world is estimated at US$ 350 billion, of which about 150 are estimated to circulate within the US (Tanzi, 1996). Hence the above estimate of US$ banknotes circulating in Russia implies that over 40% of the US$ banknotes circulating outside of the US would be in Russia (or would be held by Russians). Although not impossible, this figure seems to be on the high side. In particular the estimates by the CBR are in the order of US$ 20-22 billion. In addition Russians are known to buy large amounts of US$ banknotes for tourism abroad and for so-called shuttle imports[12)].

We therefore computed another series by subtracting from our data on net purchases or inflows the net expenditures by shuttle traders, tourists and immigrants as estimated by the CBR in the Balance of Payments Statistics. The cumulation of this smaller series leads to an end 1996 stock of US$ banknotes of 22 billion, which is very close to the estimate by the CBR[13)]. We call the broad series M0$B and the narrow series M0$N. In this section we discuss only the behaviour of the narrow one and in the rest of the paper the estimates presented also refer to M0$N. However, Appendix 2 contains estimates of demand functions for the real broad aggregate and compares them with the estimates of the narrow aggregate presented in the paper. We hope to be able to infer from this comparison which of the two estimates is more reliable.

Fig.1.1 shows the stock of rouble banknotes and of rouble M2 deflated by the Consumer Price Index. Fig.1.2 shows the real stocks of US$ banknotes and M2$N as

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[11)] For instance many Latin American countries and Lebanon. See Clements and Schwartz (1992) and Mueller (1994).

[12)] Russians travel abroad to buy foreign goods and bring them back home for sale.

[13)] For a more comprehensive description of the data and their sources see Appendix 1.

defined above. Both dollar aggregates are converted into roubles at the current rouble-US$ exchange rate and deflated by the (Russian) Consumer Price Index.

Fig.1.1.

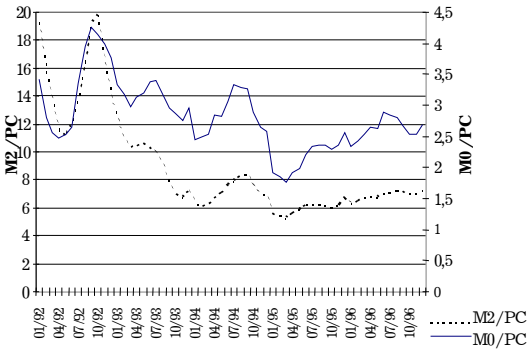
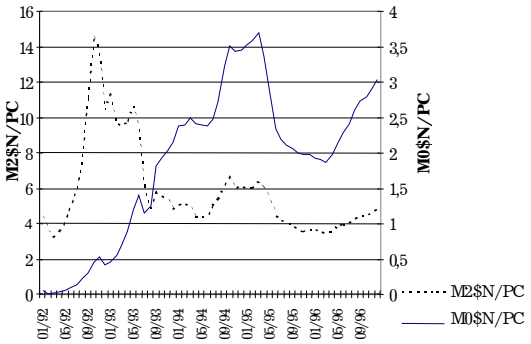
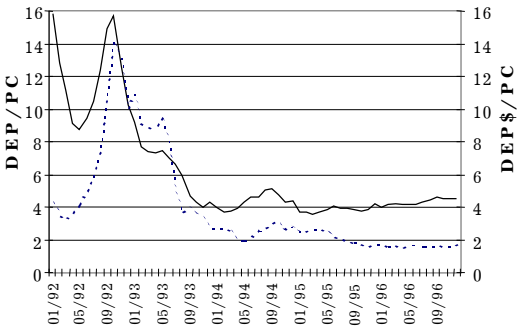


Fig.1.2.



The figures suggest the following observations. First the large increase in both rouble aggregates in mid 1992 is probably due to the rapid and unanticipated increases in the money supply in the presence of expectations by money holders that inflation would fall more rapidly after the initial post liberalization price hike of January. Once they realized that inflation did not fall as rapidly as expected they reduced accordingly their real money holdings, especially the deposit component (see Fig.1.3). Both rouble currency and rouble money in real terms continued on a downward trend until March 1995, when the new restrictive monetary course started to exert its positive effects on inflationary expectations and on inflation.

Fig.1.3.



Second the downward trend was particularly marked for rouble bank deposits suggesting a falling confidence in the stability of Russian banking system and fears of taxation. The behaviour of real rouble deposits is shown in Fig.1.3.

Third the recovery in real rouble M2 after the beginning of stabilization is slow especially if one takes into account the sharp drop in inflation and the stability of the exchange rate. From March 1995 to December 1996 real M2 grew by 1,42% per month on average (36% cumulated). The recovery was somewhat more pronounced for rouble banknotes (53% cumulated). This suggests the presence of some degree of inertia in Russia in the adjustment of real rouble monetary balances

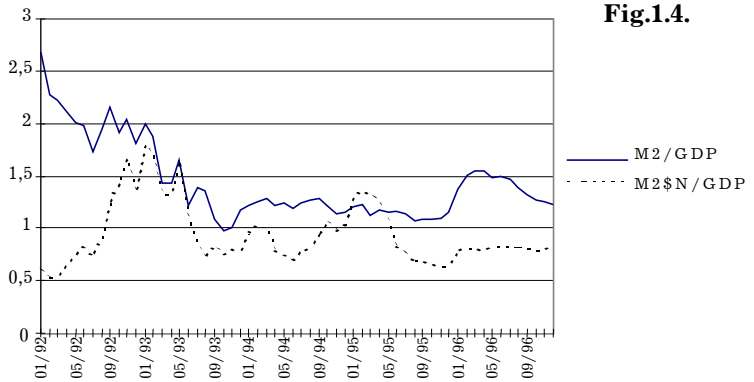
and de-dollarization which may have to do to an important degree to tax evasion and fears of taxation of unofficially accumulated wealth.

Fourth real US$ banknotes experienced a sharp upward trend from the beginning of 1992 to the beginning of stabilization in the first quarter of 1995, with sharp accelerations in the second half of 1993 and 1994 when inflation also resumed its rapid growth after it had slowed down in the summer.

Fifth particularly interesting and worrisome is the resumption of growth in real dollar banknotes holdings in the second half of 1996 (Fig.1.2). This may be the result of political uncertainties related the presidential elections and to Yelstin's heart problems, of the possible rapid growth of the hidden economy and of the black service sector especially in Moscow and St. Petersburg, and of the announced attempts by the government to become more severe with tax evaders.

Fig. 1.4 shows the ratio of rouble and dollar money stocks to GDP (M2/GDP and M2$N/GDP) or the inverse of velocity of circulation of money.

Fig.1.4.



The figure shows that from the time of the price liberalization to October 1993 the rouble money to GDP ratio fell sharply (from 2,7 to 0,97). For the period from November 1993 to December 1995 the ratio M2/GDP stabilized at the level of about 1,17 on average. Then there was a decrease of velocity in spring-summer 1996 which was followed by a moderate upward trend in the second half of 1996. After the price liberalization the ratio of dollar money (M2$N) to GDP increased instead rapidly. A peak of 1,8 was reached in January 1993, then a declining trend set in until the ratio stabilized at about 0,8 in 1996.

Fig.1.5 shows the dollarization ratio for banknotes defined as US $ banknotes divided by all banknotes and Fig 1.6 the similar ratio for bank deposits. For banknotes the ratio increases sharply to about 68% in March 1995, two months after a 17,8% peak in monthly inflation, and the rise is interrupted only by the summer slowdown in inflation in 1993 and 1994. Then de-dollarization sets in until March 1996 when the ratio reaches a minimum of 42%, which seems a rather small reduction considering the sharp fall in inflation and the high stability of the exchange rate. In the second half of 1996 a worrisome reversal sets in which brings the ratio back to 53% by year-end.

Fig.1.5.

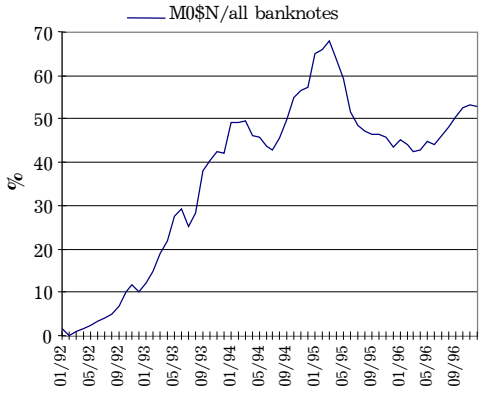
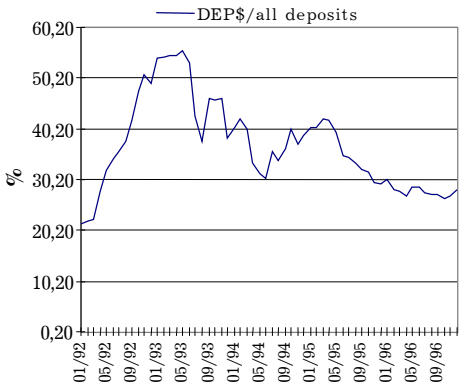


Fig.1.6.



The dollarization ratio for deposits, shown in Fig.1.6, increased from 21% in January 1992 to 55% in May 1993. Inflation had peaked at 26% in January 1993. After May 1993 a declining trend sets in which brings the ratio to 28% in December 1996. The figure suggests the following observations. First, for deposits the dollarization process was less marked in the early stage of very high inflation. Second the process came to a halt in May 1993, 21 months before the peak for banknotes was reached. Third, partly as a result of having begun earlier, the de-dollarization is much more significant for deposits and one does not observe the worrisome reversal in the second half of 1996 described above for banknotes. In general the dollarization ratio for deposits seems to be more sensitive to the turning points in inflation.

The observed differences between banknotes and deposits are probably explained in the first place by tax evasion which tends to favour banknotes to deposits. Bank deposits and transfers can be controlled more easily and in Russia any deposit above US$ 10.000 has to be reported to the tax authorities whether it occurs in dollars or in roubles. In this connection it is worth mentioning that the positive trend found in the cointegrating equation for US$ bankotes in Section 3,3 is 4% per month, while it is only 1% for US$ deposits (Section 3,4)[14]. Secondly the positive elasticity of the demand for real US$ banknotes with respect to the depreciations of the rouble is 3-4 times higher than for deposits. This implies that in the period before the introduction of the corridor, the frequent and large depreciations of the rouble led to much larger increases in US$ holdings by the Russian population.

The de-dollarization process observed for deposits has been stimulated since July 1996 by the policy of the CBR. It increased reserve requirements for dollar deposits while reducing those for rouble deposits[15]. While the data for US$ deposits

[14] There are no tax variables in the equations. Hence the trend could reflect the influence of this “unexplained” factor.

[15] In July 1996 reserve requirements on dollar deposits were increased from 1,25 to 2,5%. They stood at 6% in June 1997. During the same period reserve requirements on rouble deposits fell from 12-20% depending on maturity to 8-14%.

are certainly more reliable than for banknotes one should not forget that a more complete measure of dollarization for deposits should include in the numerator the US$ and other foreign currency deposits held by Russian residents in foreign banking systems, for which we do not have data.

