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Byung-Yeon Kim, Jukka Pirttilä
and Jouko Rautava

Money, Barter and Inflation in Russia

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Contents

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Money, Barter and Inflation in Russia

Abstract

Using a macroeconometric framework, this paper analyses relationships among money, barter and inflation in Russia during the transition period. Following the development of a theoretical framework that introduces barter in a standard small open economy macro model, we estimate our model using structural cointegration and vector error correction methods. Our findings suggest that barter has resulted partly from output losses and partly from a reduction in real money balances, but to a lesser extent. There is some evidence that the effect of barter on prices is less than that of money. We also find that increases in barter are affected by banking failure. Our results imply that a macro model that excludes barter fails to capture all the relevant information for inference on money and inflation in Russia.

Key words: Barter, money, inflation, cointegration, error-correction mechanism, Russia

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Byung-Yeon Kim, Jukka Pirttilä ja Jouko Rautava

Raha, vaihtokauppa ja inflaatio Venäjällä

Tässä tutkimuksessa tarkastellaan rahan, vaihtokaupan ja inflaation välisiä yhteyksiä Venäjän siirtymäkauden aikana käyttämällä makrotaloudellista viitekehystä. Teoreettisessa mallinnuksessa yhdistetään ensin vaihtokauppa tavanomaiseen pienen avotalouden makromalliin, minkä jälkeen estimoidaan empiirinen malli käyttämällä rakenteellista yhteisintegroituvuus- ja vektorivirheenkorjausmallia. Tulokset osoittavat, että niin tuotannon supistuminen kuin reaalisen rahan määrän pieneneminenkin ovat saaneet aikaan vaihtokaupan kasvun, mutta niin, että rahan määrän vaikutus on tuotantovaikutusta pienempi. Lisäksi saadaan jonkin verran todistusaineistoa siitä, että vaihtokaupan vaikutus hintatasoon on pienempi kuin rahamäärän. Edelleen osoittautuu, että pankkijärjestelmän heikkous on yksi vaihtokaupan syy. Tulokset osoittavat, että sellaiset makromallit, joissa ei oteta huomioon vaihtokauppaa, voivat johtaa virheellisiin päätelmiin Venäjän rahatalouden ja inflaation luonteesta.

Asiasanat: vaihtokauppa, raha, inflaatio, yhteisintegroituvuus,
virheenkorjausmekanismi, Venäjä

1 Introduction

The transformation process in the former Soviet republics and Eastern Europe can be viewed as a transition towards a market economy involving the universal use of money as a medium of exchange. In centrally planned economies, money played only a passive role in the allocation of resources for production by accommodating the decisions made by planning authorities. In this regard, it is natural to expect that the transition process would replace a plan-based coordination mechanism with a market-based one through monetisation as well as marketisation.

Contrary to such expectations, we find that the Russian economy is still only partially monetised. The Russian economy has undergone severe demonetisation since the outset of market reforms. Although price liberalisation in 1992 appears to have had a positive impact on monetisation, the share of barter started to increase rapidly in 1994. At its peak in 1998, over 50% of industrial transactions, as measured by the volume of total enterprise transactions took place without money: enterprises used various forms of monetary surrogates such as barter and inter-enterprise arrears.[1] In other words, Russian forms of barter have served as a medium of exchange and a form of credit, the functions of which are normally assigned to money.

It is interesting to observe that demonetisation in Russia clearly differs from the classical case of demonetisation which occurs during periods of hyperinflation. The demonetisation process in Russia has intensified since 1994, when inflationary pressure subdued substantially. Following an extremely unstable period at the outset of market reforms, Russia managed to introduce its first real stabilisation programme only in 1995. The annual inflation rate experienced a

[1] The Russian usage of barter includes not only the exchange of goods (pure barter) but also offsets (in which firms write off mutual debt) and veksels (bills of exchange issued by corporations, banks, or local and regional governments). Yet, pure barter dominates the other non-monetary transactions. For details on forms of barter, see Aukutsionek (1998).

sharp decrease from 840% in 1993 to 11% in 1997 but during the same period the share of barter transactions soared from 9% to 42%.

The above observations raise several questions that are interesting not only for transition economics but also for monetary or macroeconomics.[2] Why does demonetisation occur during a non-hyperinflation period? What are the macroeconomic causes of the emergence and growth of barter transactions? In particular, was a monetary shock in the form of tightened monetary policy a source of demonetisation?[3] Or, as Ramey (1992) postulated in a slightly different context, did a real shock account for increases in the demand for non-monetary forms of exchange: has barter been used by enterprises to escape difficulties in production or sales? Theories are available but an incident in which the two hypotheses can be contested empirically rarely occurs. In this sense, the Russian experience provides a unique opportunity to explore these issues.

Barter can be viewed not only as an outcome but also a determining factor of several economic variables. Recently, Marvasti and Smyth (1999) estimated successfully a modified money demand equation that includes barter. They claim that ignoring the barter variable will lead to a serious mis-specification of the model. Given the possibility that demonetisation has impacts on other economic variables (Kim, 1999; Li, 1997), we extend our investigation to the effects of barter by analysing whether and how barter affects inflation and the demand for traditional forms of money (e.g., M2).

The interaction between barter and other macroeconomic variables, especially inflation and money demand, is particularly important for the Russian economy, given the size of the barter-based economy there. Both inflation and

[2] There is evidence that barter transactions have increased rapidly in advanced market economies such as the United States (Prendergast and Stole, 1996; Marvasti and Smyth, 1999). For example, Prendergast and Stole (1996) report that the number of North American companies that use barter transactions through exchanges or trading companies increased from 160,000 in 1986 to 380,000 in 1995 and the total value of such exchanges amounted to 8.46 bn. dollars in the US in 1995. Furthermore, they claim that this figure is highly underestimated because many firms barter in the absence of intermediaries.

barter in Russia have attracted a large amount of research recently. However, they have been analysed in separate strands of literature (this research is reviewed in detail in Section 2 below). Unlike most existing studies on Russian barter, we analyse money, barter and inflation using a macro-econometric framework, focusing on the period from 1994 to 2000. In more detail, given the strong possibility of interconnections among barter, money, and inflation, we do not investigate the three variables separately, as in earlier literature, but in an integrated way using a structural system, and estimate the system using cointegration and vector error correction models.

We found stable and meaningful long-run relationships for prices, real money demand, and real barter. In addition, our cointegration results suggest that barter is negatively associated with money and output, but the effect of output on barter is about twice as much as that of money. These results support the view that barter has served mainly as a way to avoid restructuring in severe recessions. There is also some evidence that increases in the use of barter instead of money reduce the price level, implying that barter affects prices less than money does. Lastly, we found that money and barter appear to be complements in the short run, while in the long run they are substitutes.

Our results are robust in that there are few diagnostic problems in both the cointegration and error correction models. Moreover, the inclusion of the proxy for the extent of the development of the banking sector does not change our basic results. We find that the fragile banking sector increases the use of barter as much as the insufficient money supply does, but the effect of output on barter is still the largest. It is found that, in terms of magnitude, the combined impact of the two variables related to a financial shock – an insufficient money supply and a weak banking sector – is just as significant as the production effect on barter.

The structure of the paper comprises the following: Section 2 reviews the related literature on money, barter and inflation in Russia, and Section 3 offers a

[3] Theories based on trade credit suggest this possibility (Meltzer, 1960; Brechling and Lipsey,

brief survey of key events in the Russian economy during the 1990s. Section 4 discusses the various proposed causes of barter and develops a model that incorporates barter as a component in a standard small open economy macro model. The model will serve as the basis of our empirical estimations. Section 5 presents a brief description of our data and the results of unit-root tests. Section 6 provides the results of empirical analysis based on long run cointegration. Section 7 deals with a short-run error correction model and its results. Section 8 analyses the robustness of the results by considering a long-run model, including a bank lending channel. Section 9 concludes the discussion.

