THE MONETARY MODEL OF EXCHANGE RATE DETERMINATION: THE CASE OF UKRAINE

by

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Abstract

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The issue of exchange rate determination has been recently in the core of academic debates. Controversial empirical evidence of conventional monetary theories of exchange rate determination for developed countries puzzled many economists and caused further theoretic development. At that, little evidence exists for transition countries.

In this research, the basic and modified monetary models of exchange rate determination with flexible and sticky prices were tested for Ukraine for the period 1996:9-2001:9. As empirical tests show, the error-correction model (ECM) for the basic monetary model does not fit well to Ukrainian data, while the ECM for the modified monetary model better explains behavior of the exchange rate in Ukraine. The results also support flexible price version of the model and indicate the significant role of dollarization for exchange rate stability.

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GLOSSARY

Nominal exchange rate is the price of one currency in terms of another one (Krugman, Obstfeld, 2000, p.329).

Interest rate is the amount of currency that individual can earn by lending a unit of currency for a year. (Krugman, Obstfeld, 2000, p.341).

Absolute purchasing power parity (PPP) states that exchange rate is equal to relative price level, i.e. $S_{UAH/\$} = P_{UA}/P_{USA}$, where $S_{UAH/\$}$ is nominal exchange rate, P_{UA} is domestic price level, P_{USA} is foreign price level (Krugman, Obstfeld, 2000, p.397).

Relative purchasing power parity (PPP) "states that the percentage change in the exchange rate between two currencies over any period equals the difference between the percentage changes in national price levels" i.e. $\Delta S_{UAH/\$} = \Delta P_{UA} - \Delta P_{USA}$, where Δ denotes the percentage change (Krugman, Obstfeld, 2000, p.397).

Uncovered interest parity (UIP) states that expected rates of return are the same for two currencies. It can be represented as $I = I^* + (E^e - E)/E$, where I and I* domestic and foreign interest rates respectively, E is exchange rate (domestic per unit of foreign currency), E^e is expected exchange rate. (Krugman, Obstfeld, 2000, p.361).

Dollarization ratio is calculated as the relation of deposits in foreign currency to the sum of all deposits, i.e. $DR = [FCD/(FCD + DCD)]100$, where DR is dollarization ratio, FCD is foreign currency deposits, DCD is domestic currency deposits. The value of DR is between 0% and 100%.

Dollarized economy is an economy is which a foreign currency performs major functions of money, which the domestic currency does (i.e. store of value, unit of account, and medium of exchange) (Curtis, Gardner, Waller, 2001, p.1).

Chapter 1

INTRODUCTION

The issue of exchange rate determination has been recently in the core of academic debates. Despite the fact that many exchange rate determination models and their modifications have been developed, economists still cannot agree on which model best describes behavior of exchange rate[1] because empirical tests of the models are often ambiguous and sometimes even contradictory. The empirical evidence defeating conventional monetary theories of exchange rate determination for developed world puzzled many economists and caused further theoretic development. At that, existing models have been tested mainly for developed and developing countries while transition countries have not received as much attention.

In this study, basic and modified monetary models of exchange rate determination with flexible and sticky prices will be tested for Ukraine for the period 1996:9-2001:9, which is characterized by high inflation. The dollarization ratio, which may be significant in case of Ukraine, will be introduced into the basic model. The modified model shows how money demand, real income, the interest rate, and the dollarization ratio influence the

[1] See for example Smith and Wickens, 1986, p.143.

nominal bilateral exchange rate measured in Ukrainian hryvnas (UAH) per US dollar (USD).

The objectives of this research are to test the validity of the monetary model, to develop and test a modified monetary model for the case of Ukraine, to determine factors that influence the exchange rate in Ukraine, and to investigate the effect of dollarization on the exchange rate in Ukraine.

There are many works on exchange rate in Ukraine (see for example: Sultan, Lukyanenko, and Gorodnichenko, 2000; Holod, 2000; Skrypnyk and Varvarenko, 2000; Bolgarin, Mahadeva, and Shtern, 2000; Shevchuk 2001, etc.). Nonetheless, research, based on the monetary model, has never been done for Ukraine before. Thus, this approach will allow studying exchange rate from a new angle and will contribute to the empirical literature.

The paper has the following structure. Chapter 2 presents a literature review and specification of the monetary model. Chapter 3 considers markets, actors, and institutions. Chapter 4 gives description and econometric specification of the theoretical model. Chapter 5 describes the data and expected signs of the models. Chapter 6 presents empirical results of regressions and discusses them. Chapter 7 provides conclusions and policy implications.

Chapter 2

LITERATURE REVIEW

Theory

The theory of exchange rate determination was introduced in the middle of the last century. Since that time many models (and their modifications) have been developed: including the monetary model, the equilibrium and liquidity models, balance of payments approach, the portfolio balance model, the purchasing power parity (PPP) approach[2], etc. (see for example Taylor, 1995; Hallwood and MacDonald, 1986; Levich, 1983). Testing and comparing these various models is well beyond the scope of this study. Hence, I will confine myself to the theoretically well-grounded monetary approach, which has considerable, though by no means universal, empirical support across a wide range of countries, especially when tested on long run data.

Dornbusch (1976) developed the monetary model in its sticky-price variant. Frenkel (1976) and Mussa (1976) introduced the monetary model with flexible prices (Smith and Wickens (1986), p.144). After that the monetary model was further developed and empirically tested by Bilson (1978), Keran (1979),

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[2] PPP is not a theory of exchange rate determination, but it is an important building block and equilibrium condition for international financial models (Levich, 1983, p.26)

Frenkel (1980), Officer (1981), Hakkio (1982), Frankel (1982), Smith and Wickens (1986) among many others.

Specification of the monetary model

The flexible-price monetary model (associated with Frenkel and Mussa) assumes that prices of goods are flexible, and that purchasing power parity (PPP) always holds. The assumption about PPP implies that the real exchange rate is constant over time (Diamandis, Georgoutsos, and Kouretas, 1996, p.85).

The sticky-price monetary model (associated with Dornbusch, 1976) assumes that prices of goods are sticky in the short run, and that PPP holds only in the long run but does not hold in the short run because goods prices adjust slowly relatively to asset prices. This model "allows substantial overshooting for both the nominal and the real price-adjusted exchange rates beyond their long-run equilibrium (PPP) levels, since the exchange rates and the interest rates … compensate for sluggishness in the goods prices" (Diamandis, Georgoutsos, and Kouretas, 1996, p.85).

Both models also assume stable domestic and foreign money demand functions, perfect capital mobility, and uncovered interest parity.