2. The Error Correction model and the specification of the demand functions

The advantage of the EC-model is that it distinguishes between a long run relationship among the variables (the so-called co-integrating equation) and a short run dynamic equation which allows for a quite flexible adjustment towards long run equilibrium and implies that "excessive" levels of the endogenous variable with respect to the ones predicted by the long run relationship will lead to smaller than "normal" growth rates in the succeeding periods until equilibrium is reestablished. The EC-model is a more general version of the partial adjustment model and hence a more flexible one. It reduces to the latter under some conditions regarding the adjustment towards equilibrium. Taking as an example the most simple text-book version of the money demand function with only real GDP and a nominal interest rate as arguments[16] the standard co-integrating equation is given by:

(1) $m_t = \alpha_0 + \alpha_1 \cdot y_t + \alpha_2 \cdot i_{R,t} + u_t, \qquad \alpha_1 > 0, \ \alpha_2 < 0$

where:

m_t = the natural logarithm of the money stock in month t;

y_t = the log of real output;

$i_{R,t}$ = the nominal interest rate, and

u_t = the residual term.

In the empirical part of the paper we shall consider more than just two explanatory variables and the vector of explanatory variables will depend on the monetary aggregate. The dynamic equation can be estimated in one or two stages.

The two-step procedure

Equation (1) can be rewritten by lagging first all variables once and then bringing u_{t-1} to the left hand side of the equation. This yields equation (1'):

(1') $u_{t-1} = m_{t-1} - \alpha_0 - \alpha_1 \cdot y_{t-1} - \alpha_2 \cdot i_{R,t-1}$

The two-stage procedure consists in estimating eq. (1) and then using the lagged residuals to estimate the following dynamic equation:

(2) $\Delta m_t = \beta_0 + \beta_1 \cdot \Delta z_t + \beta_2 \cdot \Delta y_t + \beta_3 \cdot \Delta i_{R,t} + \beta_4 \cdot u_{t-1}, \qquad \beta_4 < 0$

where Δ is the first difference operator and z_t is a vector of exogenous variables not included in the co-integrating equation which influence only the dynamics of adjustment. The variables in the vectors z and y can be current, lagged or current and lagged. This is an empirical matter and we have always experimented with various lags, but generally only the current values had coeficients which were

[16] The demand functions actually estimated in this paper have a more complicated set of arguments.

significantly different from zero, reflecting a rather fast sped of adjustment as has to be expected in hyperinflation conditions. Since m_t is expressed in natural logarithms, the dependent variable of equation (2) is a percentage change. The variables in vector z_t can also be lagged so that their current and lagged values will appear in the regression and it is an empirical matter how many lags of each variable should be considered and how many variables will be included in vector z_t. The variables appearing in the co-integrating equation can also be included current and lagged in eq. (2). The expected sign of u_{t-1} is negative because only in that case will the cointegrated variables return towards long run equilibrium i.e only in that case is the model guaranteed.

The one-step procedure:

If one substitutes equation (1') into eq. (2) one obtains the following equation:

$$(3)\ m_t = \beta'_0 + \beta_1 \cdot \Delta z_t + \beta_2 \cdot \Delta y_t + \beta_3 \cdot \Delta i_{R,t} + \beta_4 \cdot m_{t-1} + \beta_5 \cdot y_{t-1} + \beta_6 \cdot i_{R,t-1} + \beta_7 \cdot v_t$$

where v_t is the residual of the regressions and $\beta_0 = \beta_0 - \beta_4 \cdot \alpha_0$, $\beta_5 = -\beta_4 \cdot \alpha_1$, $\beta_6 = -\beta_4 \cdot \alpha_2$. The one-step procedure to estimate the dynamic equation is superior from the econometric point of view because it imposes less restrictions on the parameters[17], but the two-step one allows to save degrees of freedom.

The problems with empirical work on Russia are several. First of all the period under study (1992-1996) is characterized by high turbulence and the possibility of structural breaks and instability of parameter estimates has to be taken into consideration. Second data on GDP are unreliable compared to Western countries[18]. One of the reasons is that the rapidly growing service sector is not sufficiently and not accurately enough accounted for. Third some data like the interest rate do not exist or are unreliable before May 1993 simply because financial markets were not developed enough. Other series like interest rate on Russian dollar denominated bonds (Taiga bonds) are available only from 1994.

Our initial vector of cointegrated endogenous variables in the long-run and of exogenous variables in the dynamic equations includes in addition to the nominal interest rate on Treasury bills (GKO), $i_{R,t}$, and real GDP, y_t, the following set of variables:

- the variability of inflation (inflation itself is already incorporated in the nominal interest rate);
- a proxy for political risk, measured as the difference between the interest rates on Taiga bonds and the interest rate on dollar bonds issued by the US Treasury;
- to measure currency substitution we used the rate of change of the exchange rate or a measure of expectations of exchange rate changes. The latter was measured as a weighted average of the forward discount of the rouble with respect to the US dollar (with a weight equal to 70%) and of the difference between i_R and the Taiga bond yield (a proxy of inflationary expectations, with weight equal to 30%). This proxy for expectations of changes in the exchange rate is the same as

[17] See Benerjee, Dolado, Galbraith and Hendry (1993).

[18] According to some estimates the hidden economy may amount to 40% of official GDP in Russia.

the one used in the pocket model of the Russian monetary sector[19].

In addition real GDP did not always perform well as a scale variable in the estimations of the rouble aggregates (M0 and M2). Even when its coefficient was significantly different from zero its elasticity was very low and we were compelled to look for alternative scale variables. The real wage bill net of wage arrears always performed better than real GDP in the rouble aggregates, while the latter performed better in the demand functions for US dollar aggregates (M0$N, M0$B, and DEP$). We shall offer a plausible explanation for this finding after discussing the empirical estimates. Finally we had to add a trend in the demand for US$ aggregates, which is not surprising in view of the description of the previous section (Fig.1.2), and some dummies for monthly seasonality, for elections, for the introduction of the corridor in July 1995, for particularly severe changes in the exchange rate and relaxation of capital control.

In the next section we present estimates of equations (1), (2) and (3) for the four aggregates: M0, M2, M0$N and dollar deposits at Russian banks (DEP$). For roubles we decided to move from the estimation of the demand function for real M0 to the estimation of the broader aggregate of real M2 because the latter is an important instrument of monetary policy and most likely the most relevant monetary aggregate for the determination of inflation. For dollar holdings no such policy concerns exist and in addition the analysis of Section 1.2 has shown that the behaviour of the demand for dollar banknotes is significantly different than for the demand for dollar deposits, making the aggregation of these two dollar stocks less meaningful.

3. The estimates of the demand functions for banknotes and money

3.1. The demand for real rouble banknotes

We rewrite the co-integrating equation (1) here with all the variables which turned out to be significant:

$$(4) \qquad m_{0,t} = c(1) + c(2) \cdot w_t + c(3) \cdot S_t^* + \Sigma_i c(i) \cdot D_{i,t}$$

where:

$m_{0,t}$=the natural logarithm of the stock of real rouble banknotes where the nominal stock has been deflated using the consumer price index;

w_t = the log of the real wage bill net of wage arrears;

S^*_t = expectations of exchange rate changes of the rouble with respect to the US dollar, a variable reflecting currency substitution;

D_3=seasonal dummy for March;

D_{12}=seasonal dummy for December;

D_C=dummy variable for the exchange rate corridor, which assumes the value of 1 until June 1995, the last full month before the introduction of the corridor, and zero since July 1995.

A more precise definition of the variables used is given in Appendix 1 which also contains the sources of the data. Table 3.1 contains the estimation of eq. (4) for

[19] See Wyplosz, Grafe and Kirsanova (1996).

rouble banknotes. The sample period is May 1993 to January 1997.

Table 3.1.

OLS estimation, Sample: 1993:05 1997:01
Dependent variable is Logarithm of Real Banknotes m_0

Variable	Coefficient	T-Statistic
c	-3,38	-14,32
w_t	0,99	18,17
S^*_t	-0,01	-2,76
D_3	-0,10	-3,16
D_{12}	-0,16	-5,54
D_C	-0,14	-6,43
Adjusted R-squared	0,90	
Durbin-Watson statistic	0,87	

The scale variable w_t has a coefficient which is significantly different from zero at the 1% level of confidence. It is also not significantly different from 1. We hardly managed to find satisfactory cointegration relationships for real rouble banknotes and money when real GDP was included instead of w_t. Real GDP was not so highly significant and had generally a coefficient below 0,5 (for details see Appendix 4). The fact that w_t performs better than real GDP in the regression is not implausible. It implies that rouble banknotes are demanded mostly by wage earners, and this may reflect more than just a consumption (transaction) motive for holding banknotes as Russian wage earners are believed to hold a large fraction of their savings in banknotes. In addition monthly GDP is available only from January 1994 and its inclusion forces us to reduce the estimation period. Fig. 3.1 shows the different dynamics of the real wage bill net of arrears (w) and of real GDP (y). It can be seen that there is more seasonality in real GDP than in the real wage bill. Moreover, there is a much larger decline in the real wage bill net of arrears in January 1995.

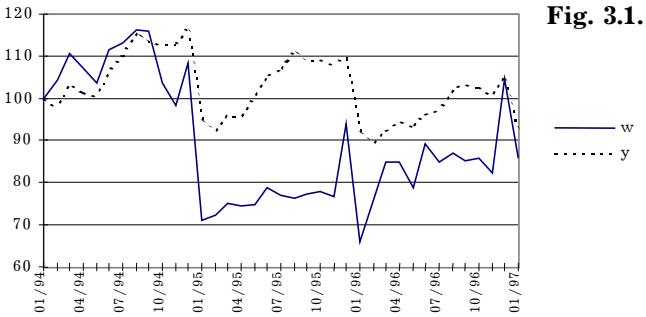


Fig. 3.1.

Also the currency substitution variable is significantly different from zero at the 1% level. The negative sign of the coefficient of the dummy D_c implies that before the introduction of the exchange rate corridor the real demand for rouble banknotes was significantly lower than afterwards. Thus with the introduction of the corridor an upward jump seems to have occurred in the real demand for rouble banknotes, which the other variables included in the equation are unable to explain. We interpret this as a sign of the increased confidence in the rouble which the corridor and the beginning of stabilization brought about.

Equation 1 is cointegrated according to the Johansen and Augmented Dickey Fuller (ADF) tests. The fact that it is cointegrated allows us to proceed with the estimation of the dynamic equations (3) and (2) which, after extensive investigations, took the following form:

(5) $\Delta m_{0,t} = c(1) \cdot \Delta w_t + c(2) \cdot \Delta S_t^* + c(3) + c(4) \cdot m_{0,t-1} +$
$+ c(5) \cdot w_{t-1} + c(6) \cdot S_{t-1}^* + \Sigma_i c(i) \cdot D_{i,t}$

(6) $\Delta m_{0,t} = c(1) \cdot \Delta w_t + c(2) \cdot \Delta S_t^* + c(3) \cdot u_{t-1} + \Sigma_i c(i) \cdot D_{i,t}$

where most variables have already been defined above. Δ is the first difference operator. The new dummies included are:

D_7= seasonal dummy for July;

D_K= dummy variable reflecting the relaxation of controls on capital inflows, implemented in August 1996. It assumes the value of 1 since September 1996 the first full month during which the new regulations were in effect;

D_E= dummy for the uncertainties caused by the 1996 Presidential election; it assumes the value of 1 in March, April, May and June 1996 and zero otherwise.

Table 3.2 contains the estimation of equations (5) and (6). The sample period is from January 1994 to January 1997. The current changes in the wage bill and in the expected exchange rate have coefficients which are significantly different from zero at the 1% level of significance. Both coefficients have the expected sign. Lagged values of these variables are insignificantly different from zero and have been removed from the regressions. The constant term in the two-step regression was insignificantly different from zero.

Table 3.2.