2 Related Literature on Inflation, Money and Barter in Russia

Most of the earlier studies on Russian inflation are based on the quantity theory of money.[4] For example, Nikolic (2000) examines the lag structure of monetary policy intermediation on inflation and finds that the speed of transmission has decreased along with the stabilisation of the economy. Buch (1998) considers a single equation error-correction model for Russian money demand and discusses policy measures that are crucial for the sustainability of stabilisation. Korhonen (1998), while building still on the money demand relationship, adopts a more sophisticated econometric methodology, that is, using cointegration analysis and vector-error correction models (VECM). Somewhat surprisingly, none of the studies allow for other explanations apart from money-caused inflation.[5]

As for the barter phenomenon in Russia, there is a heated debate among economists on what factors caused barter to become so significant. Apart from institutional weaknesses that allow barter to survive (such as poor bankruptcy

1963; Prendergast and Stole, 1996; Petersen and Rajan, 1997).

[4] For related earlier work, see Hoggarth (1996) and Korhonen and Pesonen (1998).

[5] Such analyses are available for some other transition countries, such as Poland (Kim, 2001; Blangiewicz and Charemza, 1999) and Albania (Kalra, 1999). For a recent survey on cross-

and tax legislation, and the lack of payment discipline in the public as well as the private sectors), there are, broadly speaking, two competing views. Some argue that barter is a result of lagged restructuring (Gaddy and Ickes, 1998; Guriev and Ickes, 2000), while others emphasise the lack of liquidity, caused either by an insufficient money supply or the fragility of the banking system, as a prime reason for barter transactions (Marin et al., 1998; Commander and Mumssen, 2000; Marin, 2000). Much of the empirical evidence, which is based on cross-section or panel microeconometric analyses of firm-level data, appears to support the liquidity hypothesis on barter. For instance, Carlin et al (2000) and Commander et al (2000) find that firms that have limited access to financial resources and suffer from liquidity problems are more likely to rely on barter. While other reasons including a failure in the banking system exist for the liquidity squeeze, macroeconomic policies, particularly tight monetary policy, might have choked off part of the liquidity from the economy.

A standard approach using micro data is based on replies from managers of enterprises regarding questions about whether, why and to what extent they use barter. However, studies using firm-level survey data have a certain limitation. First, managers of firms might be reluctant to respond honestly to sensitive questions concerning the extent of barter trade because such trade might be related to tax evasion (Gaddy and Ickes, 1998; Carlin et al 2000). Moreover, the causes of barter perceived by firms are not necessarily real reasons for barter. For example, respondents might have incorrect information on the liquidity situation of their partners, who engage in barter transactions themselves (Guriev and Ickes, 1999).

In this regard, using aggregate data has a certain advantage: it can provide results that are less likely to be biased. Nevertheless, little work has been done on the determinants of barter using aggregate data. To our best knowledge, the only analysis of barter using macroeconomic data is Brana and Maurel (1999). They claim that barter increases with rising interest rates, in other words, when mone-

country and panel data analysis of inflation in transition economies, see ,eg, Cottarelli and

tary policy is tightened. Yet, their model is fairly limited; it considers only three variables: barter, interest rates and a variable capturing the financial situation of firms, and subsequently fails to take into account the two competing views mentioned above in their analysis.

3 Russian Economy During the 1990s

This section reviews the economic background underlying our empirical analysis. At the outset of the Russian transition, price liberalisation together with the monetary overhang inherited from the Soviet era led to hyperinflation in 1992 (see Figure 1 for monthly inflation dynamics in Russia from 1992 to 2000). During the years 1992-1994, inflation remained high. One of the reasons was the rouble zone, in which several former Soviet Republics issued roubles independently. This was only abandoned in the latter part of 1993.

In the summer of 1995, the Russian government adopted an exchange rate-based stabilisation programme in which the nominal value of the rouble was anchored by a crawling currency peg system. The programme was largely successful in bringing inflation down: annual inflation decreased from 129% in 1995 to 22% in 1996 and to 11% in 1997. However, fiscal consolidation failed and, as a result, the government debt stock increased in an unsustainable manner. When the Asian crisis hit the global economy in late 1997, Russia's situation deteriorated rapidly. Finally, in mid-August 1998, Russia was forced to devalue the rouble and, moreover, the government stopped servicing its debts. These events led to a full-scale financial crisis and paralysed Russia's already poorly functioning banking sector. Following the crisis, the authorities managed relatively soon to establish control over inflation in spite of increased inflationary pressures due to the weakening rouble. The economy began to recover in 1999, thanks to the de-

Doyle (1999).

valuation of the rouble and the high export prices of oil. Thus, while annual inflation in 1998 reached over 80 %, it decelerated to 37 % in 1999.

As Figure 2 shows, barter was at a relatively low level at the start of the transition period. Subsequently it increased steadily, with the biggest increase associated with the period of stabilisation. The 1998 devaluation led to better competitiveness and a better liquidity position for Russian firms and was followed by a reduction in barter. Since barter in Russia increased during a relatively stable period, it is less likely to be explained merely by the normal theory of shifting to goods-for-goods trade during hyperinflation.

Several implications can be drawn from the above description for our econometric analysis. First, there are great uncertainties concerning the data on the early years of Russia's transition. Overall volatility is high, data reliability is particularly low, and the presence of the rouble zone distorted the mechanism of monetary policy transmission within Russia. In our regressions, we have therefore started our analysis from January 1994. Second, one could argue that a regime change possibly caused structural breaks in the data. Empirical work using Russian macroeconomic data in this period must be prepared to test possible structural breaks in order to confirm the reliability of results. Finally, given the volatility of inflation and exchange rates, the presence of non-normality in the data series is expected and appropriate dummy variables should be used to control for exceptional outliers.

4 A Theoretical Framework

In this section, we derive a simple theoretical model of money demand, barter and the price level. We build our model on a standard small open economy framework by incorporating barter into it. This model is expected to provide information on what variables must be included in our empirical analysis and how many cointegration vectors are expected.

The starting framework without barter is an IS-LM type of model for a small open economy with five variables: the price level, broad money, the exchange rate, the interest rate, and output. Such a model normally consists of a standard money demand relationship (the LM curve), an IS-curve which relates output to interest rates, an uncovered interest rate parity that links the interest rate to the expected depreciation of the exchange rate, and a purchasing power parity (PPP) relation that sets the domestic price level equal to the foreign prices expressed in a domestic currency.[6]

We modify this framework, taking the Russian context into account. In other words, money demand and the price level are determined in the system, but we do not explicitly model output, the exchange rate and the interest rate. We believe that, for output, the transitional recession and structural change have been far more important determinants than short-run demand management policies. Likewise, capturing interest rate or exchange rate movements with the interest rate parity relationship will be extremely difficult. This leaves us with a model consisting of two equations: a money demand equation and a price equation based on PPP.