While the assumptions of the monetary model rarely hold in the real world (especially in the short run), this model shows theoretically well-grounded relationship between exchange rate, prices, money, real incomes, and interest rates[3].

The basic monetary model can be represented the following way:

$$s = (m - m^*) + \alpha_1 (y - y^*) + \alpha_2 (i - i^*) + error \qquad (1)$$

where all small letters denote logarithms. Here s is nominal exchange rate, m is money supply, y denotes real income (or industrial production, or real output), i is nominal interest rate. Asterisk denotes a foreign country. Some researchers also employ difference in inflation[4] (π-π^*) and difference in accumulated trade balances[5] (tb-tb*).

α_1 is expected to be negative in both models since growth in real income increases the demand for money, because at a given level of prices, there is a larger value of transactions to be financed (Officer, 1981, p.639). Thus, growth in real income causes exchange rate devaluation.

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[3] See for example Holod, 2000, p.12.

[4] See for example sticky price model at Meese and Rose (1991) p.605; sticky and flexible price models at Frankel (1982) pp.517-518; flexible-price model Cao Yong, Ong Wee Ling (1995) p. 138. In the last two papers the authors put $(i – i^*) = (\pi-\pi^*)$.

According to Frankel (1982) in the sticky-price monetary model α_2 is expected to be negative. This means, "an increase in the domestic interest rate, for a given expected inflation rate, attracts an incipient capital inflow that causes the currency to appreciate" (Frankel, 1982, p. 518). In contrast, the flexible-price model presupposes that α_2 is positive. "An increase in the domestic interest rate, which is the same as an increase in the expected rates of inflation and depreciation, reduces the demand for domestic money and causes the currency to depreciate" (Frankel, 1982, p. 518).

Empirics

Frankel (1982) in his paper "The Mystery of the Multiplying Marks: A Modification of the Monetary Model" proposes to modify the monetary model. He adds real financial wealth, which is a stock, (in addition to income, which is flow), as transactions variable in the money demand function, into both flexible-price and sticky-price versions. Moreover, the author puts difference between domestic and foreign interest rates equal to the difference between levels of expected inflation. Expected inflation Frankel approximates with logarithmic change of CPI over preceding 12 months. He tests both flexible-price and sticky-price models for the German mark – U.S. dollar exchange rate for the period 1974-1980. His results support the hypothesis that real financial wealth should be included in the model while real income should be excluded. His tests provide some support for the sticky-price

[5] See for example sticky price model in Meese and Rose, 1991, p.605; Meese, 1990, p.124.

model. The author claims that while monetary model with real financial wealth fits well, the model without wealth fails in this case.

Smith and Wickens (1986) in "An Empirical Investigation into the Causes of Failure of the Monetary Model of the Exchange Rate" analyze possible reasons why the monetary model fails and test a random walk hypothesis for the exchange rate. For the test they employ bilateral sterling - U.S. dollar and the German mark – U.S. dollar exchange rates for the period 1973:3 – 1982:3. Their results show that the breakdown of PPP assumption and misspecification of money demand function are the main causes of the failure of the monetary model. If the sources of misspecification are included into the model, it substantially improves explanatory power of the monetary model.

MacDonald and Taylor (1994) in their article "The Monetary Model of the Exchange Rate: Long-run Relationships, Short-run Dynamics and How to Beat a Random Walk" put as the object of the work to show that "at least one of the main exchange rate models – the monetary model – does not behave as badly as is widely thought if it is given better treatment" (MacDonald, Taylor, 1994, p.276). The authors re-examine the flexible-price monetary model for the U.K. sterling -U.S. dollar exchange rate for the period 1976:1-1990:12. All series were found to be of first order of integration. The Johansen cointegration test shows up to three cointegrating vectors. These enable the authors to estimate an error correction model. They show that the monetary error correction model outperforms random walk forecasting as well as the basic monetary model. MacDonald and Taylor claim that properties of the monetary model can be substantially improved if monetary model is considered as long-run equilibrium condition, which allows short-run dynamics in it.

They conclude that "the monetary class of exchange rate models, interpreted carefully and with allowance made for complex short-run dynamics, may still be usefully applied, and warrants further research" (MacDonald, Taylor, 1994, p. 288).

Diamandis, Georgoutsos, and Kouretas (1996) in their work "Cointegration Tests of the Monetary Exchange Rate Model: the Canadian – U.S. Dollar, 1970 – 1994" test the validity of the sticky price monetary model. They consider the Canadian – U.S. dollar exchange rate for the period from 1970 to 1994. The model was tested for cointegration and parameter stability.

The authors use Augmented Dickey-Fuller (ADF) test to determine the order of integration of variables. Since ADF test requires choosing the number of lags to correct for autocorrelation, the authors implement Lagrange Multiplier (LM) test. This test helps to choose the number of lags for which no serial correlation was found in the residuals of the regression. All variables were found to be of first order of integration (i.e. I(1)).

The Johansen maximum-likelihood testing cointegration test was used to determine the number of cointegrating vectors. One cointegrating vector, that contains all variables of the monetary model, was founded. This means that there is a long-run relationship between Canadian-U.S. dollar exchange rate, which is described by the monetary model. All coefficients, except the U.S. output, have predicted signs of the sticky-price monetary model and statistically significant.

The authors conclude, "the monetary class of models, interpreted carefully, may still be usefully applied" (Diamandis, Georgoutsos, and Kouretas, 1996, p.95).

Rudgalvis (1996) in his paper "Establishing a New Currency and Exchange Rate Determination: the Case of Lithuania" tests the flexible price monetary model, portfolio balance model and currency substitution model. The currency substitution model he employs is the flexible price monetary model that incorporates foreign currency holdings relative to total holdings of domestic residents (through including this term into the domestic money demand).

Models were tested for the bilateral exchange rate for the Lithuanian currency to the U.S. dollar for the period 1992-1995. This time span includes periods of managed float exchange rate from 1991 to 1994 and currency board since 1994. The examining period includes introduction of a new currency in 1993.

Results show that the flexible price monetary model is supported for the period that is characterized by high level of inflation before the currency reform. Meanwhile currency substitution model performs well for the period after introduction of the new currency.

Rapach and Wohar (2001) in the paper "Testing the Monetary Model of Exchange Rate Determination: New Evidence from a Century of Data" test the long run monetary model. They use the basic monetary model and assume that in the steady state domestic and foreign interest rates are equal. Thus, the difference in interest rates is equal to zero and it disappears from the model.

The authors use annual data for 14 industrialized countries from the late nineteenth or early twentieth century to the late twentieth century. Bilateral exchange rates with U.S. dollar were used.