OLS estimation, Sample: 1994:01 1997:01
Dependent variable is Monthly Growth of Real Banknotes, $\Delta m_{0,t}$

	one-step procedure		two-step procedure	
Variable	Coefficient	T-Statistic	Coefficient	T-Statistic
Δw_t	0,79	11,47	0,48	9,79
ΔS_t^*	-0,01	-3,18	-0,01	-3,23
u_{t-1}			-0,57	-3,70
c	-2,20	-5,50		
$m_{0,t-1}$	-0,55	-5,79		
w_{t-1}	0,63	5,72		
S_{t-1}^*	-0,01	-3,34		
D_C	-0,08	-3,53		
D_{12}	-0,09	-3,79		
D_3	-0,06	-2,78	-0,08	-3,25
D_7			0,06	2,80
D_K	-0,07	-3,78	-0,04	-2,28
D_E			0,07	3,11
Adjusted R-squared		0,84	0,78	
Durbin-Watson statistic		2,11	1,82	
Breusch-Godfrey				
Serial Correlation LM Test:		0,91	3,97	
Obs*R-squared (Probability)		(0,63)	(0,14)	
White Heteroskedasticity Test:		11,99	15,27	
Obs*R-squared (Probability)		(0,61)	(0,12)	
Normality Test:		0,12	1,20	
Jarque-Bera (Probability)		(0,94)	(0,55)	
ARCH Test:		1,02	1,84	
F-statistic (Probability)		(0,32)	(0,77)	
Ramsey RESET Test: (Fitted^2)				
F-statistic (Probability)		0,01	1,08	
Ramsey RESET Test: (Fitted^2),		(0,94)	(0,299075)	
(Fitted^3)		0,64	1,84	
F-statistic (Probability)		(0,53)	(0,40)	

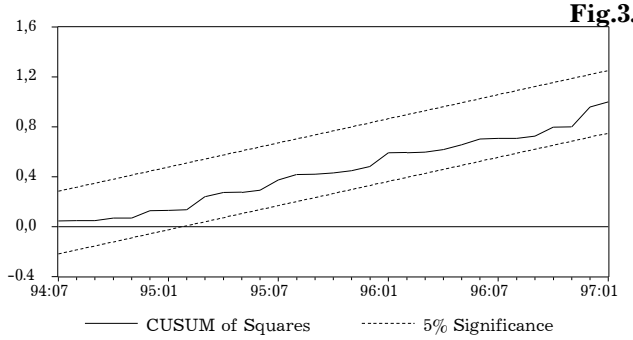
In order to take into account the possible simultaneity between rates of changes of the real stock of rouble banknotes on the one hand and of Δw_t and ΔS^*_t on the other, we estimated the regressions also by 2SLS. The results remain substantially unchanged (see Table 3.3 below).

The coefficients of u_{t-1} and $m_{0,t-1}$ in Table 3.2 indicate that the adjustment towards long run equilibrium is rapid, the estimated mean adjustment lag being less than two months. The dummy for the corridor, which was significantly different from zero only in one regression of Table 3.2, has a negative sign which implies that after the introduction of the corridor the "exogenous" rate of decline of m_0 fell in absolute value (the coefficient of D_C corrects the coefficient of the constant term). The negative sign of the coefficient of D_K is also somewhat odd. The only explanation we could give is that after the relaxation of capital controls in August 1996 the Russians started demanding more dollar banknotes to export capital to Western tax heavens in order to re-invest into the profitable Russian GKO market under foreign denomination. This reduced the demand for rouble banknotes. For an explanation of the odd positive sign of the coefficient of the election dummy D_E see Table 3.5 in Section 3.2.

The regressions of Table 3.2 are very satisfactory in terms of explanatory power (as the dependent variable is a percentage change an adjusted R^2 above 0,5 is high). In addition the residuals satisfy all the standard conditions: absence of autocorrelation (Breusch-Godfrey Serial Correlation LM Test), homoskedasticity (White Heteroskedasticity Test and ARCH Test), normality and the equations pass the Ramsey-Functional Form Misspecification test.

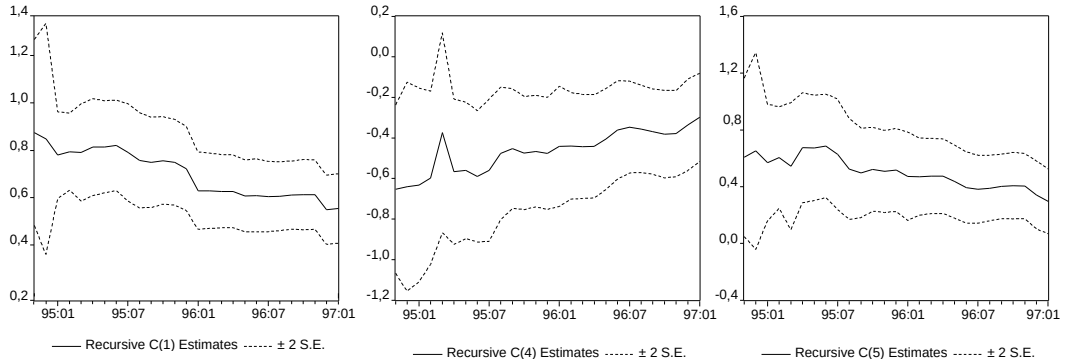
Next we performed stability tests for both regressions. The CUSUM of Squares test for the first regression of Table 3.2 is presented in Fig. 3.2. It reveals no evidence of instability, as the straight line remains within the 5% significance band. The results of the CUSUM of Squares test for the second regression of Table 3.2 are very similar and are not presented here to save space.

Fig.3.2.



The recursive parameter estimates for the one-step equation (5) are shown only for the unstable coefficients in Fig. 3.3. They show that some coefficients "jump" either in February-March 1995 or at the end of 1995, when the stabilization policy started showing signs of greater consolidation. These jumps tend to suggest in conjunction with the other evidence presented above that important regime-changes occurred when the stabilization efforts became serious or soon thereafter.

Fig.3.3.



In order to take into account the possibility that the coefficients of Δw_t and ΔS^*_t could be biased by the fact that these variables may be endogenously determined, we reestimate eq. (6) by 2SLS. The list of instruments used includes the exogenous variables of the model, the "endogenous" variables lagged once and twice, some dummies and a constant term: Δw_{t-1}, Δw_{t-2}, ΔS_{t-1}^*, u_{t-1}, D_3 D_7, D_K, D_E, D_{12}, D_1, $D_{10/94}$, $D_{6/95}$. We do this only for this dynamic equation because of problems of degrees of freedom with the other one. The results are presented in Table 3.3. The table shows that no significant changes occur in the estimated parameters of Δw_t, ΔS^*_t and u_{t-1}, which suggests that there are no major problems of reverse causation between the variables involved.

Table 3.3.

2SLS estimation, Sample: 1994:02 1997:01
Dependent variable is Monthly Growth of Real Banknotes, $\Delta m_{0,t}$

Variable	Coefficient	T-Statistic
Δw_t	0,45	8,47
ΔS_t^*	-0,014	-2,22
u_{t-1}	-0,57	-3,69
D_3	-0,09	-3,10
D_7	0,06	2,74
D_K	-0,04	-2,30
D_E	0,07	3,13
Adjusted R-squared		0,77
Durbin-Watson statistic		1,79
Breusch-Godfrey Serial Correlation LM Test:		
Obs*R-squared (Probability)		3,83(0,15)
White Heteroskedasticity Test:		
Obs*R-squared (Probability)		15,97(0,10)
Normality Test:		
Jarque-Bera (Probability)		1,19(0,55)
ARCH Test:		
F-statistic (Probability)		1,88(0,76)
Ramsey RESET Test: (Fitted^2)		
F-statistic (Probability)		1,14(0,30)
Ramsey RESET Test: (Fitted^2), (Fitted^3)		
F-statistic (Probability)		0,70 (0,50)

3.2. The demand for rouble M2 (rouble banknotes and rouble deposits)

The estimated cointegrating equation is given by.

$$(7) \quad m_{2,t} = c(1) + c(2) \cdot w_t + c(3) \cdot i_{R,t} + c(4) \cdot \sigma_{\pi,t} + \Sigma_i c(i) \cdot D_{i,t} ,$$

where the new symbols stand for:

$m_{2,t}$ = natural log of the real stock of rouble banknotes and deposits;

$i_{R,t}$ = nominal interest rate on GKO;

$\sigma_{\pi,t}$ =variability of inflation.

The OLS estimate of the cointegrating equation (7) is given in Table 3.4. The precise definition of the variables and their sources are given in Appendix 1. The sample period is May 1993 to January 1997, as for m_0.

Table 3.4.

OLS estimation, Sample: 1993:05 1997:01
Dependent variable is Logarithm of Monthly Real Money, $m_{2,t}$

Variable	Coefficient	T-Statistic
c	-0,81	-3,29
w_t	0,64	11,92
$i_{R,t}$	-0,01	-2,37
$\sigma_{\pi,t}$	-0,03	-3,52
D_3	-0,10	-2,48
D_{12}	-0,10	-2,63
Adjusted R-squared	0,80	
Durbin-Watson statistic	0,57	

The coefficients of the explanatory variables are all significant at the 1% confidence level and have the expected sign. A high yield on GKO and a high variability of inflation reduce the demand for real money. The interest rate elasticity calculated at sample mean is -0,08, while the elasticity with respect to the variability of inflation, also calculated at sample means, is -0,09. The elasticity of real money with respect to the wage bill (net of wage arrears) is 0,64, significantly lower than 1. The wage bill performs much better than real GDP, as for m_0 (for details see Appendix 4). The equation is cointegrated according to the Johansen and the ADF tests and there is only one co-integrating equation. It is worth noting that for m_2 we do not need a dummy for the corridor in order to estimate a satisfactory cointegrating equation.

Equations (8) and (9) are the dynamic equations estimated, eq. (8) is the dynamic equation estimated in one step and eq. (9) the one estimated in two steps.

$$(8) \quad \Delta m_{2,t} = c(1) \cdot \Delta w_t + c(2) \cdot \Delta \sigma_{\pi,t} + c(3) \cdot \Delta i_{R,t} + c(4) \cdot \Delta(i_{R\$,t} - i_{U,t}) + c(5) + \\ + c(6) \cdot m_{2,t-1} + c(7) \cdot w_{t-1} + c(8) \cdot \sigma_{\pi,t-1} + c(9) \cdot i_{R,t-1} + \Sigma_i c(i) \cdot D_{i,t}$$

$$(9) \quad \Delta m_{2,t} = c(1) \cdot \Delta w_t + c(2) \cdot \Delta \sigma_{\pi,t} + c(3) \cdot \Delta i_{R,t} + c(4) \cdot \Delta(i_{R\$,t} - i_{U,t}) + c(5) \cdot u_{t-1} + \\ + \Sigma_i c(i) \cdot D_{i,t} ,$$

where the new symbols stand for:

$i_{R\$,t}$ = the nominal interest rate on Taiga bonds (in US$). These are dollar bonds issued by the Russian government;

$i_{U,t}$ = the US Treasury bill rate (in US$); hence the differential ($i_{R\$,t}$ - $i_{U,t}$) measures the 'country risk' or 'political risk' of Russia as a borrower in international financial markets vis-a-vis the US;

u_{t-1} =the residual from the cointegrating eq. (7) and

$D_{4/95}$=dummy variable which is equal to 1 in April 1995 and 0 otherwise. It catches the positive effect on rouble money demand of the return in confidence brought about by the restrictive monetary policy and the by sharp drop in inflation.

The estimates of eq.(8) and eq.(9) are presented in Table 3.5. The estimation period is May 1994 to January 1997 shorter than for the other estimates presented, so far because of the inclusion of the variable ($i_{R\$,t}$ - $i_{U,t}$) in these regressions. All the coefficients have the expected sign and are statistically significant at the 1% confidence level. The constant term in the two-step regression was never significantly different from zero and was therefore removed.