We introduce barter in the above framework and change the model accordingly. In addition, we add an equation determining barter in terms of the existing framework. This gives rise to the following three-equation system:

$$m_t - p_t = \alpha + \beta(y_t - p_t) + \gamma(b_t - p_t) + \delta r_t + \lambda e_t, \quad (1)$$

$$b_t - p_t = \rho + \zeta(y_t - p_t) + \mu r_t + \psi(m_t - p_t), \quad (2)$$

$$p_t = \pi + \sigma e_t + \theta p_t^* + \eta(b_t - p_t), \quad (3)$$

[6] Because of the paucity of data in the empirical part, we only consider here the determination of the overall price level instead of separate prices for tradable and non-tradable sectors. While we believe that the exchange rate channel is a key determinant of the overall price level in Russia, this assumption is nevertheless a simplification.

in which p_t denotes the price level, m_t (nominal) broad money demand, e the exchange rate defined as the ratio of the rouble to the US dollar, p_t^* the foreign price index, y_t output, r_t the nominal interest rate, and b_t the nominal value of barter.[7]

The money demand equation (1) represents a modification of standard money demand in an open economy. The real money demand $(m_t - p_t)$ is positively correlated with real output but negatively with the interest rate as well as the exchange rate.[8] Yet the inclusion of barter into the real money equation requires some justification. Commander et al (2000) find that barter is used mainly as a means of payment and as a source of trade credit in Russia, suggesting that barter is a substitute for the transaction demand role of money. We modify the money demand equation, taking into account the role of barter suggested above. First, an increase in the use of barter as a payment device reduces, ceteris paribus, the transaction demand for real money balances.

Second, barter fulfils the function of trade credit. The interpretation of barter as a form of trade credit is in line with the findings of earlier work on the impacts of trade credit on monetary policy transmission mechanisms and inflation, pioneered by Meltzer (1960) and Brechling and Lipsey (1963). According to the theory, the total liquidity of the firms is a sum of bank and trade credits. If monetary policy is tightened, firms may substitute trade credit for bank lending, and therefore the use of trade credit may offset some of the impacts of traditional monetary policy transmission through the bank lending channel. Recent empirical work by Petersen and Rajan (1997) and Kohler, Britton and Yates (2000) supports this argument and suggests that firms facing liquidity constraints are more prone to rely on trade credit, especially during periods of tight monetary

[7] All variables are in logs.

policy. In the Russian context, this means that the total credit available in the economy is the sum of money and trade credit (in the form of barter), and that tightened monetary policy may encourage firms to shift from using money to using barter.

Barter as a form of trade credit can also be incorporated into the money demand relationship. As shown in a well-known article by Bernanke and Blinder (1988), the IS-LM framework may be modified to take the bank lending channel into account (or, in other words, the credit view of monetary policy). We also modify the LM curve to consider the possibility of trade credit in the form of barter. In sum, both the transaction-demand view of money and theories of money as a source of bank lending can justify the inclusion of barter as a substitute for money in the money demand equation. Thus, the expected signs for the parameters in (1) are as follows: $\beta > 0; \gamma < 0; \delta < 0; \lambda < 0$.

The equation for the real value of barter (2) is also intended to reflect potential substitutability between money and barter. In a manner similar to the discussion above, real money should be included in the barter equation if money and barter are mutual substitutes. Therefore, it is expected that barter is a decreasing function of real money. Note that money and barter may be imperfect substitutes, implying that they do not necessarily move in a one-to-one relation. In addition, it is likely that barter is an inferior means of payment and source of credit (because of higher transaction costs, higher interest rates and the default risk in the barter form of trade credit). Thus, it may be the case that barter reacts negatively to a reduction in real money balances, but the availability of barter itself does not necessarily induce firms to abandon the use of money, which is a more efficient means of transaction.

While it is probable that barter increases if real money balances decrease, the overall effect of tightened monetary policy (reducing the money supply or in-

[8] As Walsh (1998) suggested, the standard LM relationship (or the money demand relationship) can be deduced from the micro foundations of the use of money (from the money-in-the-utility function or cash-in-advance models) that justify the transaction-demand role of money.

creasing interest rates) on barter is ambiguous. Brana and Maurel (1999) claim that barter increases as a response to higher interest rates on bank loans. However, the relation between interest rates and barter may be more complicated. Barter as a form of trade credit also bears (implicit) interest.[9] If the interest rates on bank loans increase, an arbitrage relation between different forms of assets (or liabilities) implies that the interest rate on trade credit (barter) increases as well. In fact, if trade credit and bank loans were perfect substitutes, their interest rates would have to be equal for both types of credits to be demanded. Together with the innocuous assumption that the demand for credit decreases with interest rates, this implies that barter is a decreasing function of interest rates, even if the interest rate that is included in the barter equation is interest on bank lending. Thus, we expect the negative association between barter and money but the relationship between barter and the interest rate is ambiguous.

The role of barter as a substitute for money is directly related to explanations of the lack of liquidity in transition economies (Commander and Mumssen, 2000; Marin 2000), discussed already in the previous section. Another broad category of explanations for the emergence and growth of barter (Gaddy and Ickes, 1998; Guriev and Ickes, 2000) suggests that barter is a result of the lagged restructuring of firms in conditions of declining demand and reduction in output. According to these explanations, a decline in output increases the use of barter, as firms use barter as a survival strategy. Thus we expect a negative sign for output in the barter equation.[10] To reiterate, the expected signs in (2) are: $\zeta < 0; \psi < 0; \mu = ?$.

The price equation (3) is derived from the PPP relation with the addition of barter. This implies that the price level is an increasing function of the exchange

[9] Typically, in trade credit deals the customer gets a discount if he pays by cash immediately and must pay the full amount if he utilises the extended maturity. In Russia, there is also evidence that cash prices are lower than barter prices, suggesting that barter deals bear interest (see, for example, Commander and Mumssen 1998).

[10] In principle, if barter is used dominantly for transaction purposes, barter demand would be increasing with output (in a way similar to the way in which real money reacts to output). Yet, it is also plausible that the survival motive for engaging in barter dominates, suggesting a negative relationship between barter and output.

rate (depreciation) and the foreign price level. Because of the relatively minor impact of foreign price inflation (in comparison to Russian domestic inflation), and because of the rather severe degrees-of-freedom restriction, we will exclude foreign price impacts in the empirical part. Barter is admittedly introduced into the price equation in a rather atheoretical way. However, there can be several ways in which barter may affect prices. Increased liquidity resulting from a rise in barter forms of credit could lead to a higher price level. Yet barter is not only a substitute for monetary variables in Russia: it reflects demonetisation in the economy. As monetisation usually leads to inflation (Li, 1997), demonetisation can decrease the price level. Of course, an additional motive to introduce barter in the price equation is our empirical strategy that relies on a system approach; one of the purposes of this strategy is to check if the price level actually depends on the level of barter as well. The coefficients in the price equation are presumed to take the following signs: $\sigma > 0; \theta = 0; \eta = ?$.

In the following empirical analysis, we attempt to identify the three long-run equations, (1), (2), and (3).

5 Data and Unit Root Tests

The theoretical framework outlined in the previous section suggests that we use six variables: prices (*p*), money (*m-p*), interest rates (*r*), exchange rate (*e*), output (*y-p*), and barter (*b-p*).[11] All variables are in log forms. Table A1 in the Appendix provides the detailed definitions and statistical sources of the data. The data is monthly, covering the period from January 1994 to December 2000, although we use data from January 1992 to December 2000 for the figures presented be-

[11] Barter may be measured in a number of ways. The simplest one is to use the index based on the enterprise survey conducted by the Russian Economic Barometer. This variable (*sb*) refers to the log of the share of barter in total enterprise transactions. In order to follow our idea of treating barter as a potential source of credit, we use the log of the volume index of barter, *b-p*,

low. For the output data, we use industrial output instead of GDP, because monthly official GDP data is not available.[12]

We have conducted both augmented Dickey-Fuller (ADF) and Phillips-Perron tests for unit roots, with the sample covering the years 1994 – 2000.[13] Both the cases, of including constant and trend versus including only constant, were considered in the tests. Of course, we are fully aware that results from unit root tests using a small sample must be interpreted cautiously.