Rapach and Wohar implement unit root tests, than estimate cointegration relationship using ordinary least squares (OLS). After that they perform cointegration tests. For those countries for which cointegration was found, they, firstly, estimate error-correction models (ECM) and, secondly, compare forecasts of the exchange rate from naïve random walk model and the "monetary fundamentals".

Results of estimations show substantial support for the basic long run monetary model for France, Italy, the Netherlands, and Spain; moderate for Belgium, Finland, and Portugal; weak for Switzerland. There is no support of the model for Australia, Canada, Denmark, Norway, Sweden, and the United Kingdom.

There is evidence that "monetary fundamentals" forecast exchange rate for Belgium, Italy, and Switzerland, but there is no evidence for France, Portugal, and Spain.

As can be seen from literature review, the class of monetary models of exchange rate determination is still very useful and performs rather well if it is treated properly with some modifications when they are necessary.

Chapter 3

MARKETS AND INSTITUTIONS

Actors and institutions

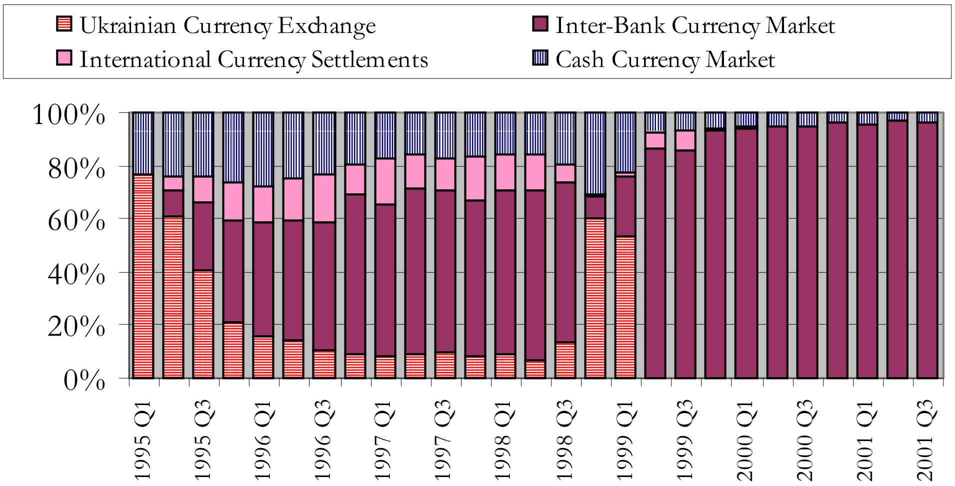
As some experts claim, the currency exchange market has not been developed perfectly in Ukraine. "There is yet no clear definition for all its operators, nor has it been defined in all major points such as, conditions of its use for current currency exchange operations, and currency exchange operations related to the flow of capital, operation at foreign currency exchanges, foreign currency hedging, etc." (UEPLAC, Ukrainian Economic Trends, June 2001, p.72).

There are four segments of Currency market in Ukraine:

1. Ukrainian Currency Exchange (UCE).
2. Inter-Bank Currency Market (IBCM).
3. International Currency Settlements (ICS).
4. Cash Currency Market (CCM).

As can be seen from Figure 1, the main share of currency trade belongs to IBCM, the market at which Ukrainian commercial banks trade foreign currencies with each other and with the National Bank of Ukraine.

Figure 1. Volumes of currency trade at different market segments for the period 1995:Q1-2001:Q3



Source of data: UEPLAC

The main actors of Foreign Exchange market and their roles are:

1. The National Bank of Ukraine (the central bank) has substantial influence on macroeconomic policy, conducts monetary policy and, intervenes Money and Foreign Exchange Markets to restore equilibrium.

2. About 190 commercial banks (not including their branches) are registered in Ukraine. They realize international transactions and may give credits and open accounts in foreign currency (usually in USD).

3. Foreign and domestic investors make international transactions, may make payments and receive credits in foreign currency.

4. Firms and enterprises make or receive payments in foreign currency.

5. Households and individuals buy and sell currency, and may put their savings in foreign currency.

Evolution of exchange rate policy in Ukraine

The appearance of the official market for foreign exchange in Ukraine took place in 1992 when the Interbank currency exchange opened. Prior to this event, the restrictions on the holdings of foreign currency by individuals were lifted starting the official circulation of foreign exchange. Nevertheless, at that time foreign currency circulated mostly in the unofficial market due to the failure of government to set the price correctly.

Since introduction of the new national currency "hryvna" in September 1996, exchange rate policy has been changed several times (see Table 1 and Figure 2). Some experts[6] argue that introduction of "currency band" was a mistake but because of a lack of currency reserves and undeveloped financial market the choice of policy was restricted. In 1998 at the period of world financial turmoil hryvna was devalued by more than 55% due to substantial outflow of foreign capital. Since January 2000 exchange rate has been announced to be floating but in reality it is a managed float.

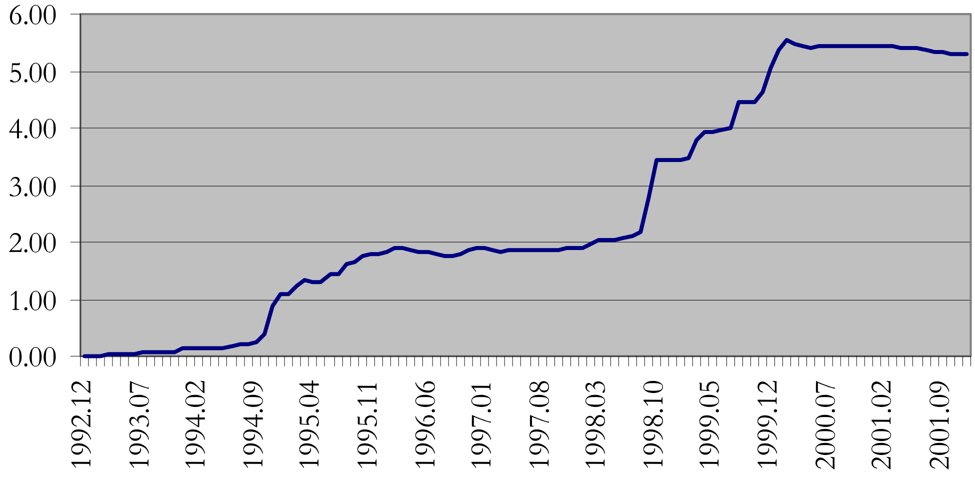
[6] Dehtyarchuk M. (March, 2000); "Політика обмінного купсу в Україні" ("Policy of exchange rate in Ukraine"); available from
www.case.org.ua/hiid/ext/Our_Works_new.nsf/ (accessed 12.10.01)

Table 1. Exchange rate policies in Ukraine during the period 1997-2001.