Table 3.5.

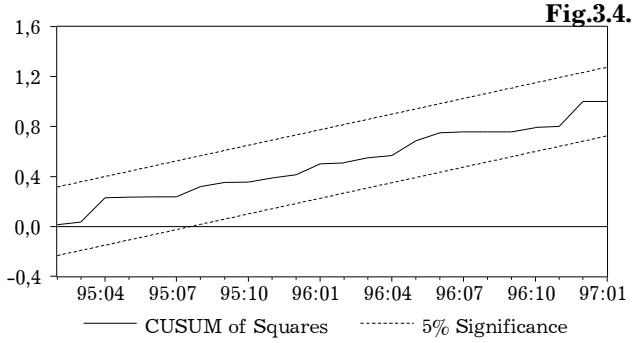
OLS estimation, Sample: 1994:05 1997:01
Dependent variable is Monthly Growth of Real Money, $\Delta m_{2,t}$

	one-step procedure		two-step procedure	
Variable	Coefficient	T-Statistic	Coefficient	T-Statistic
Δw_t	0,35	10,83	0,23	7,93
$\Delta\sigma_{\pi,t}$	-0,01	-2,80	-0,02	-3,35
$\Delta i_{R,t}$	-0,006	-3,02	-0,004	-2,15
$\Delta(i_{R\$,t} - i_{U,t})$	-0,11	-2,95	-0,10	-2,85
u_{t-1}			-0,51	-5,25
c	-0,58	-4,10		
$m_{2,t-1}$	-0,57	-6,61		
w_{t-1}	0,39	6,22		
$\sigma_{\pi,t-1}$	-0,01	-2,43		
$i_{R,t-1}$	-0,01	-3,71		
D_3	-0,06	-4,00	-0,06	-3,50
D_E	0,04	2,95	0,03	3,00
D_{10}			-0,03	-2,59
$D_{4/95}$			0,05	2,75
Adjusted R-squared		0,88	0,86	
Durbin-Watson statistic		2,05	1,65	
Breusch-Godfrey				
Serial Correlation LM Test:		0,82	1,37	
Obs*R-squared (Probability)		(0,66)	(0,50)	
White Heteroskedasticity Test:		22,78	9,54	
Obs*R-squared (Probability)		(0,20)	(0,79)	
Normality Test:		3,19	2,71	
Jarque-Bera (Probability)		(0,20)	(0,26)	
ARCH Test:		0,24	0,39	
F-statistic(4,29) (Probability)		(0,91)	(0,81)	
Ramsey RESET Test: (Fitted^2)				
F-statistic (Probability)		2,52	0,001	
Ramsey RESET Test: (Fitted^2),		(0,13)	(0,97)	
(Fitted^3)		1,89	0,14	
F-statistic (Probability)		(0,18)	(0,87)	

The major findings are first that changes in the political risk variable influence the dynamics of adjustment of real money demand towards its equilibrium value; they do not affect m_2 in the long run. Second a dummy for the corridor is not needed in the dynamic equation for m_2, contrary to what we found for m_0, probably because the observed changes in the yield on GKO, in the variability of inflation and in political risk between the period before and after the introduction of the corridor are sufficient to explain the behaviour of real money during the whole sample period. Third the speed of adjustment of real money demand is as rapid as for m_0 (two months or slightly less, depending on the regression). Fourth the coefficient of D_E is positive and this runs against expectations because election uncertainties should reduce money demand, not increase it. We shall offer below an explanation for this apparently odd finding while discussing the stability of the coefficient of i_R. Fifth the explanatory power of the regressions is high and the residuals are well behaved (they are not autocorrelated, heteroskedastic, and normally distributed). In addition the hypothesis of no Autoregressive Conditional Heteroskedasticity of the error terms cannot be rejected and the Ramsey Reset tests reveals no evidence of Functional Form Misspecification.

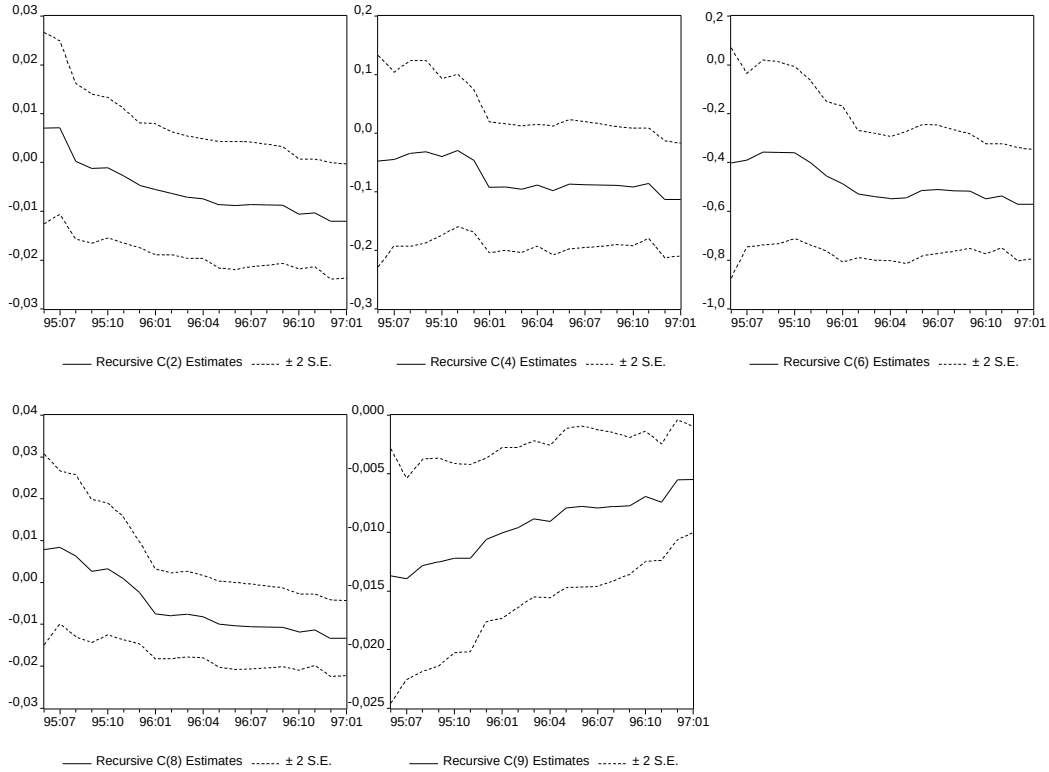
The stability tests for one step dynamic equation are presented in figures 3.4-3.5**.** The CUSUM of Squares test for the one-step regression reveals no evidence of instability, as the straight line remains within the 5% significance band (Fig.3.4). On the other hand for the two-step regression (the figure is not presented in the paper) one can observe some instability around the time of the introduction of the exchange rate corridor. However, the two-step procedure implies that more constraints are imposed on the coefficients of the model (see eq.(3)) and this entails a smaller flexibility in explaining changes in real money demand.

Fig.3.4.



The recursive parameter estimates for regression (8) of Table 3.5 are shown in Fig. 3.5 only for the less stable parameters. While for the two-step procedure all five parameters are remarkably stable, for the one-step procedure several are stable. The most unstable ones are the coefficients of the first difference and the lagged value of the variability of inflation (C(2) and C(8)), of lagged money (C(6)) and wages (C(7)) and of the lagged GKO yield (C(9)).

Fig.3.5.



The fall in the absolute value of the interest elasticity of money demand through time (see coefficient C(9) in Fig. 3.5) may be a consequence of the fact that in early 1995 real interest rates became positive (or much less negative) also on bank deposits and that this may have increased substantially the attractiveness of holding interest yielding deposits. Especially if one does not include an own rate of return on holding money in the estimates of the demand function this can lead to a fall in the absolute value of the elasticity. But there is another factor which may have reduced the absolute value of the elasticity in the latter part of the sample period. In the months prior to the presidential election of 1996 nominal and real interest rates on GKO increased dramatically. Net domestic assets of the CBR went up sharply and fiscal policy became expansionary for electoral reasons. Partly because of the increase in uncertainty about the political future of Russia which affected risk premia and partly because of the attempt by the CBR to prevent the rouble from depreciating too much, nominal and real yields on GKO reached unprecedented levels. During this period the absolute value of the interest elasticity of money demand is likely to have shifted significantly. In order to test this hypothesis we use the dummy D_E which assumes the value of 1 in March, April, May and June 1996 and zero otherwise, to construct the variable $i_R{}^*D_E$ and reestimate the first regression of Table 3.5 with this variable along with i_R, but without D_E. In other

words we test whether there has been a significant change in the coefficient of i_R during the electoral campaign. The results are presented in Table 3.6.

Table 3.6.

OLS estimation, Sample: 1994:05 1997:01
Dependent variable is Monthly Growth of Real Money $\Delta m_{2,t}$

Variable	Coefficient	T-Statistic
Δw_t	0,35	10,49
$\Delta\sigma_{\pi,t}$	-0,01	-2,50
$\Delta i_{R,t}$	-0,004	-2,17
$\Delta(i_{R\$,t} - i_{U,t})$	-0,11	-2,78
c	-0,57	-3,83
$m_{2,t-1}$	-0,58	-6,42
w_{t-1}	0,39	5,97
$\sigma_{\pi,t-1}$	-0,01	-2,58
$i_{R,t-1}$	-0,007	-3,57
$i_R D_{E,t}$	0,004	2,37
D_3	-0,04	-2,68
Adjusted R-squared		0,87
Durbin-Watson statistic		1,98
Breusch-Godfrey Serial Correlation LM Test:		
Obs*R-squared (Probability)		0,51(0,77)
White Heteroskedasticity Test:		
Obs*R-squared (Probability)		24,06 (0,19)
Normality Test:		
Jarque-Bera (Probability)		3,69 (0,16)
ARCH Test:		
F-statistic (Probability)		0,13(0,98)
Ramsey RESET Test: (Fitted^2)		
F-statistic (Probability)		1,63(0,21)
Ramsey RESET Test: (Fitted^2), (Fitted^3)		
F-statistic (Probability)		1,42 (0,26)

The coefficient of $i_{R,t}$•D_E is statistically significant at the 5% level of confidence and positive. This implies that the value of the semi-elasticity was -0,004 during the pre-election period as opposed to -0,007 for the whole sample period or that the elasticity was -0,04 as opposed to -0,08. Not taking this break into account entails that for the pe-election period the model predicts a more substantial decline in the demand for real m_2 than the actual decline and this explains the positive value of the coefficient of D_E in Table 3.5. Furthermore this fact contributes to explain the downward drift in the absolute value of the coefficient of $i_{R,t}$ in Fig. 3.5.

Consistency of the OLS estimator requires the weak exogeneity of the explanatory variables. However, it is reasonable to suspect that some of the explanatory variables in the regressions of Table 3.5 may be endogenous. One way to test this is to perform Granger Causality tests for all possible pairs of variables involved in the dynamic equations. Granger Causality tests between such pairs of variables, not shown here to save space, reveal that there is bi-directional causality between $\Delta i_{R,t}$ and $\Delta(i_{R\$,t} - i_{U,t})$[20] and also between the growth of w_t and $\Delta(i_{R\$,t}$ -

[20] The results of the Granger Causality tests are available from the authors upon request.

$i_{U,t}$). We decided nevertheless to reestimate the regressions of Table 3.5 by using the instrumental variable technique (2SLS). This is done in Table 3.7, but only for the two-step procedure (the second regression of Table 3.5) because the number of degrees of freedom is not high enough to reestimate with sufficient confidence also the one-step regression.