The results of ADF tests suggest that real money (*m-p*), industrial production (*y-p*) and the interest rate (*r*) are I(1) variables. For barter (*b-p*) and the exchange rate (*e*), we obtain mixed information: they appear either as I(1) or I(2) variables, depending on whether a trend is included in the test. Because the graphs of first differences of the interest rate and the exchange rate do not seem to be trending, we infer that these variables are I(1) as well. Yet, the price level (*p*) could be a I(2) variable, according to the ADF tests. On the other hand, results from the Phillips-Perron test suggest that all the variables are at most I(1). Overall, these somewhat conflicting results can be reconciled so that the price level *p* is an I(1) variable as well as all other variables.

6 Empirical Analysis: Structural Cointegration

On the basis of the theoretical framework, we attempt to identify three equations: the price equation (*p*), the equation for money demand (*m-p*), and the equation for barter (*b-p*). Other variables we use in estimations include the interest rate (*r*), the exchange rate (*e*), and industrial output (*y-p*). As above in the unit root analysis, we use the sample from January 1994 to December 2000.

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obtained by multiplying the index of industrial output by the share of barter trade. We use the share of barter to check robustness in Section 8.

[12] While most of the quarterly GDP data is available for the late 1990s from reliable sources, data on the early years of the Russian transition is difficult to obtain.

[13] A table consisting of the test results is available from the authors upon request.

Since the unit root tests suggest that all the variables are non-stationary in levels, we examine possible long-run equilibrium relationships among the variables using cointegration techniques. We follow Johansen's FIML-based technique in determining the long-run relationships (Johansen, 1988; Johansen, 1991). The method is based on estimating a vector autoregressive (VAR) model that can be expressed in an error-correction form, where the parameters of the error-correction term can be partitioned for the speed of adjustment and cointegration parameters.

Before the actual cointegration analysis, we try to determine a correct lag length. Starting with six lags, which was due to the small sample size, we sequentially test using F-tests to determine whether the number of lags could be reduced. This procedure suggests VAR (4). We also include three dummies (October 1994, June 1995 and September 1998)[14]. Such a system is sufficient for removing diagnostic problems in the vector form tests for the system and most single equation based tests. (see Table 2 for the diagnostic test results).

The results from the cointegration analysis with unrestricted constant term and no trend are provided in Table 1. Both the *trace* and the *max* test statistics suggest that there would be three cointegration vectors (CV). In contrast, based on the small sample-corrected critical values, the number of cointegration vectors could be either two or three at 95% critical values, but three at 90% critical values. We take three cointegration vectors, partly because it is consistent with our theoretical framework and partly because it can be supported by the results of cointegration tests.

[14] October 1994 and September 1998 dummies are directly related to crisis periods. In June 1995, Russia suffered from political instability due to the war in Chechnya and prepared to adopt an IMF stabilisation programme with a fixed exchange rate system (that was introduced in the beginning of July).

For exact identification, we need three restrictions on each of the long-run equations. Following normalisation and exact identification suggested by our theoretical framework, we have estimation results as Table 2 shows. [15]

Overall, the estimation results contain reasonable parameter signs and estimates. Money demand is positively and negatively associated with output and the exchange rate, respectively. The latter suggests that devaluation or depreciation leads to a decrease in real money holdings in roubles. In addition, an increase in barter reduces real money demand, which indicates potential substitutability between money and barter, along the lines of our theory. Yet the standard error of barter in the money equation appears to be high. According to the second cointegration vector, barter depends negatively on output, suggesting that difficulties in production result in rises in barter transactions. An increase in real money also reduces barter, which supports the hypothesis that barter is related to liquidity problems. The negative association between barter and interest rates is consistent with the reasoning in the theory section. Finally, the price level is increasing with the exchange rate, which is in line with PPP. The results suggest that the price level is negatively associated with real money and barter. Recalling the discussion in the theory section, this can be interpreted that the real sector effects of barter dominate the possible price increases from increased liquidity due to trade credit.

We now proceed to hypothesis testing based on the identified relationships suggested by Table 2. Table 3 presents the results from likelihood ratio-based test

[15] In contrast to our theory, we imposed a zero restriction on the coefficient on the interest rate in the first cointegration vector. This was prompted by the fact that the sign of the coefficient on the interest rate in the vector, which we interpret as a money equation, turned out to be positive. However, given a strong possibility of currency substitution between roubles and hard currencies, the sign of r in the real money equation is ambiguous in the Russian context. High interest rates available for rouble deposits will increase currency substitution from hard currencies to roubles, while they reduce rouble cash holding for transaction purposes. Moreover, the poor development of the Russian financial sector may justify the zero restriction. In addition, we keep the exchange rate in the money equation because it provides a proxy for inflation expectations through the forward-looking properties of the exchange rate.

results for linear restrictions. The test statistics have a χ^2 distribution with the number of restrictions as degrees of freedom.

Let us first consider hypotheses related to barter. Our theory suggests that money and barter are substitutes. We first test if real money holding is not affected by barter [(b-p)=0 in CV1]. The test result demonstrates that this is clearly the case and thus barter can be dropped from the equation for money, suggesting money demand was not affected by barter. However, the hypothesis that barter is not caused by real money [(m-p)=0 in CV2] is strongly rejected. The joint restriction that money and barter are independent of each other [(b-p)=0 in CV1 and (m-p)=0 in CV2] is also rejected. This evidence indicates that money and barter are indeed substitutes, supporting our view of barter as a form of trade credit. It also appears that the link is one-directional: barter does not affect real money in the long run. This may reflect the efficiency gain from using money over barter transactions.

One of the most interesting findings from the above analysis is that tight monetary policy (reduction in real money balances) is one of the causes of the emergence and growth of barter. To our best knowledge, this is the first study based on macro-level data to show direct evidence for the view that barter is a result of the lack of liquidity among firms.[16] Another hypothesis related to barter is that it has served as a survival strategy for firms in conditions of declining production. The restriction that output does not affect barter [(y-p)=0] in CV2 is rejected, suggesting that barter is in fact a result of production decline. Our analysis therefore supports the view that barter is a way to avoid restructuring. The long-run relation of barter [(b-p) = - 1.162(m-p) - 1.972(y-p)- 0.341r], as in Table 2, implies that the impact of output on barter is about twice as much as that of money on barter.

Finally, the result of the test for the restriction that r=0 in CV2 reveals that barter decreases when interest rates rise. This finding is in contrast to the view

that high interest rates encouraged firms to use barter (Brana and Maurel, 1999). However, it is consistent with the discussion in the theory section, suggesting that demand for trade credit in terms of barter is a decreasing function of its interest rate (which is, in turn, positively related to the interest rate on bank lending through lenders' and borrowers' arbitrage conditions). As far as the combined impact of tight monetary policy using both the money supply and interest rates is concerned, the overall effect is not well pronounced, because a reduction in real money balances leads to increases in barter, while a rise in interest rates induces barter to decline.

As for other determinants of real money in CV1, the test results [(e=0) and (y-p)=0 in CV1] imply that both the exchange rate and industrial output must be kept in the model. Finally, restrictions on the price equation reveal that the price level is not dependent on real money. This is expected given the fact that a homogeneity restriction was already imposed when we used real money in the price equation. However, the PPP hypothesis is supported because the restriction on e=0 in CV3 is clearly rejected. This implies that the exchange rate is one of the key determinants of Russian inflation, ie the depreciation/devaluation of the rouble leads to higher prices for imported goods and services. Naturally, a high level of dollarisation of the domestic economy can enhance this impact.