Date of currency policy announcement	Boundaries of exchange rate (hryvnas per one U.S. dollar)	Announced date of the end of the currency policy	Maintained or not maintained at the target level
May, 1997	1.70 – 1.90	The end of 1997	Maintained
October 31, 1997	1.75 – 1.95	The first half of 1998	Until 19.01.1998
January 19, 1998	1.80 – 2.25	The end of 1998	Until 03.09.1998
September 5, 1998	2.50 – 3.50	Was not announced	Until 08.02.1999
February 9, 1999	3.40-4.60	The end of 1999	Until mid 1999:11
January, 2000	None (dirty float)	None	Not applicable

Source: Dehtyarchuk M. (March, 2000); "Політика обмінного курсу в Україні" ("Policy of exchange rate in Ukraine"), p. 14; available from www.case.org.ua/hiid/ext/Our_Works_new.nsf/ (accessed 12.10.01)

Figure 2. Official exchange rate of hryvnia against one US dollar for the period 1992:12-2001:12

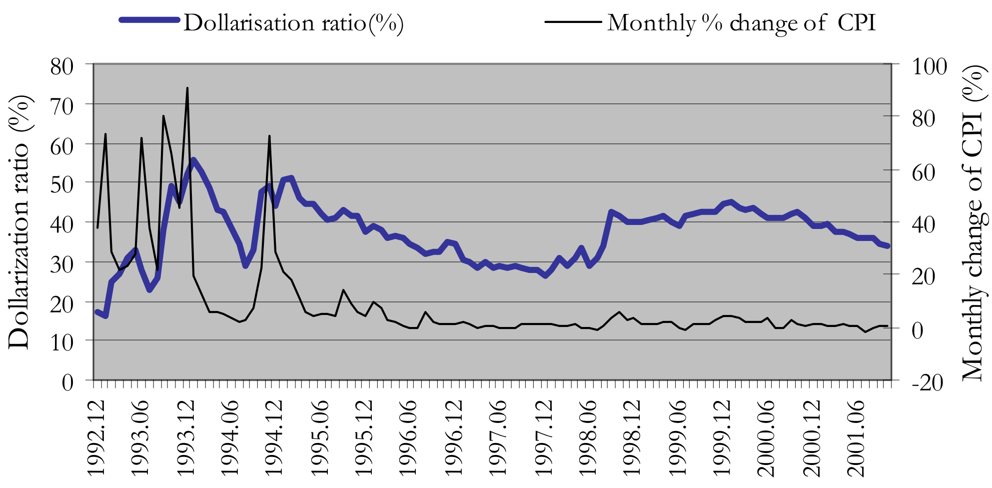


Source of data: NBU

Dollarization of the Ukrainian economy

Some time after Ukraine became independent in 1991, former Soviet Union currency "rubles" continued to circulate in Ukraine. However, in January 1992 the temporary transition currency "coupons" were introduced and circulated for some time along with rubles. "The ruble was a weak currency … falling rapidly in value relative to the US dollar, a fall driven largely by inflation throughout the ruble zone. This situation of rapidly eroding value spurred a demand for dollars instead of rubles as a store of value, a crucial (and enduring) aspect of dollarization in Ukraine" (Curtis, Gardner, Waller, 2001, p.3). As can be seen from the Figure 3, inflation rates were very high in 1992-1994. To protect savings, people exchanged money for reliable foreign currencies (usually U.S. dollars). Figure 3 shows the dynamics of inflation and the dollarization ratio in Ukraine.

Figure 3. Dollarization ratio (%) and monthly (%) change of CPI for the period 1992:12-2001:10



Source of data: UEPLAC

In 1995-1996 inflation fell and stabilized at the moderate level. In September 1996, the permanent national currency "hryvna" (UAH) was introduced. However, this has not influenced preferences of agents to dollars. The U.S. dollar up to the present has continued to fulfill three main functions of money in Ukraine: store of value, unit of account, and medium of exchange.

Chapter 4

METHODOLOGY

Model description

Absolute purchasing power parity (PPP) means "that exchange rates are equal to relative price levels" (Krugman, Obstfeld, 2000, p.397) and can be written as follows:

$$S = P / P^* \quad (2)$$

Where S is nominal exchange rate, P and P* are domestic and foreign price levels respectively.

"While PPP concludes that the exchange rate is relative price of goods in the two countries, monetary theory suggests that the exchange rate is the relative price of two moneys." (Levich, 1983, p.32). So, in the monetary approach exchange rate represented as relative demand for money of two countries.

Let us express the demand for the real money balances (M^d/P) as

$$M^d/P = L\ (Y, i, K) \quad (3)$$

Where M denotes demand for money, P is the price level, L is some function of a real income (Y), the interest rate (i), and other factors (K) that determine money demand. Real money demand is positively related to income and negatively related to the interest rate.

The demand for real money balances in equilibrium is equal to real money supply.

$$M^d/P = M^s/P \qquad (4)$$

where M^s is money supply. (3) and (4) can be rewritten as

$$P = M^s / L(Y, i, K) \qquad (5)$$

Since money supply is equal to money demand, prices can be expressed as

$$P = M / L(Y, i, K) \qquad (6)$$

where M is equilibrium quantity of money.

Price level of the foreign country can be presented in the same way

$$P^* = M^* / L^*(Y^*, i^*, K^*) \qquad (7)$$

Where * denotes the foreign country.

According to Levich (1983, p.34) for the flexible price monetary model[7] we can write money demand as

$$M^d/P = Y^{\gamma 1} e^{-\gamma 2 i} K \qquad (8)$$

where e is an exponent, γ1 and γ2 are elasticities of income and interest rate respectively.

So, following the logic introduced above, price levels can be written as

$$P = M / Y^{\gamma 1} e^{-\gamma 2 i} K \qquad (9)$$

$$P^* = M^* / Y^{*\,\gamma 1^*} e^{-\gamma 2^* i^*} K^* \qquad (10)$$

If we introduce (9) and (10) into (2), we will get

$$S = (M / Y^{\gamma 1} e^{-\gamma 2 i} K) / (M^* / Y^{*\,\gamma 1^*} e^{-\gamma 2^* i^*} K^*) \qquad (11)$$

$$S = (M/M^*) (Y^{*\,\gamma 1^*} / Y^{\gamma 1}) (e^{-\gamma 2^* i^*} / e^{-\gamma 2 i}) (K^* / K) \qquad (12)$$

Take logarithms of (12) (small letters denotes logarithms of capital letters)

$$s = m - m^* - \gamma_1 y + \gamma^*_1 y^* + \gamma_2 i - \gamma^*_2 i^* - k + k^* \qquad (13)$$

If there are no other factors determining money demand (i.e. k=k*=0), than

[7] Note that for the sticky price version one should use $M^d/P = Y^{\gamma 1} e^{\gamma 2 i} K$ (i.e. γ2 is without minus).

$$s = m - m^* - \gamma_1 y + \gamma^*_1 y^* + \gamma_2 i - \gamma^*_2 i^* \qquad (14)$$

Equation (14) is the fundamental equation of monetary model with flexible prices (Taylor, 1995, p.21). Accordingly fundamental equation for the sticky price monetary model is

$$s = m - m^* - \gamma_1 y + \gamma^*_1 y^* - \gamma_2 i + \gamma^*_2 i^* \qquad (15)$$

The difference between the sticky and the flexible price monetary models is explained above (see pp. 4 - 6).