Table 3.7.

2SLS estimation, Sample: 1994:07 1997:01
Dependent variable is Monthly Growth of Real Money Demand, $\Delta m_{2,t}$

Variable	Coefficient	T-Statistic
Δw_t	0,20	6,12
$\Delta \sigma_{\pi,t}$	-0,02	-2,36
$\Delta i_{R,t}$	-0,005	-2,18
$\Delta(i_{R\$,t} - i_{U,t})$	-0,08	-1,86
u_{t-1}	-0,53	-5,24
D_3	-0,05	-3,49
D_E	0,03	3,25
D_{10}	-0,03	-2,72
$D_{4/95}$	0,05	2,92
Adjusted R-squared	0,87	
Durbin-Watson statistic	1,83	
Breusch-Godfrey Serial Correlation LM Test:		
Obs*R-squared (Probability)	3,14 (0,21)	
White Heteroskedasticity Test:		
Obs*R-squared (Probability)	6,79 (0,94)	
Normality Test:		
Jarque-Bera (Probability)	2,16 (0,34)	
ARCH Test:		
F-statistic (Probability)	1,10 (0,38)	
Ramsey RESET Test: (Fitted^2)		
F-statistic (Probability)	0,10 (0,75)	
Ramsey RESET Test: (Fitted^2), (Fitted^3)		
F-statistic (Probability)	0,12 (0,89)	

The list of instrumental variables includes the exogneous variables of the model, the "endogenous" variables lagged once and twice, some dummies and the constant term: Δw_{t-1}, Δw_{t-2}, $\Delta \sigma_{\pi,t-1}$, $\Delta i_{R,t-1}$, $\Delta i_{R,t-2}$, $\Delta(i_{R\$,t-1} - i_{U,t-1})$, $\Delta(i_{R\$,t-2} - i_{U,t-2})$, u_{t-1}, D_3, D_E, D_{10}, $D_{4/95}$, D_1, $D_{10/94}$, $D_{6/95}$. Comparing the results of Table 3.7 with the second column of Table 3.5, one observes a significant reduction only in the coefficient of $\Delta(i_{R\$,t} - i_{U,t})$, which also becomes less significantly different from zero (the level of confidence falls from 1% to 10%). Overall the coefficients of the regression remain very robust and the residuals continue to be very well behaved. Hence we conclude that some possible endogeneity of Δw_t and $\Delta(i_{R\$,t} - i_{U,t})$ does not render the OLS estimates of Table 3.5 invalid.

3.3. The demand for US$ dollar banknotes

In the cointegrating equation for this aggregate we have included real GDP, the rate of change of the rouble-dollar exchange rate as a proxy for currency

substitution, the differential between the Taiga bond yield and the yield on US Treasury bonds, measuring political risk, a time trend and a number of dummies:

$$(10)\quad m_{0\$n,t} = c(1) + c(2)\cdot t + c(3)\cdot \Delta S_t + c(4)\cdot \Delta S_t D_c + c(5)\cdot y_t + c(6)\cdot (i_{R\$,t} - i_{U,t}) + \\ + \Sigma_i c(i)\cdot D_{i,t}$$

where:

$m_{0\$n,t}$ = natural logarithm of the real stock of US$ banknotes circulating within Russia, narrow estimate;

y_t = natural logarithm of real GDP;

ΔS_t = rate of change of the rouble-dollar exchange rate; S_t is the natural logarithm of the exchange rate;

$\Delta S_t D_c$ = first difference of $S_t{}^* D_c$, where D_c is the corridor dummy which has already been defined

t = time trend

$D_{5/6,95}$ = dummy variable for the increase in confidence after the beginning of monetary stabilization and before the introduction of the corridor, it assumes the value of one in May and June 1995 and zero otherwise.

The other variables have been defined above. Equation (10) has been estimated by OLS for the period April 1994-December 1996 (the series $i_{R\$,t}$ is not available before). The variable $\Delta S_t D_c$ (the product of the corridor dummy D_c and of the rate of the change of the exchange rate) has been added along with ΔS_t to take into account the fact that the real demand for US$ banknotes may have reacted in a significantly different way to changes in the exchange rate before and after the introduction of the exchange rate corridor. The sum of the coefficients of $\Delta S_t D_c$ and ΔS_t measures the effect of changes in the exchange rate until June 1995 (included) and the coefficient of ΔS_t measures the effect from July 1995 onwards[21]. It was found that before the introduction of the corridor an exchange rate depreciation led to a significant increase in the demand for dollar banknotes and after it led to a significant reduction. One interpretation is that exchange rate expectations were "extrapolative" until June 1995 in the sense that a depreciation of the rouble led savers to expect a further depreciation, while they were "regressive" after June, in the sense that a depreciation of the rouble led to expectations of a future appreciation. This seems possible as the exchange rate band is believed to be have been quite credible from the very beginning and as the corridor is considered by many to be one of the pillars of Russian stabilization policy.

However, there is a slight conceptual problem with eq. (10) becuase the introduction among the explanatory variables of the product of ΔS_t and the corridor dummy runs somewhat against the logic of the search for a long-run (co-integrating) relationship between the variables. The introduction of this product is an implicit admission that there is a break in the long-run relationship and therefore no unique long run relationship for the whole sample period. Yet some econometricans argue that there is nothing wrong with the hypothesis of a break and with the inclusion of dummies like D_c. The tabulated critical values for the Jahansen and ADF tests are, however, not valid any more. For these reasons it was

[21] The corridor was introduced on July 6 1995.

decided not to present the estimates of eq. (10) and to move directly to the presentation of the dynamic equations for which these problems do not exist.

The specification of the one-step and two-step dynamic equations estimated is given in the following eqs. (11) and (12):

$$(11)\quad \Delta m_{0\$n,t} = c(1)\cdot\Delta\Delta S_t + c(2)\cdot\Delta y_t + c(3) + c(4)\cdot t + c(5)\cdot m_{0\$n,t-1} + \\ + c(6)\cdot\Delta S_{t-1} + c(7)\cdot y_{t-1} + \Sigma_i c(i)\cdot D_{i,t}$$

$$(12)\quad \Delta m_{0\$n,t} = c(1)\cdot\Delta\Delta S_t + c(2)\cdot\Delta\Delta S_t D_c + c(3)\cdot\Delta y_t + c(4)\cdot u_{t-1} + c(5) + \\ + \Sigma_i c(i)\cdot D_{i,t},$$

where all the variables have already been defined above. The new dummies are:
$D_{3,96}$ = dummy variable assuming the value of 1 in March 1996 and zero otherwise. In March 1996 Yelstin started actively campaigning for reelection;
$D_{8,96}$ = dummy for the relaxation of controls on capital inflows on August 15 1996; it assumes the value of 1 in August and zero otherwise.

The OLS estimates of eqs. (11) and (12) are shown in Table 3.8. Real GDP turns out to be the relevant scale variable instead of the wage bill net of arrears as for the rouble aggregates. This can be explained by the fact that the average person demanding US$ banknotes is very different than the one demanding rouble banknotes and rouble deposits. In particular many firms (or their managers) in Russia are believed to invest (hide) profits in US$. The coefficient of Δy_t is significantly different from zero at the 1% confidence level. The long run elasticity of real GDP is significantly below one. Δy_t and $\Delta\Delta S_t$ have been also lagged several times, but only their current values turned out to have coefficients which were significantly different from zero. Also the coefficient of $\Delta\Delta S_t$ is significantly different from zero at the 1% confidence level. In the regression using the one-step procedure we are unable to find any structural break in the coefficient of the lagged exchange rate or of its rate of change, while in the regression using the two-step procedure we do find a structural break in the coefficient of $\Delta\Delta S_t$. This difference is probably due to the greater flexibility of the one-step procedure which imposes no restrictions on the parameters of the lagged variables appearing in the cointegrating equation (see eq. (3)). Because of the absence of restrictions on the parameters of the lagged variables of the cointegrating equation we consider the one-step dynamic regression as more reliable than the two-step one[22)].

For this reason we tend to trust more the mean adjustment lag of about 4 months estimated on the basis of the first regression than the one of less than 2 months estimated on the basis of the second (see the coefficients of $m_{0\$n,t-1}$ in the first and of u_{t-1} in the second). An adjustment lag of 4 months is much longer than the one estimated for the demand for rouble aggregates and could contribute towards the explanation of the inertia in the dollarization ratio for banknotes found in Section 1 (see Fig. 1.5).

[22)] See Benerjee, Dolado, Galbraith and Hendry (1993).

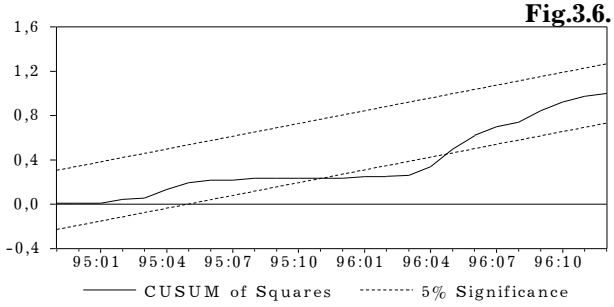
Table 3.8.

OLS estimation, Sample: 1994:05 1996:12
Dependent variable is Monthly Growth of the stock of Real Dollar Banknotes, $\Delta m_{0\$n,t}$

	one-step procedure		two-step procedure	
Variable	Coefficient	T-Statistic	Coefficient	T-Statistic
$\Delta\Delta S_t$	1,20	6,56	-2,02	-4,77
$\Delta\Delta S_t D_c$			2,78	6,20
Δy_t	0,41	3,97	0,37	3,34
u_{t-1}			-0,58	-5,21
c	-1,07	-2,50	0,02	3,99
t	0,01	5,31		
$m_{0\$,t-1}$	-0,24	-4,77		
ΔS_{t-1}	0,99	5,34		
y_{t-1}	0,19	2,20		
D_C	0,17	3,52		
$D_{4/5/6/95}$	-0,12	-3,50	-0,16	-6,26
$D_{3/96}$			-0,08	-2,58
$D_{8/96}$			0,04	1,98
Adjusted R-squared		0,86		0,83
Durbin-Watson statistic		1,92		1,43
Breusch-Godfrey				
Serial Correlation LM Test:		0,22		4,44
Obs*R-squared (Probability)		(0,90)		(0,11)
White Heteroskedasticity Test:		15,88		13,21
Obs*R-squared (Probability)		(0,32)		(0,28)
ARCH Test:		0,50		1,24
F-statistic(4,29) (Probability)		(0,74)		(0,32)
Normality Test:		5,28		0,93
Jarque-Bera (Probability)		(0,07)		(0,63)
Ramsey RESET Test: (Fitted^2)				
F-statistic (Probability)		0,05		0,43
Ramsey RESET Test: (Fitted^2),		(0,82)		(0,52)
(Fitted^3)		0,30		0,41
F-statistic (Probability)		(0,74)		(0,67)

The standard tests indicate that the residuals are well behaved (normality, absence of autocorrelation and of heteroskedasticity). Next we present the stability tests for the one step estimated regression of Table 3.8. The CUSUM of Squares test, shown in Fig.3.6, indicates that regr. (11) estimated with the one-step procedure is unstable at the 5% level of significance. The instability occurs in the first half of 1996 at the time of Yeltsin's campaign for reelection. The recursive parameter estimates

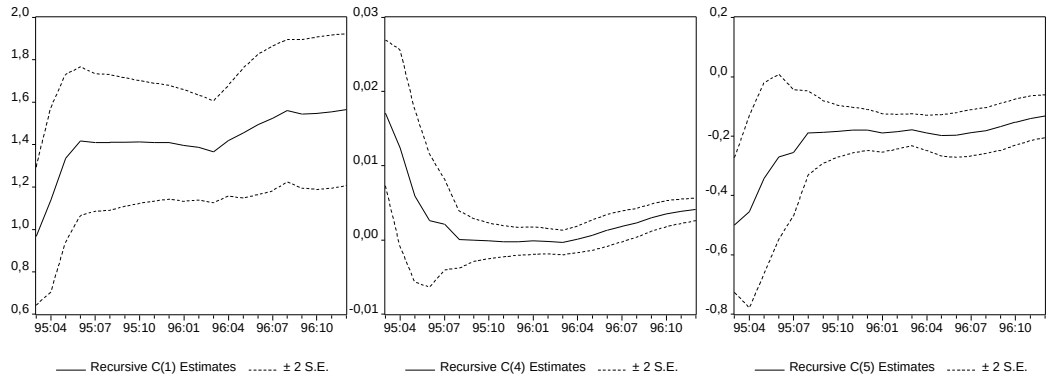
Fig.3.6.



for this regression, shown in Fig.3.7, indicate a break in the coefficients of $\Delta\Delta S_t$, of the time trend and of $m_{0\$,t-1}$ about one year earlier, during the initial phase of the restrictive monetary policy which finally brought inflation under control.