The elimination of barter in CV3 [(b-p)=0 in CV3] is rejected, suggesting that the price level is negatively associated with real barter, and suggesting the negative effect of demonetisation on prices. In other words, firms relying on barter instead of money contribute to reducing prices. There are two channels through which barter might affect prices. The first is a direct channel: the use of barter might directly affect cash prices of goods through enterprises dumping goods in cash.[17] The second channel is indirect: barter might affect prices negatively by increasing production, which would not be possible without using bar-

[16] Brana and Maurel (1999) find some indirect evidence for this hypothesis. Contrary to real money (m-p) used by us, they use the interest rate as an indicator of monetary policy tightness.
[17] A similar argument is offered by Oppenheimer and Granville (2001).

ter, and subsequently the cash prices for these goods would decline due to increases in supply. Because barter and wage arrears are often related, some impacts may also arise from the demand side: larger wage arrears, which are associated with an increase in barter, reduce consumers' purchasing power. Note that the above discussion does not mean that barter prices would be lower than cash prices. In contrast, there is much evidence from Russia that suggests that the opposite is the case (Commander and Mumssen, 2000). Our results refer not to barter prices themselves but to the impact of barter on cash prices, which are the basis of price statistics: the effect of nominal barter on prices is less than one, while that of nominal money is approximately one. In terms of the share of barter, we found that a one percentage-increase in the share of barter (ie a decrease in the share of monetary transactions) leads to a 0.37% decrease in prices.[18]

On the basis of the above discussion, we impose zero restrictions on barter in CV1 and money in CV3. The joint test implying this structure is clearly accepted, suggesting our final long-run estimates as presented in Table 4. As for the speed of adjustment suggested by the alpha matrix, the speed of adjustment to the deviations from the own equilibrium relationship has a reasonable sign and magnitude both for the money and barter equations. The speed of adjustment with respect to the price equation is much slower, which reflects the fact that deviations from the PPP relationship are rather persistent.

In order to understand the effects of barter on other endogenous variables, we use impulse response functions. We use the Generalised Impulse Response (GIR) functions, which describe the time profile of the effect of a unit shock to a particular equation on relevant endogenous variables, taking into account the contemporaneous interactions of all the endogenous variables of the system. Unlike other impulse responses, the GIR proves to be invariant to the ordering of the variables in the VAR (Pesaran and Shin, 1998). We assume that the shock is suf-

[18] We used the share of barter *sb*, instead of (*b-p*), and obtained similar results regarding most of the aspects of estimations. The sizes of coefficients on output in CV2 and the share of barter in CV3 changed: the former increased to 2.895 and the latter decreased to 0.367.

ficiently small so that it does not change the parameters of the underlying VAR model.

Figure 3 shows impulse responses of prices, money and output to a shock in barter. The effects appear to die out within about 60 months. As we expected, a rise in barter transactions decreases money and prices in the long-run. The effect of a shock to barter on money turns out to be always negative. As for prices, they increase for a short period following the shock but the effect becomes negative afterwards. An interesting result is found in the effect on output. The short-run impact of barter output is positive, which is in line with our finding that firms engage in barter transactions in order to escape severe recessions. Yet its long-run impact is negative, suggesting that inefficiencies arising from the use of barter and delays in restructuring dominate the short-run positive impact. In other words, by relying on barter, enterprises might avoid output losses or bankruptcy in the short-run but in the long-run the cost of barter transactions is high enough to make the economy suffer from output loss, possibly due to delays in restructuring. In addition, the figure shows that the short-run positive impact can last for only about one year.

Finally, in order to determine which variables need to be modelled in the short-run dynamics, we examine the weak exogeneity properties of the variables, which refers to the case in which the speed-of-adjustment parameters of a variable with respect to all cointegration vectors may be restricted to zero. The interpretation is that, if a variable is weakly exogenous, it does not adjust to deviations from the long-run equilibrium. The results are presented in Table 5, which reveal that only the interest rate satisfies the condition of weak exogeneity.

7 Short-run Analysis: a Vector Error-Correction Model (VECM)

The above estimates give rise to three error-correction mechanisms (*ecm*):

Real money: $ecm1=(m-p) - 2.4595(y-p) + 0.4856e$;

Real barter: $ecm2=(b-p) + 1.1259(m-p) + 1.8622(y-p) + 0.3188r$;

Price level: $ecm3=p + 0.4511(b-p) - 0.7382e$;

The estimates of the parsimonious VECM are given in Table A2 in the Appendix.[19] We do not model interest rates because the variable is exogenous to other variables. The table also contains the diagnostic tests for this model. The system-based test results reveal that the model does not suffer from any diagnostic problems, although the single equation tests indicate a slight problem in the price equation. We have also carried out stability analysis of the model.[20] No structural break in the system using Chow tests was detected as a whole, but in the price and real money equations, there are small breaks during the latter half of 1998 that appear to reflect the turbulence of the financial crises. In addition, we further checked the stability of our results using recursive estimations and found few diagnostic problems.

Some remarks might be necessary regarding the results. First, as we discussed before, all error-correction terms in their own equation have a correct sign. This supports the conclusion that our estimation results are fairly robust. Second, barter and money seem to be complements in the short run, while they are substitutes in the long run: the equation for first-differenced real money (barter) suggests that barter (money) increases money (barter) demand. Third, the

[19] Again, we also include the same dummies as before (October 1994, June 1995 and September 1998), and this time also dummies to capture the financial crises in November 1994 and August 1998.

[20] This analysis is not included for the sake of brevity, but it is available from the authors upon request.

error-correction term of the two different sources of finance, namely barter in the money equation and money in the barter equation, is negative, implying that barter and money above their long-run equilibrium levels decrease money and barter demands, respectively. Fourth, as the result obtained from estimating the first-differenced price equation, there is a significant negative effect of barter on inflation with three lags. Together with the finding from the long-run estimation, this suggests that barter reduces the price level both in the short run and in the long run. Lastly, the significant error-correction term in the equation for change in output indicates that, if barter is above the long-run level, output goes down. This is a rather interesting finding: barter may lead to efficiency losses in the long run, while an increase in barter raises output in the short run.

8 Robust Test: Banking Failure as a Cause of Barter

One can possibly argue that the money supply, measured by M2, is a poor indicator of the financial conditions of enterprises. Several studies suggest that the reluctance of financial institutions to lend to enterprises, rather than an insufficient money supply in itself, is a direct cause of barter (Marin et al, 1999; Schoors, 2001; Gara, 2001). We test this hypothesis using our existing framework, which can also serve the role of checking the robustness of our baseline cointegration results presented in Section 5.

We use data on bank claims on the private sector to test the above hypothesis. Yet using this data makes our sample period shorter, because it is available only from June 1995. This prevents us from conducting our estimation employing all the seven variables, including a proxy for the development of the banking system. We reduce the number of variables to six by dropping interest rates from our estimation equation, assuming that the interest rate affects the economy mainly through its role in the lending of banks to enterprises. This is justified by findings based not only on our own previous results but also on others, that the effect of

interest rates on the economy is not well pronounced in transition economies (Domac and Elbirt, 1998; Kim, 2001).

The lending of financial institutions to the private sector can be affected not only by the efficiency of the banking sector, but also by monetary policy that uses the money supply or interest rates as instruments. In order to find an appropriate proxy for the efficiency of the banking sector, we regress bank claims on the private sector (*rcl*) on money supply (*m-p*) and interest rates (*r*). The residuals of this auxiliary regression, which are no longer affected by monetary policy or interest rates, reflect genuine fragility in the banking system and are subsequently interpreted as a proxy for the extent of the development of the banking sector. In addition, this procedure can ensure orthogonality of the variable to other variables such as money supply. Residuals following the estimation of cointegration are calculated as follows:[21]

$$bsd = rcl - 0.423(m-p) + 0.242r$$

where *bsd* is an indicator for banking sector development and *rcl* is the log of real bank claims on the private sector.