Econometric specification of the model

The following regression, based on (14) and (15), will be used as a benchmark one:

$$s_t = \beta_0 + \beta_1 m_t + \beta_2 m^*_t + \beta_3 y_t + \beta_4 y_t^* + \beta_5 i_t + \beta_6 i_t^* + \varepsilon_t \quad (16)$$

where β_0 is a constant, ε is an error term.

Since the basic monetary model does not include variables that may be significant in explanation of exchange rate behaviour in Ukraine, the basic model will be modified with the dollarization ratio[9]. This can be done by substitution dollarization ratio instead of k (13).

$$s_t = \beta_0 + \beta_1 m_t + \beta_2 m^*_t + \beta_3 y_t + \beta_4 y_t^* + \beta_5 i_t + \beta_6 i_t^* + \beta_7 dr_t + dummy + \varepsilon_t \quad (17)$$

Where

dr – dollarization ratio (percentage ratio of deposits in foreign currency US dollars to all deposits, i.e. in domestic UAH and foreign currencies).

dummy – dummy to investigate the fixed effect of the exchange rate devaluation.

Regressions (16) and (17) will be tested. They enable us to test following hypothesis:

H_0: Neither the basic nor the modified (flexible or sticky price) monetary model explains the exchange rate in Ukraine.

H_1: Either the basic or the modified (flexible or sticky price) monetary model explains the exchange rate in Ukraine.

H_0: dollarization does not influence the exchange rate.

H_1: dollarization influences the exchange rate.

9 See for example the research by Rudgalvis, 1996.

Table 2. Variables of basic and modified model and their expected signs.

Variables		Expected signs	
Denotation	Meaning	Model 1: basic model	Model 2: modified model
Log(EXR)	Log of the nominal exchange rate	N/A (dependant variable)	N/A (dependant variable)
Log(M2)	Log of the monetary aggregate M2	+	+
Log(FM2)	Log of the foreign monetary aggregate M2	–	–
Log(RINC)	Log of the real income	–	–
Log(FRINC)	Log of the foreign real income	+	+
NDR	Nominal deposit interest rate (domestic)	+ / –	+ / –
TBR	Treasury bill rate (foreign nominal interest rate)	– / +	– / +
Log(DR)	Dollarization ratio	N/A *	+

* Not applicable because it is not present in the model 1.

Since Ukraine is a high inflation country, it is expected to receive model with flexible prices. In high inflation countries, inflation shocks are high, that is why the incentives to change prices are also high and there is no price rigidity (Grauwe, Grimaldi, 2001, p. 26).

Chapter 5

DATA DESCRIPTION

This research covers the period 1996:09 – 2001:09 in monthly terms. There are two main arguments to start from 1996:09. The first is that 1996:9 is the date of currency reform (hryvna was introduced) and new exchange rate policy was implemented. The second is macroeconomic instability in the earlier periods.

The data on Ukraine was taken from the two sources. The first source of data is the National Bank of Ukraine. It provides data on:

- The official exchange rate (UA hryvnas per one US dollar) (in the econometric models it is denoted as (EXR);
- Monetary aggregate M2 millions of UA hryvnas (M2);
- Nominal deposit interest rate of commercial banks for deposits in hryvnas only (NDR).

The second source is Ukrainian-European Policy and Legal Advice Center (UEPLAC). The following data is used from this source:

- Real income in billions of constant 1990 rubles (RINC).
- The dollarization ratio in percent (DR). It is calculated by UEPLAC as the ratio of deposits in foreign currency to the sum of all deposits. Actual degree

of dollarization is expected to be higher than this ratio for deposits. Since there is no data on the amount of dollars in circulation in Ukraine, the dollarization ratio is available only for deposits.

US data, in particular data for Treasury bill rate has been taken from IFS-CD. Treasury bill rate , percent per annum, is employed as a proxy for the interest rate (TBR).

The Federal Reserve Bank of St. Louis is the source of the monetary aggregate M2, in billions of US dollars (FM2);
(http://www.stls.frb.org/fred/data/monetary/m2ns)

The U.S. Department of Commerce, Bureau of Economic Analysis became a source of real disposable personal income (FRINC), in billions of chained 1996 dollars, seasonally adjusted annual rate. This is the only source of the monthly real income data that was found.

Chapter 6

EMPIRICAL RESULTS

It is very important to test time series for stationarity because nonstationary series may lead to spurious regression with too high coefficient of determination (R^2), which measures goodness of fit of regression to the data. While a spurious regression seemingly looks good, it can lead to incorrect conclusions.

Time series are stationary if their means and variances are constant over time, and the value of covariance between two periods depends only on the gap between these periods and not on the actual time at which this covariance is calculated (Charemza, Deadman, 1997, p.85). Time series are nonstationary if one or more of listed above conditions are violated.

The Augmented Dickey-Fuller (ADF) test is used in order to determine order or orders of integration of time series that will be used in regressions afterward. First, it is determined (for the ADF test) whether time series have intercept or trend, or both (See Appendix 1). Second, the ADF test in levels with one lag is employed. After that Breusch-Godfrey serial correlation Lagrange Multiplier (LM) test is used to test residuals, from regression employed in the ADF test, on autocorrelation. If nR^2 (probability for number of observations multiplied on R-squared) is less than 0.10 we reject the hypothesis that there is no autocorrelation in residuals. If there is no autocorrelation, one lag in the ADF test is enough. However, if there is autocorrelation in residuals, it is necessary to add one more lag. This procedure has to be repeated until residuals will show absence of autocorrelation. Thus, the correct number of lags is obtained for the ADF test[10]. Third, the ADF test in levels with determined number of lags is used to test the null hypothesis of unit root versus the alternative that series are stationary. If module of the ADF test statistic is smaller than module of MacKinnon critical values, the hypothesis of nonstationarity and the existence of a unit root cannot be rejected. Fourth, if series are nonstationary in levels, it is necessary to repeat all process described above for series in first differences and if necessary for series in second differences.