The stability tests presented confirm that a structural break occurred in the demand for dollar banknotes in Russia at the time of the introduction of the corridor or slightly later, as the period of hectic purchases of dollar banknotes came to an end and the purchases settled down to a more moderate pace.

Fig.3.7.



In order to take into account the possibility that some or all current explanatory variables may be endogenously determined we reestimated the second regression of Table 3.8 by 2SLS, using as instruments the values of the "endogenous" variables lagged once and twice, the exogenous variables, some dummies and a time trend: $\Delta\Delta S_{t-1}$, $\Delta\Delta S_{t-1}$ D_c, Δy_t, u_{t-1}, $\Delta(i_{R\$,t-1} - i_{U,t-1})$, c, t, $D_{4/5/6,95}$, D_C, D_K, D_E, $D_{3/96}$. The first regression of Table 3.8 was not reestimated by 2SLS because the number of degrees of freedom is not sufficiently high. The results are presented in Table 3.9. There is a significant change in the coefficients of the rates of change of the exchange rate, but the coefficients of all explanatory variables remain significantly different from zero and the residuals of the regression continue to be well behaved. Thus the possibility that the current explanatory variables may be partly endogenous does not invalidate the OLS estimates presented in Table 3.8.

Table 3.9.

2SLS estimation, Sample: 1994:07 1996:12
Dependent variable: Monthly Growth of Stock of Real Dollar Banknotes, Δ $m_{0\$n,t}$

Variable	Coefficient	T-Statistic
$\Delta\Delta S_t$	-2,94	-3,66
$\Delta\Delta S_t$ D_c	3,33	2,58
Δy_t	0,40	2,64
u_{t-1}	-0,64	-3,84
c	0,03	4,15
$D_{5/6,95}$	-0,19	-3,42
$D_{3/96}$	-0,10	-2,46
Adjusted R-squared	0,74	
Durbin-Watson statistic	1,48	

Continued

Breusch-Godfrey Serial Correlation LM Test:	2,61
Obs*R-squared (Probability)	(0,27)
White Heteroskedasticity Test:	4,79
Obs*R-squared (Probability)	(0,90)
ARCH Test:	3,69
F-statistic(4,29) (Probability)	(0,45)
Normality Test:	1,14
Jarque-Bera (Probability)	0,57
Ramsey RESET Test: (Fitted^2)	
F-statistic (Probability)	0,88
Ramsey RESET Test:	(0,38)
(Fitted^2), (Fitted^3)	0,52
F-statistic (Probability)	(0,60)

3.4. The demand for US$ bank deposits at Russian banks

The explanatory variables which turned out to have significant coefficients in this demand function are the same as those in the demand for dollar banknotes. This holds for both the co-integrating equation and for the dynamic one. We skip the presentation of the co-integrating equation as for the demand for US$ banknotes because of the need to include the variable $\Delta S_t D_c$. A devaluation of the rouble had a positive impact on the demand for dollar deposits before the introduction of the corridor and a negative one after, like for US$ banknotes. The relevant scale variable is again real GDP instead of the real wage bill net of arrears. The political risk variable has a significant and positive effect on the demand for dollar deposits and there is a positive trend in this demand function (1,2% per month) which is, however, much smaller than for US$ banknotes (3,6% for the narrow aggregate and 5% for the broad one (see Appendix 2)). The time trend reflects the influence of variables not included in the model, like fear of taxation and fear that officially owned finanacial wealth may be automatically considered to be of a dubious origin which in many cases it is. This stronger underlying trend in the demand for US$ banknotes contributes to the explanation of the slower dedollarization after inflation reached its peak (see Section 1).

Table 3.10 contains the OLS estimates of the dynamic equations. Current real GDP and current changes in the exchange rate influence very significantly the dynamics of adjustment. Contrary to what we found for the one-step estimate of the demand for US$ banknotes, lagged political risk has a coefficient which is significanly different from zero at the 5% confidence level. The average adjustment lag is about 3 months according to the one-step estimate and slightly more than 2 according to the two-step estimate. The constant term in the two-step regression is not significantly different from zero.

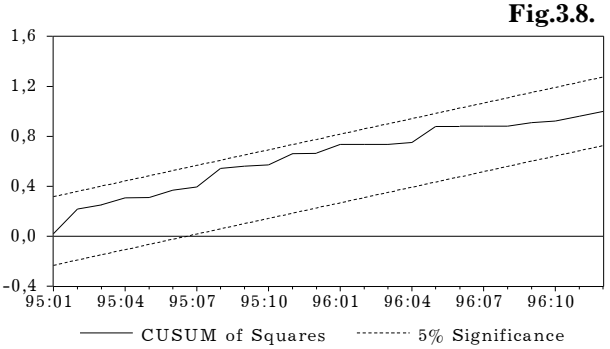
Table 3.10.

OLS estimation, Sample: 1994:05 1996:12
Dependent variable is Monthly Growth of Stock of Real Dollar Deposits, $\Delta dep\$_t$

	one-step procedure		two-step procedure	
Variable	Coefficient	T-Statistic	Coefficient	T-Statistic
$\Delta\Delta S_t$	1,45	6,23	-1,24	-2,41
$\Delta\Delta S_t$ D_c			2,68	4,75
Δy_t	0,71	3,88	0,66	4,35
u_{t-1}			-0,44	-3,21
c	-0,98	-1,25		
t	0,01	2,96		
$dep\$_{t-1}$	-0,31	-3,65		
ΔS_{t-1}	0,69	2,89		
y_{t-1}	0,17	1,06		
$(i_{R\$,t-1} - i_{U,t-1})$	0,10	2,22		
D_C	0,14	2,97		
$D_{10/94}$	0,16	2,89	0,17	4,00
$D_{7/94}$	0,22	4,73	0,17	3,84
$D_{5/96}$	0,10	2,30	0,10	2,33
$D_{4/95}$			0,10	2,28
Adjusted R-squared		0,76	0,74	
Durbin-Watson statistic		2,19	2,08	
Breusch-Godfrey				
Serial Correlation LM Test:		5,08	0,01	
Obs*R-squared (Probability)		(0,08)	(0,99)	
White Heteroskedasticity Test:		9,78	15,40	
Obs*R-squared (Probability)		(0,94)	(0,22)	
ARCH Test:		2,55	1,81	
F-statistic(4,29) (Probability)		(0,64)	(0,77)	
Normality Test:		2,83	2,19	
Jarque-Bera (Probability)		(0,24)	(0,33)	
Ramsey RESET Test: (Fitted^2)				
F-statistic (Probability)		3,46	3,77	
Ramsey RESET Test: (Fitted^2),		(0,06)	(0,05)	
(Fitted^3)		6,02	4,18	
F-statistic (Probability)		(0,05)	(0,12)	

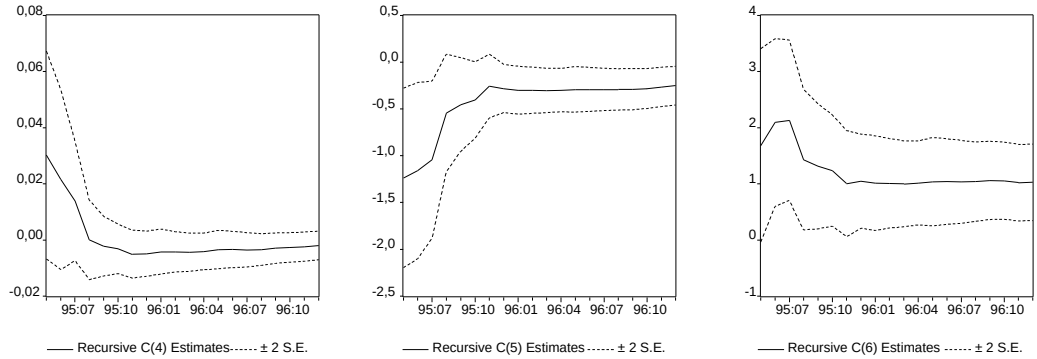
The standard tests indicate that the residuals are well behaved (normality, absence of autocorrelation and of heteroskedasticity). The CUSUM of Squares test shows that one-step regression is stable (see Fig.3.8), while for two-step regression the statistic reaches the 5% margin of the band around May 1996, just before the presidential election. Some coefficients of the one-step regression show show instability in the first half of 1995: parameter C(4), the coefficient

Fig.3.8.



of the trend, parameter C(5), the coefficient of the lagged dependent variable which measures the speed of adjustment towards long run equilibrium and parameter C(6) of changes in the exchange rate. The recursive parameter estimates for the above mentioned coefficients are shown in Fig. 3.9. All coefficients fall in absolute value. In particular the coefficient C(6) shows a reduced influence of exchange rate changes on the demand for US$ deposits.

Fig.3.9.



The 2SLS estimate of two-step regression is presented in Table 3.11. The list of instruments for 2SLS estimation is $\Delta\Delta S_{t-1}$, $\Delta\Delta S_{t-2}$, $\Delta\Delta S_{t-1} D_c$, Δy_t,$\Delta(i_{R\$,t-1} - i_{U,t-1})$, u_{t-1}, c, t, $D_{10/94}$, $D_{4/95}$, $D_{7/94}$, D_K, $D_{5/96}$. As for the other aggregates all coefficients remain significantly different from zero.

Table 3.11.

2SLS estimation, Sample: 1994:07 1996:12
Dependent variable is Monthly Growth of the Stock of Real Dollar Deposits, $\Delta dep\$_t$

Variable	Coefficient	T-Statistic
$\Delta\Delta S_t$	-1,47	-1,77
$\Delta\Delta S_t D_c$	2,96	3,47
Δy_t	0,68	4,22
u_{t-1}	-0,50	-3,34
$D_{10/94}$	0,18	3,89
$D_{7/94}$	0,16	3,671
$D_{3/96}$	0,10	2,30
$D_{4/95}$	0,10	2,22
Adjusted R-squared		0.75
Durbin-Watson statistic		2.20
Breusch-Godfrey Serial Correlation LM Test:		
Obs*R-squared (Probability)		0.01(0.99)
White Heteroskedasticity Test:		
Obs*R-squared (Probability)		14.77 (0.25)
ARCH Test:		1.91(0.75)
F-statistic(4,29) (Probability)		
Normality Test:		1.82(0.40)
Jarque-Bera (Probability)		
Ramsey RESET Test: (Fitted^2)		
F-statistic (Probability)		2.91(0.10)
Ramsey RESET Test: (Fitted^2), (Fitted^3)		
F-statistic (Probability)		1.31(0.29)

4. Summary and conclusions

This paper has presented estimates of demand functions for the main monetary aggregates in Russia from mid 1993 or mid 1994 (depending on data availability) to the end of 1996. The econometric model used as starting point is the EC-model. Hence for each aggregate the paper presents estimates of the long run relationship among the cointegrated variables and of the dynamic equations estimated in one step and in two steps. We found well behaved demand functions for the real aggregates in roubles (m_0 and m_2), despite the substantial changes in the inflationary environment, in the exchange rate and several shocks which hit the Russian economy during the sample period, like electoral uncertainties, exchange rate crises and changes in regulations concerning capital inflows. For rouble aggregates the estimated functions are reasonably stable and the speed of adjustment towards equilibrium relatively fast or about two months on average.