The test results are consistent with theoretical predictions: when the money supply increases or interest rates decrease, the lending of financial institutions to the private sector grows. We expect that the proxy, *bsd*, is negatively associated with barter if barter is caused by the poor development of financial institutions. Following cointegration, exactly identifying restrictions, which are the same restrictions we used in Section 5, were imposed on the coefficients.[22] Table 6 presents the cointegration results.[23]

[21] We used four lags as in our previous estimations and four impulse dummies: January 1998, September 1998, May 1999, and July 1999. Cointegration tests suggest the existence of one cointegration vector. Only few diagnostic problems were found.

[22] Four lags and one impulse dummy, September 1998, were used in the cointegration. There were few diagnostic problems.

[23] We use the share of the volume of barter transactions in total enterprise transactions (*sb*) to check further the reliability of our previous estimation using the real volume of barter (*b-p*).

Overall, no drastic changes were found, although interest rates were dropped from the system. [24] The most interesting result is found regarding the second cointegration vector. As in our baseline results, the share of barter is negatively correlated with real output and real money. The impact of real output on barter is twice as much as that of real money, which is fairly consistent with previous results. Now we find that the proxy for the development of the banking sector affects barter.[25] A 1% increase in bank lending to the private sector that is not associated with monetary or interest rate policies causes a 1% decrease in the share of barter. The sum of the coefficients on the variables which are related to a financial shock on enterprises, namely an insufficient money supply and banking failure, is about the same as the size of the coefficient on a real output shock. In sum, increases in the share of barter have resulted from two roots: a real output shock and a financial shock and the relative effects of the two roots in terms of size are nearly equal.

9 Conclusion

Using data on Russia from 1994 to 2000, this paper analyses relationships among barter, money and prices, focusing on the causes and effects of barter on the other variables. Following the development of a model that includes barter in a standard macro economy model, we employ structural cointegration and vector error-correction techniques to estimate the model.

[24] There is a change in the sign of the coefficient on barter. However, the zero restriction on the coefficient is accepted (the statistic of the LR test, $\chi^2(1)$, is 0.0531 (p-value: 0.8177)). A relatively larger change took place regarding the third cointegration vector. The real money supply increases prices, while the share of barter seems negatively associated with prices. Yet zero restrictions on the coefficients on both variables are accepted, suggesting prices are affected largely by the exchange rate but not by other variables. The statistic of the LR test, $\chi^2(2)$, is 2.6726 (p-value: 0.2628). Separate tests on money and barter also suggest that a zero restriction is accepted.

[25] The zero restriction on the coefficient is rejected: the statistic of the LR test, $\chi^2(1)$, is 13.699 (p-value: 0.0033).

We found a meaningful long-run relationship for money, barter and price equations. In particular, there is evidence that the exchange rate affects both the equations for money and prices: depreciation or devaluation affects the demand for money negatively, and increases the price level as suggested by the PPP.

On the basis of long-run cointegration results, we found that the emergence and growth of barter in the Russian economy are associated with both firms' motivation for survival in the presence of sales or production difficulties, and the lack of liquidity experienced by firms. In other words, both of the competing hypotheses on the causes of barter, namely restructuring and liquidity explanations for barter, are supported by our analysis using aggregate data. Yet the effect of the former on barter is twice as much as that of the latter, suggesting a dominant motive for barter trade is to avoid bankruptcy among firms which face low production and perhaps low profitability. We further introduced the proxy for banking failure and estimated the model together with other variables. We found that both variables related to the financial side of enterprises, the money supply and the proxy, are significant and the sum of the effects are nearly same as the production effect on barter.

As for the relationship between barter and prices, there is some evidence that the effect of barter on prices is lower than that of money. In other words, the share of barter transactions in total enterprise transactions is negatively associated with prices. This implies that firms that might experience difficulty in sales for money, use barter to increase production and subsequently engage in barter transactions. One plausible explanation is that maintaining production leads to a greater supply of goods in the market and thus reduces cash prices.

Results from cointegration and VECM are rather impressive in terms of diagnostic tests: only few diagnostic problems were found in the system and all error-correction terms are significant with correct signs. Although it is difficult to comment on short-run dynamics in general, we found two interesting results: barter and money seem to be substitutes in the long run but complements in the short run; barter reduces the price level both in the short run and in the long run.

Our results have some implications for the empirical modelling of the equations for the demand for money and prices. A macro model which excludes barter as a regressor, in an economy which experiences the growth of barter transactions, might fail to capture all the relevant information for inference on money and inflation. What is the relationship between money and barter? Does the money supply affect the growth of barter transactions or does the money supply react to changes in the volume of barter transactions? What are the implications of barter transactions for inflation? We found some answers to these questions in the Russian economy, but more research is needed on the economies of other countries. Another question we have not dealt with is whether barter is really a long-run phenomenon in Russia. Our results are confined to a specific time period in Russia and it will be interesting to follow whether barter is sustainable in the long-run and why. To test this, however, we need to wait a few more years.

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Figures and tables

Figure 1. Inflation Dynamics in Russia 1992-2000, (monthly inflation, %)