Table 3. Order of integration: ADF test in levels

Variable	Order of integration	ADF test statistic	MacKinnon critical values for rejection of hypothesis of a unit root			Breusch-Godfrey serial correlation LM test
			1%	5%	10%	Probability for nR^2*
Log(EXR)	not 0	-1.57	-4.12	-3.49	-3.17	0.42
Log(M2)	not 0	-2.09	-4.12	-3.49	-3.17	0.40
Log(FM2)	not 0	-2.69	-4.12	-3.49	-3.17	0.18
Log(RINC)	not 0	-1.77	-4.12	-3.49	-3.17	0.15
Log(FRINC)	not 0	-2.15	-4.12	-3.49	-3.17	0.25
NDR	not 0	-2.28	-4.12	-3.49	-3.17	1.00
TBR	not 0	-1.65	-3.55	-2.91	-2.59	0.17
DR	not 0	-1.33	-3.54	-2.91	-2.59	0.76

* When probability for $nR^2 < 0.10$ we reject the hypothesis that there is no autocorrelation in residuals.

[10] See for example MacDonald and Taylor, 1994, p.280; Diamandis, Georgoutsos, Kouretas, 1996, p.87.

Table 4. Order of integration: ADF test in first differences

Variable	Order of integration (for variables in levels)	ADF test statistic	MacKinnon critical values for rejection of hypothesis of a unit root			Serial Correlation LM Test nR2 Probability*
			1%	5%	10%	
D[log(EXR)]	1	-5.14	-4.12	-3.49	-3.17	0.25
D[log(M2)]	1	-6.51	-4.12	-3.49	-3.17	0.86
D[log(FM2)]	1	-7.90	-4.12	-3.49	-3.17	0.48
D[log(RINC)]	1	-9.01	-4.12	-3.49	-3.17	0.21
D[log(FRINC)]	1	-6.13	-4.12	-3.49	-3.17	0.47
D[NDR]	1	-6.15	-4.12	-3.49	-3.17	0.86
D[TBR]	1**	-3.39	-3.55	-2.91	-2.59	0.27
D[DR]	1	-5.96	-3.55	-2.91	-2.59	0.57
* When probability < 0.10 we reject hypothesis that there is no autocorrelation in residuals.						
** Order of integration at 5 % significance level						

As Table 4 shows, all series are of first order of integration. (See Appendix 2 for more details). In Appendixes 3 and 4 is shown that residuals from ordinary least squares estimations of the basic and the modified models are stationary. This implies existence of long-run relationship and allows estimation of error-correction models (ECM).

Table 5. Summary output of error-correction models for the basic and the modified monetary models.

Variable	Model 1 the basic model		Model 2 the modified model	
	Coefficient	Prob.	Coefficient	Prob.
C	0.017244	0.1507	-0.000811	0.9109
D(LOG(M2))	0.177293	0.5413	0.287895	0.0803
D(LOG(FM2))	0.908549	0.3739	0.836209	0.1740
D(LOG(RINC))	-0.001112	0.9828	-0.010066	0.7292
D(LOG(FRINC))	-2.181290	0.1941	-1.083160	0.2710
D(NDR)	0.006287	0.0097	0.002408	0.0763
D(TBR)	0.006129	0.8534	-0.005831	0.7602
D(DR)			0.008387	0.0001
DUMMY			0.055472	0.0000
RESID1(-1)	-0.158626	0.0664		
RESID2(-1)			-0.375918	0.0002
R-squared	0.177546		0.737836	
Adjusted R-squared	0.066831		0.690647	
S.E. of regression	0.044206		0.025452	
Sum squared resid	0.101616		0.032391	
Log likelihood	106.2905		140.5902	
Durbin-Watson stat	1.001711		1.567415	
Mean dependent var	0.018495		0.018495	
S.D. dependent var	0.045761		0.045761	
Akaike info criterion	-6.114228		-7.190885	
Schwarz criterion	-5.834982		-6.841828	
F-statistic	1.603631		15.63562	
Prob(F-statistic)	0.155206		0.000000	

As the summary output for the basic monetary model (model 1) presented in the Table 5 shows, the model does not fit well to the data for several reasons. First, foreign money and foreign real income have counterintuitive signs, while foreign interest rate, although having possibly right sign, have it the same as the domestic one. Furthermore, neither foreign money nor foreign income nor foreign interest rate is significant in the model. The only significant terms in the model are domestic interest rate and equilibrating error term. Although the domestic interest rate is positive and significant in the model, the statistical insignificance of the goodness of fit measured by R^2 and F-statistics for the model as a whole does not allow deriving any reasonable conclusion on the type of the basic monetary model (whether it is sticky price or flexible price) we do have in Ukraine.

The results are different for the modified monetary model (model 2), which differs from the basic one by dollarization and dummy, tracking periods of significant devaluation. Inclusion of these variables dramatically improves performance of the model, turning the goodness of fit to statistically significant one, as measured by both R^2 and F-statistics. This, in other words, means that parameters of the model are jointly statistically significant and explain 74% of variation in exchange rate. Domestic money supply, nominal deposit rate, dollarization ratio, and dummy are statistically significant at 10% level and growth rates in these variables explain short-term variation in the growth rate of the exchange rate. Equilibrating error RESID2(-1) is statistically significant and shows adjustment toward long-run equilibrium.

Constant term, foreign money, domestic and foreign income, foreign interest rate are not statistically significant at 10% level of significance. Moreover, foreign money and foreign income have as in the basic monetary model counterintuitive signs, which, however, can be reasonably explained. In this study, the bilateral USD-UAH exchange rate has been investigated, which in fact violates comparable countries assumption. Actually, the monetary theory of exchange rate determination implicitly assumes the two-country model, where both countries are more or less comparable. In the case of Ukraine versus USA, it is definitely unreasonable assumption since a permanent increase of money in USA is likely to add to world inflation, causing upward adjustment of exchange rates across the world. The same would not hold true for Ukraine, since Ukraine is a small country relative to USA. This poses a reasonable argument for the positive sign of foreign money in our specification to be expected.

The insignificance of the income can be explained by the fact that for Ukraine USA is not a major trading partner, as evidenced by low volumes of export-import circulated between the two countries.