The main explanatory variables of the rouble aggregates are the real wage bill net of wage arrears (used as a substitute for real GDP which does not perform that well) and an opportunity cost variable: exchange rate expectations for the demand for rouble banknotes and the nominal interest rate on GKO for the broader monetary aggregate M2. In addition the demand for M2 is significantly influenced by the variability of inflation and by changes in political risk, measured by the difference between the yield on Taiga bonds and the yield on US Treasury bonds. The same variable for political risk also influences the demand for dollar aggregates with the opposite sign; thus during the period under analysis currency substitution between rouble and dollars was triggered in Russia both by changes in political risk and by changes in the rouble-dollar exchange rate or expectations thereof. In this sense the stabilization of the exchange rate and the return of some degree of political stability were two crucial steps in the attempt to de-dollarize the Russian economy and gain more control over rouble monetary aggregates.

The estimated demand functions for real dollar aggregates ($m_{0\$n}$ and dep$) are not equally well behaved. They present a major break around the time of the introduction of the exchange rate corridor (July 1995) and we tried to take this into account by allowing the coefficient of the variable reflecting currency substitution (the rate of change of the exchange rate) to change after the new exchange rate policy was introduced. However, this does not solve all the problems with these demand functions. They are either unstable according to the CUSUM of Squares test (like the demand for M0$N) or some of their parameters experience structural breaks in the first half of 1995. This may be also due to the unreliability of some of the variables used, especially the series for banknotes and real GDP.

Nevertheless, the estimates presented show that real GDP is the relevant scale variable for the dollar demand functions (as opposed to the net wage bill for the rouble aggregates), that deprecations and appreciations of the exchange rate (reflecting currency substitution) are very important in explaining the dynamics of these aggregates and that changes in political risk and a time trend are also significant. However, the coefficients of the latter two variables are usually unstable.

An interesting finding is that the estimated mean adjustment lags are significantly higher for dollar aggregates (about 3-4 months on average) than for rouble aggregates (about 2 months on average). However, for dollar deposits they are highly unstable and increase rapidly through time as stabilization proceeds. They

are probably a negative function of inflation or of the rate of change of the exchange rate, an hypothesis we did not test in this study.

The demand functions estimated could be useful in simulating monetary programs for Russia. They could also give useful indications as to whether large increases in the money supply caused by capital inflows are matched or not by increases in real money demand and hence whether they are inflationary or not. Finally they could shed useful insights into the past and future speed of de-dollorization. All this is left for future work. The objective of this paper was limited to the analysis of whether stable demand functions existed for the main Russian rouble and US$ monetary aggregates and to the analysis of which are the main variables influencing them.

Appendix 1. Sources and definition of the data used

Here we present the precise definition of the data, the period for which they are available and the sources. All data are monthly.

M0 is the stock of rouble banknotes circulating outside the CBR and commercial banks (January 1992 to January 1997, Bulletin CBR).

M2 is the stock of money. It equals the sum of M0 and rouble deposits at Russian banks (January 1992 to January 1997, CBR).

M0$N is a narrow estimate of the stock of US dollar banknotes circulating in Russia (January 1992 to December 1996). To construct this estimates we use the following data:

1) the net purchases of foreign currency by households from banks as the difference between the purchases and sales of hard currency of households, monthly, since January 1992 (Estimates of Russian Economic Trends).

2)The net inflow of foreign currency through the authorised banks, monthly, since June 1993 (Bulletin CBR).

3) the net expenditures for shuttle trade, tourism, and by immigrants and others, quarterly, since September 1993 (Balance of Payments, CBR).

Then, we calculated the series of the stock of dollar banknotes as follows:

a) For the period from January 1992 to August 1993 we simply used monthly net purchases of hard currency by households as a proxy for net inflows of dollar banknotes through authorised banks.

b) For the period from September 1993 onwards we used more reliable data on the net inflows of foreign currency through the authorised banks and linked it up the series on net purchases of foreign currency by households available before.

c) For the period since September 1993 we subtracted from net inflow of dollar banknotes through authorised banks the net expenditures by shuttle traders, tourists and immigrants as estimated in the CBR Balance of Payments (series 3 above)

d) Then we cumulated the gross flows from January 1992 to August 1993 and the net flows (see c) from September 1993 onwards to obtain an estimates of the stock of dollar banknotes in circulation. Implicitly, we assume that at the end of 1991 the stock of US dollar banknotes held in Russia was zero.

M0$B a broad estimate of the stock of US dollar banknotes circulating in Russia (January 1992 to December 1996). To construct this estimates we use the same series 1) and 2) and simply cumulate gross flows. The main difference between

the narrow and the broad estimates is therefore that for the latter one we did not correct the net inflows of dollar banknotes through banks for the net expenditures by shuttle traders, tourists and immigrants.

DEP$ is a stock of dollar deposits in Russian banks (January 1992 to December 1996, IMF, Bulletin CBR)

M0$N/All banknotes is the currency substitution ratio for banknotes, where "all banknotes" is a sum of rouble (M0) and dollar (M0$N) banknotes circulating in Russia (January 1992 to December 1996).

DEP$/All deposits is the currency substitution ratio for deposits, where "all deposits" is a sum of rouble and dollar (DEP$) deposits in Russian banks (January 1992 to December 1996).

PC is a Consumer price Index (January 1992 to January 1997, Goskomstat).

GDP is a nominal GDP (January 1992 to January 1997, Goskomstat).

y is a real GDP (January 1994 to January 1997, Goskomstat).

w is a real net of arrears wage bill (April 1992 to January 1997, Goskomstat). To get w we subtract the monthly changes of wage arrears from the average wage multiplied by employment, and then deflated the difference by the Consumer Price Index.

$\mathbf{i_R}$ is the average nominal yield on GKO (May 1993 to January 1997, MICEX)

$\mathbf{i_{R,\$}}$ is nominal yield on Taiga bonds (April 1994 to January 1997, Moscow Times)

$\mathbf{i_U}$ is a nominal yield on US medium term Treasury bills (January 1992 to January 1997, IMF).

S is a natural logarithm of the rouble-US dollar exchange rate (January 1992 to January 1997, MICEX).

$\mathbf{S^*}$ is a proxy for expectations of exchange rate changes, which is calculated as the weighted average of the rouble-dollar forward discount (April 1993 to January 1997, MICEX.) with weigh equal to 0,7 and the difference between average nominal yield on GKO(i_R) and the nominal yield on Taiga bonds ($i_{R,\$}$), with weight equal to 0,3.

$\boldsymbol{\sigma_\pi}$ is a variability of inflation, measured as the standard deviation of inflation from months t-7 to month t-1 (July 1992 to January 1997).

Appendix 2. The demand for dollar banknotes using the broader estimate ($m_{0\$b}$)

Table A2.8 contains the one and two-steps estimates of the dynamic equation for $m_{0\$b}$. It should be compared with Table 3.8 in the text. The main differences between the two tables are that the mean adjustment lags estimated from the one-step and the two-step procedure are now the same (about 3 months), while before they were not. The regression estimated with the two-step procedure does not pass the Ramsey Reset Test for Functional Form Misspecification. The residuals of both regressions are not autocorrelated, they are normally distributed and not heteroskedastic.

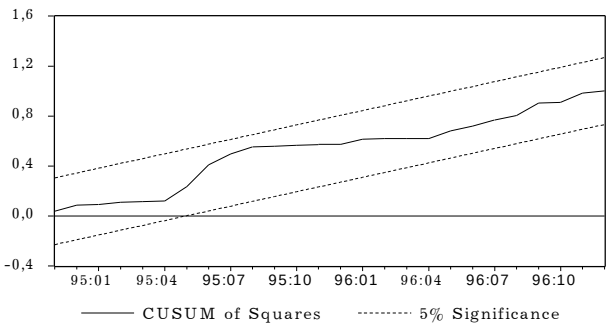
Table A2.8.

OLS estimation, Sample: 1994:05 1996:12
Dependent variable is Monthly Growth of Demand for Real Dollar banknotes, $\Delta m_{0\$b,t}$

	one-step procedure		two-step procedure	
Variable	Coefficient	T-Statistic	Coefficient	T-Statistic
$\Delta\Delta S_t$	1,18	13,50	-0,80	-2,96
$\Delta\Delta S_t D_c$			1,93	6,43
Δy_t	0,32	6,23	0,27	3,69
u_{t-1}			-0,27	-2,28
c	-0,45	-2,29	0,03	6,40
t	0,01	8,59		
$m_{0\$,t-1}$	-0,24	-9,13		
ΔS_{t-1}	0,95	9,98		
y_{t-1}	0,13	3,08		
D_C	0,08	4,59	0,03	3,46
$D_{4/95}$	-0,04	-2,40	-0,10	-5,34
$D_{12/94}$	-0,05	-3,74	-0,09	-4,11
$D_{10/94}$			0,09	4,06
Adjusted R-squared		0,95	0,88	
Durbin-Watson statistic		2,33	2,09	
Breusch-Godfrey				
Serial Correlation LM Test:		2,29	0,30	
Obs*R-squared (Probability)		(0,32)	(0,86)	
White Heteroskedasticity Test:		13,60	17,73089	
Obs*R-squared (Probability)		(0,56)	(0,12)	
ARCH Test:		0,63	0,39	
F-statistic(4,29) (Probability)		(0,64)	(0,81)	
Normality Test:		3,15	0,90	
Jarque-Bera (Probability)		0,206836	0,636363	
Ramsey RESET Test: (Fitted^2)				
F-statistic (Probability)		0,27	2,67	
Ramsey RESET Test: (Fitted^2), (Fitted^3)		(0,61)	(0,12)	
F-statistic (Probability)		0,25	6,22	
		(0,78)	(0,01)	

Fig. A2.6 shows the CUSUM of Squares test of the one-step estimated regression of Table A2.9. It indicates this the equation is stable. The CUSUM of Squares test of the two-step regression of Table A2.8 shows that the statistic touches the margin of the 5% significance band (not shown here). The figure showing the recursive parameter estimates does not present big differences

Fig.A2.6.



with respect to Fig.3.7 in the text and is not shown here to save space.