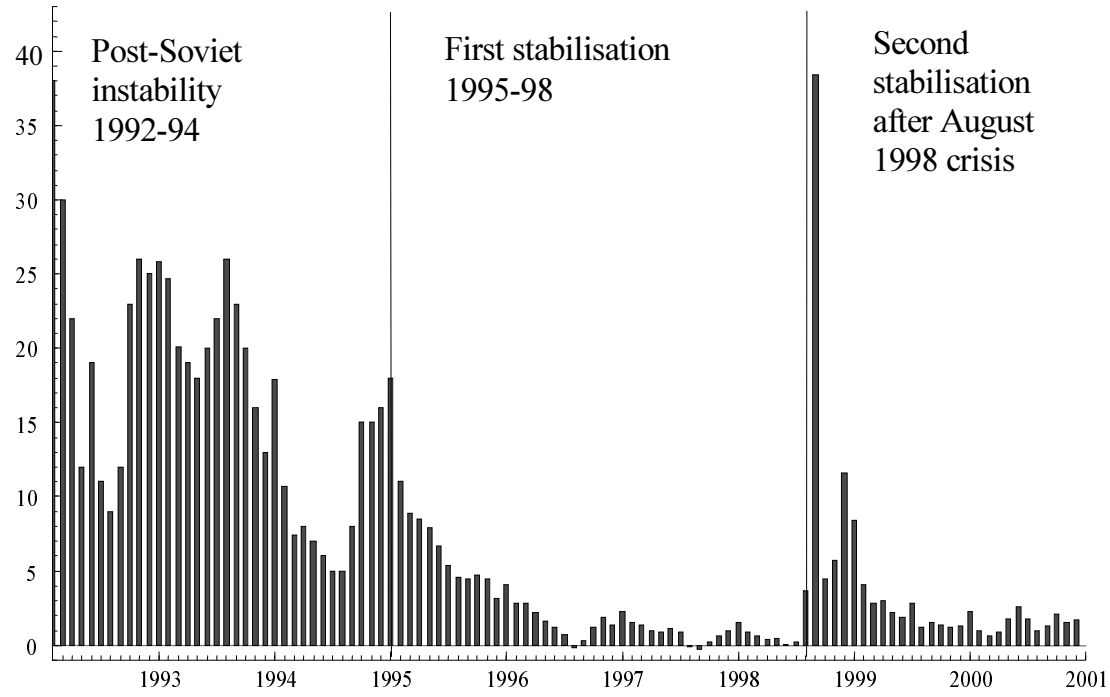
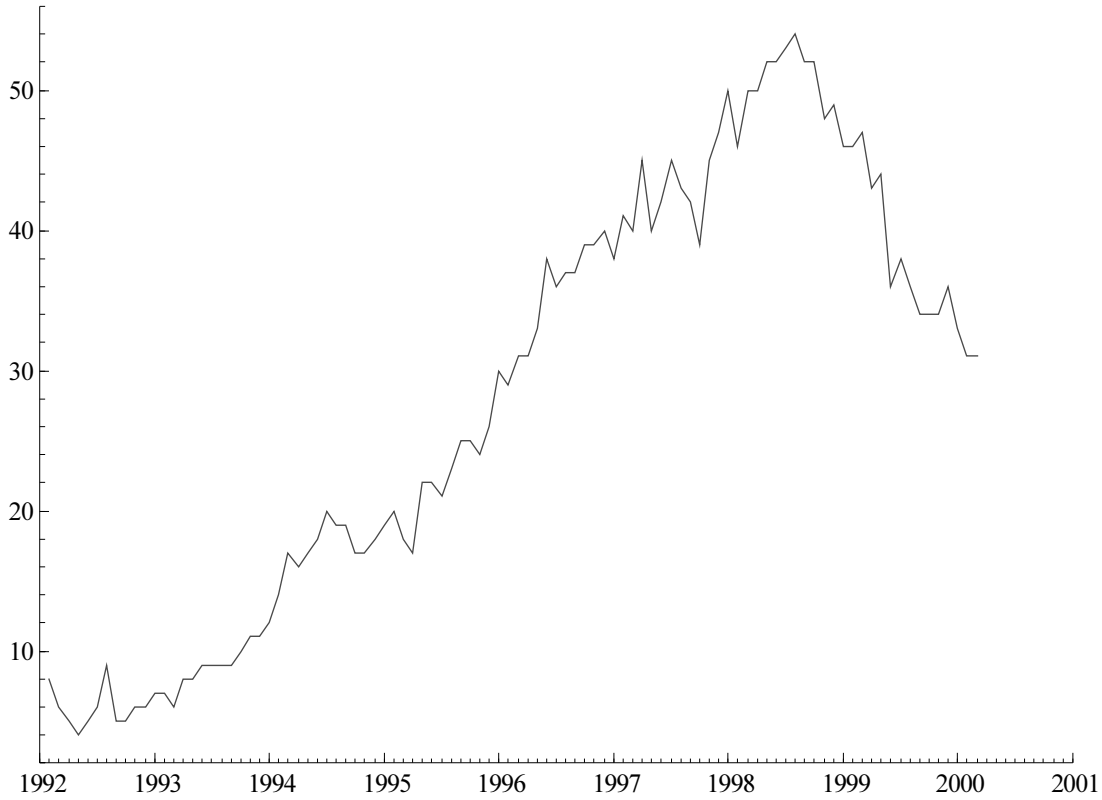


Figure 2: The Trend of Barter: as a Share of Total Industrial Transactions (%)



Source: Russian Economic Barometer

Figure 3: Generalises Impulse Responses of Prices, Money and Output to One Standard Error Shock in the Equation for Real Barter

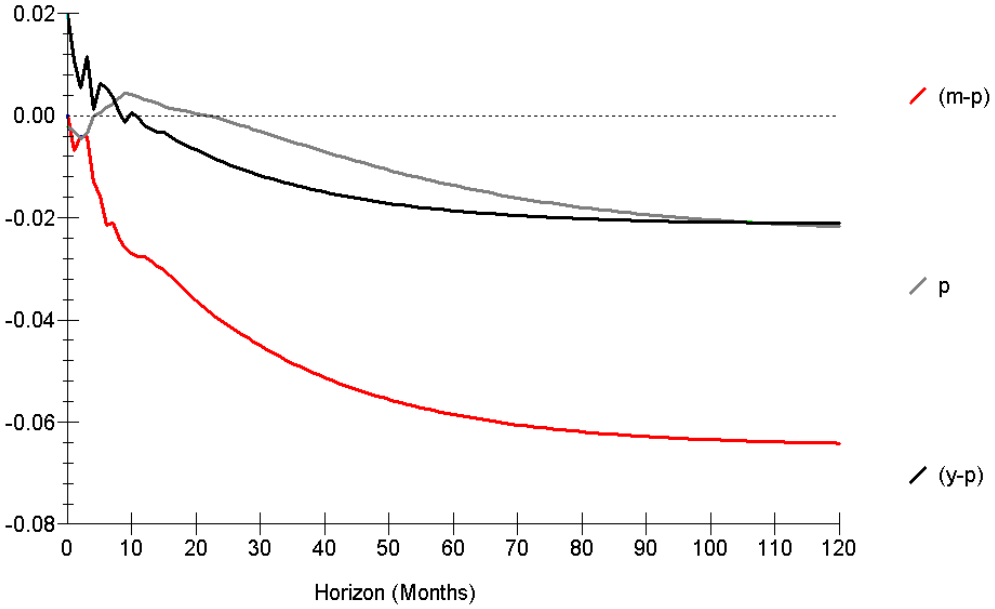


Table 1: Cointegration Tests

Ho:rank=p	*max* test	using T-nm	95%	*trace* test	using T-nm	95%
p == 0	80.04**	57.17**	39.4	198.1**	141.5**	94.2
p <= 1	54.04**	38.6*	33.5	118.1**	84.36**	68.5
p <= 2	41.53**	29.66*	27.1	64.06**	45.76	47.2
p <= 3	14.5	10.36	21.0	22.53	16.1	29.7
p <= 4	7.877	5.627	14.1	8.035	5.739	15.4
p <= 5	0.158	0.1129	3.8	0.158	0.1129	3.8

Max test is the maximal eigenvalue test for rank and trace is the trace test for rank. T-nm denotes the small sample-adjusted critical values for rank. Significance at 5 % and 1 % level are indicated with * and **, respectively.

Table 2: Estimation Results from Restricted Cointegration Analysis

Parameters of cointegration vectors

m-p	*b-p*	*p*	*y-p*	*e*	*r*
1.0000	0.1199	0.0000	-2.1205	0.4396	0.0000
1.1618	1.0000	0.0000	1.9719	0.0000	0.3410
0.3523	0.6179	1.0000	0.0000	-0.6615	0.0000

Standard errors

m-p	*b-p*	*p*	*y-p*	*e*	*r*
0.0000	0.9837	0.0000	0.4148	0.0329	0.0000
0.1433	0.0000	0.0000	0.4389	0.0000	0.0316
0.3030	0.1712	0.0000	0.0000	0.0691	0.0000

Diagnostic test results

Alternative	Test	Value (probability)
Serial correlation	F (180, 132)	1.2261 (0.1075)
Normality	$\chi^2(12)$	17.219 (0.1415)
Heteroscedasticity	$\chi^2(1008)$	988.16 (0.6663)

Table 3: Hypothesis Test Results based on LR Tests (rank=3).

Hypothesis	Test statistic (p-value in brackets)
(*b-p*)=0 in CV1	Chi^2(1) = 0.44991 [0.5024]
(*m-p*)=0 in CV2	Chi^2(1) = 26.469 [0.0000] **
(*b-p*)=0 in CV1 and (*m-p*)=0 in CV2	Chi^2(2) = 27.008 [0.0000] **
(*y-p*)=0 in CV2	Chi^2(1) = 9.0596 [0.0026] **
(*b-p*)=0 in CV1 and (*y-p*)=0 in CV2	Chi^2(2) = 9.0608 [0.0108] *
r=0 in CV2	Chi^2(1) = 25.099 [0.0000] **
(*y-p*)=0 in CV1	Chi^2(1) = 13.539 [0.0011] **
(*y-p*)=0 and (*b-p*)=0 in CV1	Chi^2(2) = 14.081 [0.0028] **
e=0 in CV1	Chi^2(1) = 21.716 [0.0000] **
(*m-p*)=0 and CV3	Chi^2(1) = 0.70701 [0.4004]
(*b-p*)=0 and CV3	Chi^2(1) = 6.4622 [0.0110] *
(*b-p*)=0 and (*m-p*)=0 in CV3	Chi^2(2) = 8.0424 [0.0179] *
e=0 in CV3	Chi^2(1) = 6.1158 [0.0134] *
(*b-p*)=0 in CV1 and (*m-p*)=0 in CV3	Chi^2(2) = 1.0552 [0.5900]

Table 4: Final Estimates of Long-run Model.