The signs and significance of the interest rates requires careful consideration as long as it leads to a conclusion with respect to a type of monetary model in Ukraine and the role of interest rates in it. As the results show, domestic interest rate is positive and statistically significant in the model. According to results, one percent increase in the growth rate of domestic interest rate leads to increase of the growth rate of the exchange rate by 0.0024. The foreign currency interest rate is negative and statistically insignificant. Its insignificance can be explained by capital control in Ukraine. It may be concluded that the signs of interest rate coefficients correspond to the theory of flexible price monetary model of exchange rate determination, where the domestic interest rate bears inflationary expectations and therefore has a positive impact on to exchange rate.

Thus, the first hypothesis that neither the basic nor the modified (flexible or sticky price) monetary model explains the exchange rate in Ukraine cannot be rejected. However, the modified monetary model performs much better than the basic monetary model and explains exchange rate dynamics in Ukraine. The second hypothesis, that dollarization does not influence the exchange rate, is rejected.

Chapter 7

CONCLUSIONS AND POLICY IMPLICATIONS

The results described in the previous section have led to the following conclusions. First, the data supports the flexible price monetary model, modified for the case of Ukraine, which, however, accords with similar studies[11] for high inflation countries. This conclusion has been drawn on the basis of positive sign and statistical significance of domestic interest rate in the error correction model. As theory predicts, this implies that interest rate has a nominal effect on the exchange rate, reflecting inflationary expectations. Second, dollarization measured by dollarization ratio, exercises significant influence on the exchange rate. This means that the reduction of high dollarization and the factors that cause it (such as fragility of financial system, low public trust to banking and finance institutions and government, high potential risk) would decrease the impact of destabilizing forces on the exchange rate.

The results from the modified monetary model show that the exchange rate in Ukraine is explained largely by dollarization ratio, domestic money supply, domestic nominal deposit rate, and dummy all of which are statistically significant at 10% level in the model. Other variables, such as foreign money,

[11] See for example Rudgalvis, 1996;

foreign real income, and foreign interest rate are not statistically significant at 10% significance level. These conclusions lead to the following policy implications:

- Stability and sustainability of exchange rate depends on the degree of dollarization and factors that influence it. Thus, exchange rate policy has to be selected taking into account high degree of dollarization and everything it entails.
- Currency market liberalization and ease of capital control is likely to change parameters of the model. In particular, it is natural to expect that foreign country interest rate will become significant.
- Money supply can be employed as a tool to influence the exchange rate, while great caution should be exercised with regard to interest rate since it reflects inflationary expectations.

This research supposes two possible directions of further study. First, the basic and the modified monetary models can be tested for the Russian Ruble – UA Hryvna and German DM – UA Hryvna and compared with the results of this study. Second, since the monetary model has several weaknesses like questionable assumptions that rarely hold and simplification of the real world, it would be useful to develop a more realistic model.

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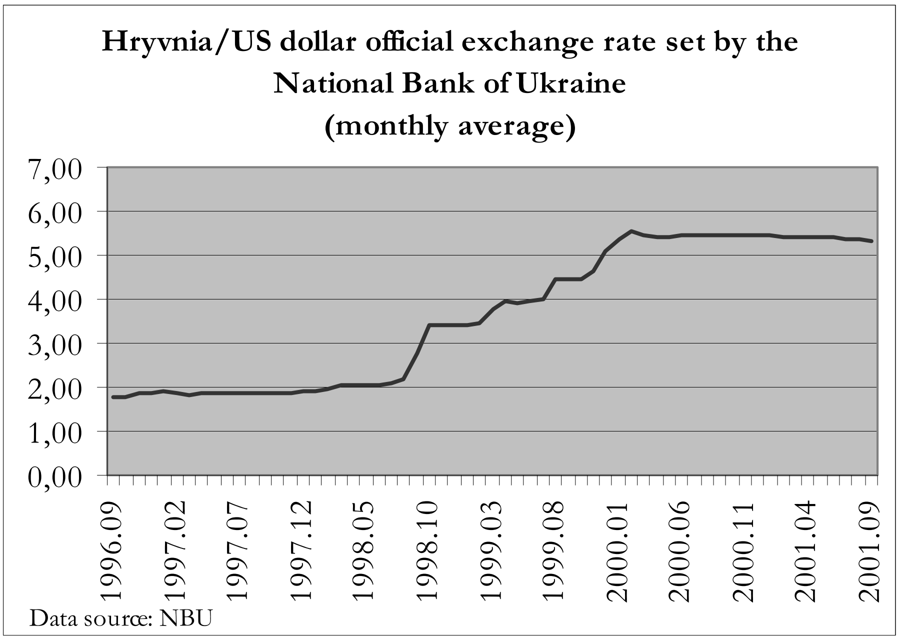
APPENDIX 1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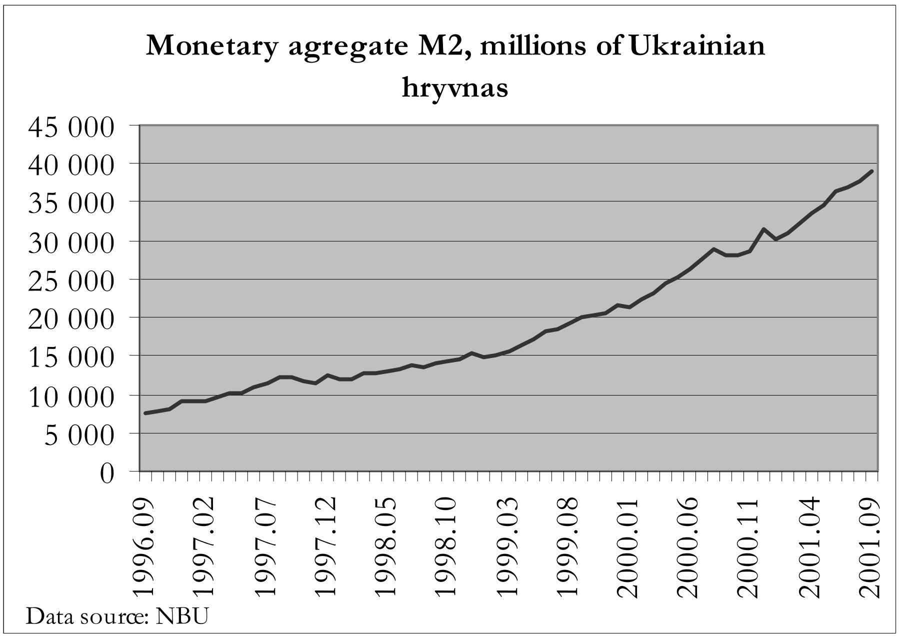
5,00
4,00
3,00
2,00
1,00
0,00
1996.09
1997.02
1997.07
1997.12
1998.05
1998.10
1999.03
1999.08
2000.01
2000.06
2000.11
2001.04
2001.09
Data source: NBU