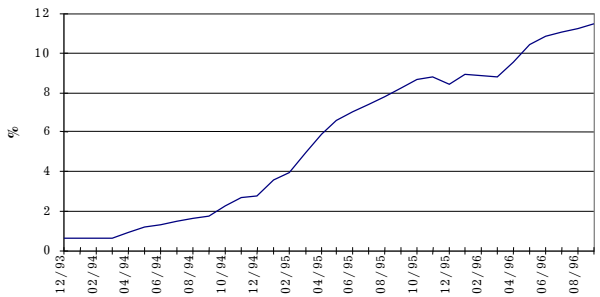
It would be difficult on the basis of the evidence presented in this appendix and in Section 3.3 to decide for which aggregate, the narrow or the broad one, we were able to estimate more satisfactory demand functions and hence in which estimate of the stock of dollar banknotes holdings we should put more confidence. If one decided to trust the one-step procedure more, as theory would suggest, then the broad aggregate performs slightly better because the demand function is stable and because the explanatory power of the regression is higher. In addition for the broader aggregate the mean adjustment lags estimated from the one-step and the two-step procedures are the same. But we admit that the evidence in favour of the broad aggregate is very thin, indeed.

The 2SLS estimate of the two-step regression of Table A2.8 does not significantly change the results of the OLS estimate. Hence the relevant table is not shown here to save space.

Appendix 3. The growing share of Veksels

Veksels, promissory notes issued by enterprises and banks, have started to grow since the beginning of 1994. They acquired more and more the role of medium of exchange. Therefore it is worth to define a broader rouble monetary aggregate which adds Veksels to rouble M2 and which we call for convenience M3. Fig.A3.1 shows the share of Veksels in M3.

Fig.A3.1.



The share increased from 0,6% at the beginning of 1994 to 11,5 in September 1996. We have not estimated a demand for m_3, given the still limited importance of Veksels in m_3 for the average of the sample period. However, they may have become important to forecast inflation in Russia towards the end of the sample period. The test of this hypothesis is something we leave for future research on the changing determinants of Russian inflation.

Appendix 4. Estimation of the demand for money with alternative scale variables: w and y

Here we present the estimated demand functions for both rouble and dollar monetary aggregates with the alternative scale variables w and y. In order to ease the comparison we reproduce here the regressions already presented in the text. We limit the comparison to the one-step dynamic regressions in order to save space. Table A4.1 contains the one-step estimation of the dynamic equation of rouble banknotes with the real wage bill net of arrears (w_t) and the real GDP (y_t) as a scale variable. The first regression is reproduced from Table 3.2 of the text, first column. The regression with real GDP as scale variable yields very unsatisfactory results.

The coefficients of all lagged levels of the variables (the cointegrating variables) are insignificantly different from zero at the 5 or 10% level. This suggests the absence of a cointegration relationship among $m_{0,t}$, y_t and S_t^*. Formal tests of cointegration without the political risk variable confirm this hypothesis. With the political risk variable we find only weak cointegration.

Table A4.1.

OLS estimation, Sample: 1994:01 1997:01
Dependent variable is Monthly Growth of Real Banknotes, $\Delta m_{0,t}$

	real wage bill net of arrears (w_t)		real GDP (y_t)	
Variable	Coefficient	T-Statistic	Coefficient	T-Statistic
Δw_t	0,79	11,47		
Δy_{t_*}			0,81	3,80
ΔS_t^*	-0,01	-3,18	-0,01	-1,43
c	-2,20	-5,50	1,27	1,55
$m_{0,t-1}$	-0,55	-5,79	-0,06	-0,80
w_{t-1}	0,63	5,72		
y_{t-1_*}			-0,26	-1,40
S_{t-1}^*	-0,01	-3,34	-0,003	-0,67
D_C	-0,08	-3,53	-0,005	-0,16
D_{12}	-0,09	-3,79	0,03	0,75
D_3	-0,06	-2,78	-0,07	-1,66
D_K	-0,07	-3,78	-0,03	-1,10
Adjusted R-squared		0,84		0,48
Durbin-Watson statistic		2,11		1,58

The one-step dynamic regression with the political risk variable performs somewhat better than the one without but is still highly inferior to the one presented in the text (with w). In particular the speed of adjustment to equilibrium becomes highly implausible. This is shown in Table A4.2 below. The constant term was never significantly different from zero.

Table A4.2.

OLS estimation, Sample: 1994:05 1997:01
Dependent variable is Monthly Growth of Real Banknotes, $\Delta m_{0,t}$

Variable	Coefficient	T-Statistic
Δy_t	0,91	6,01
$\Delta(i_{R\$,t} - i_{U,t})$	-0,25	-3,21
$m_{0,t-1}$	-0,13	-1,94
y_{t-1}	0,04	2,05
$(i_{R\$,t-1} - i_{U,t-1})$	-0,06	-1,72
$D_{8/96}$	-0,08	-2,62
Adjusted R-squared	0,64	
Durbin-Watson statistic	2,14	
Breusch-Godfrey Serial Correlation LM Test:		
Obs*R-squared (Probability)	1,84 (0,40)	
White Heteroskedasticity Test:		
Obs*R-squared (Probability)	17,04 (0,11)	
Normality Test:		
Jarque-Bera (Probability)	0,07 (0,96)	
ARCH Test:		
F-statistic (Probability)	0,93 (0,46)	
Ramsey RESET Test: (Fitted^2)		
F-statistic (Probability)	2,40 (0,13)	
Ramsey RESET Test: (Fitted^2), (Fitted^3)		
F-statistic (Probability)	1,17 (0,32)	

From Tables A4.1 and A4.2 we can conclude that the wage bill net of arrears performs much better as scale variable in the demand function for real rouble banknotes. The same conclusion holds for the demand function of real rouble money.

Tables A4.3 and A4.4 show that in the one-step regressions w performs much better than y also for the real demand for m2. The first column of Table A4.3 is reproduced from Table 3.5 in the text. Table A4.4 includes the political risk variable in the dynamic equation.

Table A4.3.

OLS estimation, Sample: 1994:01 1997:01
Dependent variable is Monthly Growth of Real Money, $\Delta m_{2,t}$

	real wage bill net of arrears (w_t)		real GDP (y_t)	
Variable	Coefficient	T-Statistic	Coefficient	T-Statistic
Δw_t	0,35	10,83		
Δy_t			0,52	4,49
$\Delta\sigma_{\pi,t}$	-0,01	-2,80	-0,009	-1,07
$\Delta i_{R,t}$	-0,006	-3,02	-0,007	-1,72
$\Delta(i_{R\$,t} - i_{U,t})$	-0,11	-2,95	-0,10	-1,41
c	-0,58	-4,10	-0,02	-0,03
$m_{2,t-1}$	-0,57	-6,61	-0,13	-1,78
w_{t-1}	0,39	6,22		
y_{t-1}			0,06	0,45
$\sigma_{\pi,t-1}$	-0,01	-2,43	0,001	0,24
$i_{R,t-1}$	-0,01	-3,71	-0,0065	-1,98
D_3	-0,06	-4,00	-0,07	-2,23
D_E	0,04	2,95	0,04	1,21
Adjusted R-squared		0,88		0,60
Durbin-Watson statistic		2,05		1,66

Although according to the Johansen test there is a cointegration relationship among real rouble money ($m_{2,t}$), real GDP (y_t), and the country risk variable ($i_{R\$,t} - i_{U,t}$) the results of estimation of the dynamic equation are absolutely unsatisfactory (see Table A4.4).

Table A4.4.

OLS estimation, Sample: 1994:01 1997:01
Dependent variable is Monthly Growth of Real Money, $\Delta m_{2,t}$

Variable	Coefficient	T-Statistic
Δy_t	0,52	5,30
$\Delta(i_{R\$,t} - i_{U,t})$	-0,22	-4,34
$m_{2,t-1}$	-0,03	-0,39
y_{t-1}	0,02	0,51
$(i_{R\$,t-1} - i_{U,t-1})$	-0,02	-0,86
$D_{10/94}$	-0,09	-2,78
$D_{8/96}$	-0,04	-2,02
Adjusted R-squared	0,66	
Durbin-Watson statistic	1,84	

We turn now to the substitution of y with w in the demand functions for US$ assets. The estimation of the dynamic equations for the demand for dollar banknotes and dollar deposits with w instead of y as a scale variable yields almost satisfactory

results (see Tables A4.7 and A4.8). However, the mean adjustment lag is implausibly high (one year for dollar banknotes and about six months for dollar deposits and w_t is insignificant and in the long-run cointegration equations (see Tables A4.5, A4.6). These findings cast doubts on the use of w as a scale variable in the demand function for dollar aggregates.

Table A4.5.

OLS estimation, Sample: 1994:04 1996:12
Dependent variable is Logarithm of Monthly Real Demand for Dollar Banknote, $m_{0\$n,t}$

Variable	Coefficient	T-Statistic
c	-0,14	-0,30
t	0,03	10,55
ΔS_t	-6,85	-3,59
$\Delta SD_{c,t}$	7,83	4,02
w_t	-0,04	-0,43
$(i_{R\$,t} - i_{U,t})$	-0,006	-0,61
D_C	0,72	10,49
$D_{4/95}$	-0,27	-3,16
Adjusted R-squared	0,86	
Durbin-Watson statistic	1,22	

Table A4.6.

OLS estimation, Sample: 1994:04 1996:12
Dependent variable is Logarithm of Monthly Real Demand for Dollar Deposits, $DEP\$_t$

Variable	Coefficient	T-Statistic
c	-0,33	-0,35
t	0,009	2,12
ΔS_t	-6,56	-3,23
$\Delta SD_{c,t}$	7,60	3,67
w_t	0,10	0,62
$(i_{R\$,t} - i_{U,t})$	0,15	1,25
D_C	0,31	5,10
$D_{10/94}$	0,22	2,24
Adjusted R-squared	0,86	
Durbin-Watson statistic	1,11	

Table A4.7.

OLS estimation, Sample: 1994:01 1997:01
Dependent variable is Monthly Growth of Real Dollar Banknotes, $\Delta m_{0\$n,t}$

	real GDP (y_t)		real wage bill net of arrears (w_t)	
Variable	Coefficient	T-Statistic	Coefficient	T-Statistic
$\Delta\Delta S_t$	1,20	6,56	1,07	6,32
Δy_t	0,41	3,97		
Δw_t			0,13	3,02
c	-1,07	-2,50	-0,92	-4,64
t	0,01	5,31	0,006	4,33
$m_{0\$,t-1}$	-0,24	-4,77	-0,13	-2,82
ΔS_{t-1}	0,99	5,34	0,90	5,15
y_{t-1}	0,19	2,20		
w_{t-1}			0,17	4,03
D_C	0,17	3,52	0,07	1,50
$D_{4/5/6/95}$	-0,12	-3,50	-0,06	-1,89
Adjusted R-squared		0,86	0,87	
Durbin-Watson statistic		1,92	1,68	

Table A4.8.

OLS estimation, Sample: 1994:05 1996:12
Dependent variable is Monthly Growth of Stock of Real Dollar Deposits, $\Delta dep\$_t$

	real GDP (y_t)		real wage bill net of arrears (w_t)	
Variable	Coefficient	T-Statistic	Coefficient	T-Statistic
$\Delta\Delta S_t$	1,45	6,23	1,25	4,82
Δy_t	0,71	3,88		
Δw_t			0,21	2,82
c	-0,98	-1,25	-0,31	-0,85
t	0,01	2,96	0,005	3,29
$dep\$_{t-1}$	-0,31	-3,65	-0,21	-2,63
ΔS_{t-1}	0,69	2,89	0,35	1,48
y_{t-1}	0,17	1,06		
w_{t-1}			0,04	0,50
$(i_{R\$,t-1} - i_{U,t-1})$	0,10	2,22	0,03	3,56
D_C	0,14	2,97	0,14	2,86
$D_{10/94}$	0,16	2,89	0,17	2,86
$D_{7/94}$	0,22	4,73	0,22	4,43
$D_{5/96}$	0,10	2,30	0,1	2,1
Adjusted R-squared		0,76	0,77	
Durbin-Watson statistic		2,19	2,19	

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