Parameters of cointegration vectors

m-p	*b-p*	*p*	*y-p*	*e*	*r*
1.0000	0.0000	0.0000	-2.4595	0.4856	0.0000
1.1259	1.0000	0.0000	1.8622	0.0000	0.3188
0.0000	0.4511	1.0000	0.0000	-0.7382	0.0000

Standard errors

m-p	*b-p*	*p*	*y-p*	*e*	*r*
0.0000	0.0000	0.0000	0.4372	0.0349	0.0000
0.1326	0.0000	0.0000	0.4215	0.0000	0.0247
0.0000	0.1454	0.0000	0.0000	0.0517	0.0000

Speed of adjustment

m-p	*b-p*	*p*	*y-p*	*e*	*r*
-0.1008	-0.4998	0.0148	-0.0810	0.0498	-0.0816
-0.2140	-0.3707	0.0524	-0.2082	0.0808	0.0217
0.0034	0.1868	-0.0391	0.0138	-0.0506	0.0477

Table 5. Weak Exogeneity Test Results

Variable	LR-test, rank=3
m-p	Chi^2(5) = 31.592 [0.0000] **
b-p	Chi^2(5) = 31.255 [0.0000] **
p	Chi^2(5) = 45.966 [0.0000] **
y-p	Chi^2(5) = 25.392 [0.0001] **
e	Chi^2(5) = 18.283 [0.0026] **
r	Chi^2(5) = 2.7661 [0.7360]

Table 6: Parameters of Cointegration Vectors Using a Proxy for the Development of the Banking Sector, 1995 (10) - 2000 (12):

m-p	*sb*	*p*	*y-p*	*e*	*bsd*
1.0000	-0.0449	0.0000	-2.4500	0.4701	0.0000
1.0223	1.0000	0.0000	2.2145	0.0000	1.0929
-0.4061	0.0410	1.0000	0.0000	-0.7032	0.0000

Table A1: List of Variables

Variables	Description	Sources
p	Log of consumer price index	Central Bank of Russia
m-p	Log of real domestic M2	Russian Economic Trends
e	Log of Rouble/USD exchange rate, period average	Central Bank of Russia, Russian Economic Trends
r	Log of commercial banks' lending rate	1992-1994: World Bank (1995), 1995-2000: IMF
y-p	Log of real industrial production	Goskomstat
sb	Share of barter in sales of industry	Russian Economic Barometer
b-p	Log of the real volume of barter (*b=sb*y*)	Own calculations

Table A2: VECM Estimation Results and Diagnostics

	D(m-p)	t-value	*D(b-p)*	t-value	*Dp*	t-value	*D(y-p)*	t-value	*De*	t-value
D(m-p)$_{-1}$	-0.134	-1.387	-0.568	-2.202	0.073	2.171	-0.738	-5.364	-0.204	-2.959
D(m-p)$_{-3}$	0.020	0.220	1.395	5.880	-0.098	-3.155	0.743	5.868	-0.075	-1.183
D(b-p)$_{-1}$	0.069	1.357	-0.592	-4.346	-0.008	-0.437	0.037	0.503	0.004	0.122
D(b-p)$_{-2}$	0.098	2.198	-0.530	-4.451	-0.016	-1.043	-0.097	-1.535	-0.034	-1.065
D(b-p)$_{-3}$	0.147	3.170	-0.170	-1.374	-0.041	-2.540	0.172	2.596	-0.043	-1.313
Dp$_{-1}$	-0.575	-2.193	-0.707	-1.010	0.649	7.089	-0.565	-1.513	-0.408	-2.181
Dp$_{-2}$	-1.021	-4.438	-0.958	-1.561	0.093	1.156	-0.379	-1.155	0.477	2.909
D(y-p)$_{-3}$	-0.261	-3.318	-0.217	-1.033	0.112	4.081	-0.253	-2.256	0.147	2.623
De$_{-1}$	0.083	0.806	0.362	1.319	-0.193	-5.368	0.091	0.624	0.243	3.311
De$_{-2}$	0.403	4.188	0.423	1.646	-0.001	-0.020	0.161	1.173	-0.212	-3.087
De$_{-3}$	-0.007	-0.144	0.684	5.139	0.065	3.760	0.391	5.512	0.222	6.253
ecm1	-0.069	-2.757	-0.403	-6.027	0.002	0.191	-0.065	-1.829	0.022	1.254
ecm2	-0.152	-5.550	-0.203	-2.771	0.022	2.308	-0.150	-3.827	0.055	2.812
ecm3	-0.018	-0.987	0.165	3.312	-0.023	-3.492	0.028	1.070	-0.050	-3.792
Dr	-0.035	-1.435	-0.044	-0.674	0.025	2.884	-0.061	-1.757	0.031	1.756
oct94	-0.122	-4.029	-0.078	-0.970	0.084	7.972	0.057	1.328	0.182	8.427
nov94	-0.078	-2.444	-0.206	-2.428	0.058	5.240	-0.054	-1.201	-0.059	-2.613
june95	0.090	2.853	0.113	1.341	-0.025	-2.263	0.054	1.192	-0.114	-5.055
aug98	-0.104	-3.587	0.025	0.324	0.043	4.259	-0.030	-0.714	0.079	3.788
sep98	-0.280	-9.901	-0.055	-0.732	0.323	32.769	-0.074	-1.851	0.742	36.827
Constant	3.339	6.261	2.986	2.097	-0.369	-1.982	3.036	3.996	-0.921	-2.420
serial correlation, F (5, 58)	1.040 (0.403)		0.646 (0.666)		1.242 (0.301)		2.634 (0.033) *		1.441 (0.223)	
normality, Chi^2(2)	1.513 (0.469)		3.941 (0.139)		1.916 (0.384)		4.549 (0.103)		1.904 (0.386)	
functional form, F (5, 53)	0.600 (0.700)		0.336 (0.889)		0.385 (0.857)		1.091 (0.376)		0.545 (0.741)	
heterosce. F(35, 27)	0.342 (0.998)		0.438 (0.989)		2.254 (0.016) *		0.512 (0969)		1.179 (0.333)	
Vector autocorrelation, F(125,172)	1.089 (0.302)									
Vector normality, Chi^2(10)	10.274 (0.417)									
Vector heterosce. Xi^2 F(525,242)	0.560 (1.000)									

Notes

P-values for diagnostic tests are provided in parentheses. Five dummies were used in these estimations: Oct. and Nov. 1994 and Aug. and Sep. 1998 dummies are directly related to rouble crisis periods. The dummy of June 1995 attempts to capture political instability due to the war in Chechnya and related events in Budjonnovsky (and preparation for a macroeconomic regime change (in July Russia adopted an IMF stabilisation programme with a fixed exchange rate system). On the basis of long-run cointegration results, the error correction terms are calculated as follows:

$ecm1=(m-p) - 2.4595(y-p) + 0.4856e$;

$ecm2=(b-p) + 1.1259(m-p) + 1.8622(y-p) + 0.3188r$;

$ecm3=p + 0.4511(b-p) - 0.7382e$

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