Monetary agregate M2, millions of Ukrainian hryvnas
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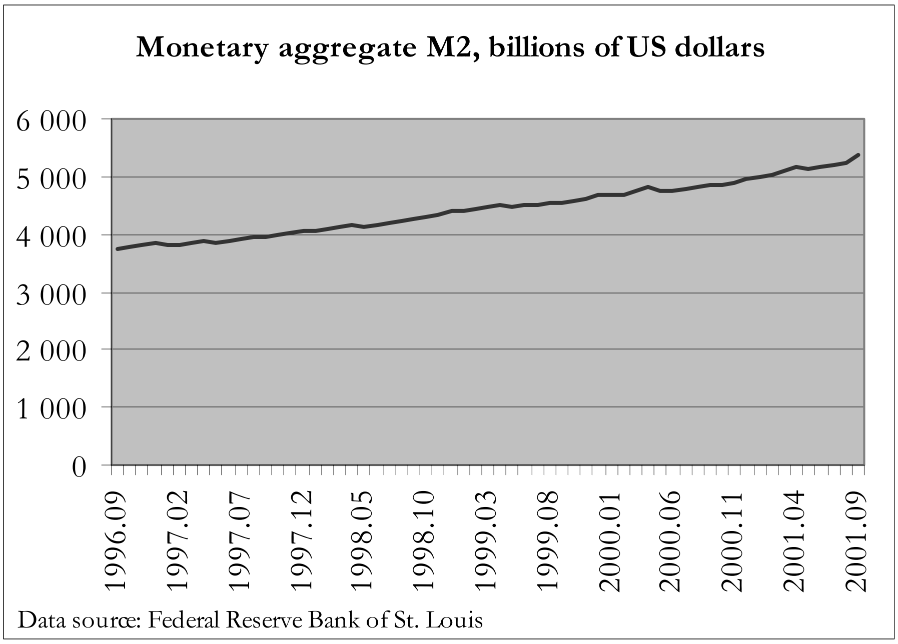
35 000
30 000
25 000
20 000
15 000
10 000
5 000
0
1996.09
1997.02
1997.07
1997.12
1998.05
1998.10
1999.03
1999.08
2000.01
2000.06
2000.11
2001.04
2001.09
Data source: NBU


Monetary aggregate M2, billions of US dollars
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5 000
4 000
3 000
2 000
1 000
0
1996.09
1997.02
1997.07
1997.12
1998.05
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2000.01
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2001.09
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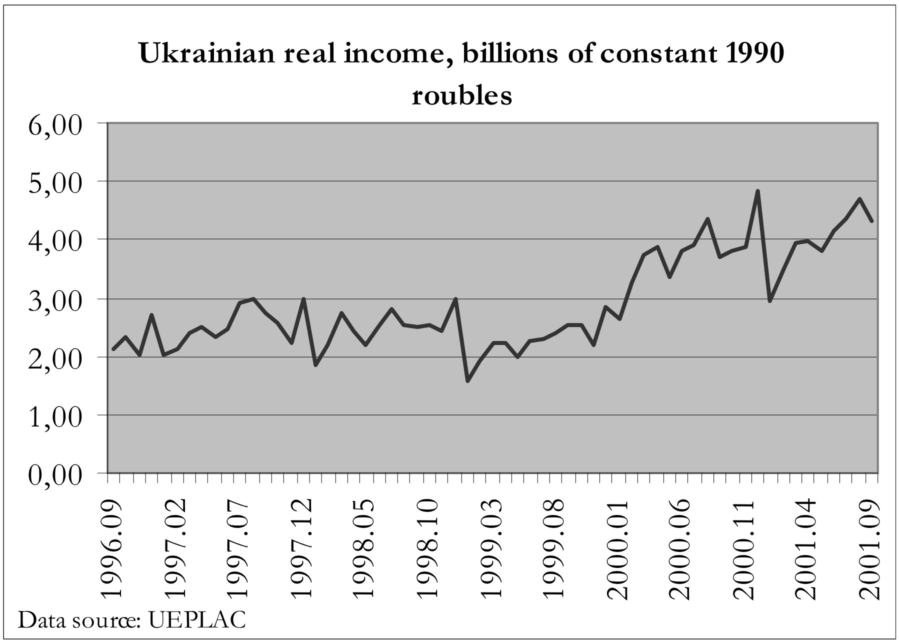
Ukrainian real income, billions of constant 1990 roubles
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5,00
4,00
3,00
2,00
1,00
0,00
1996.09
1997.02
1997.07
1997.12
1998.05
1998.10
1999.03
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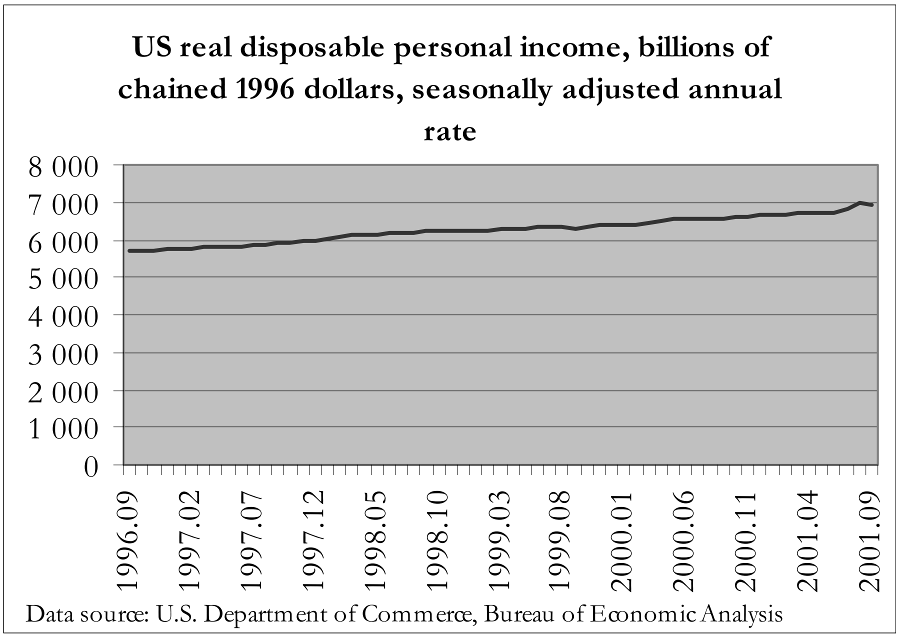
2000.01
2000.06
2000.11
2001.04
2001.09
Data source: UEPLAC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8 000
7 000
6 000
5 000
4 000
3 000
2 000
1 000
0
1996.09
1997.02
1997.07
1997.12
1998.05
1998.10
1999.03
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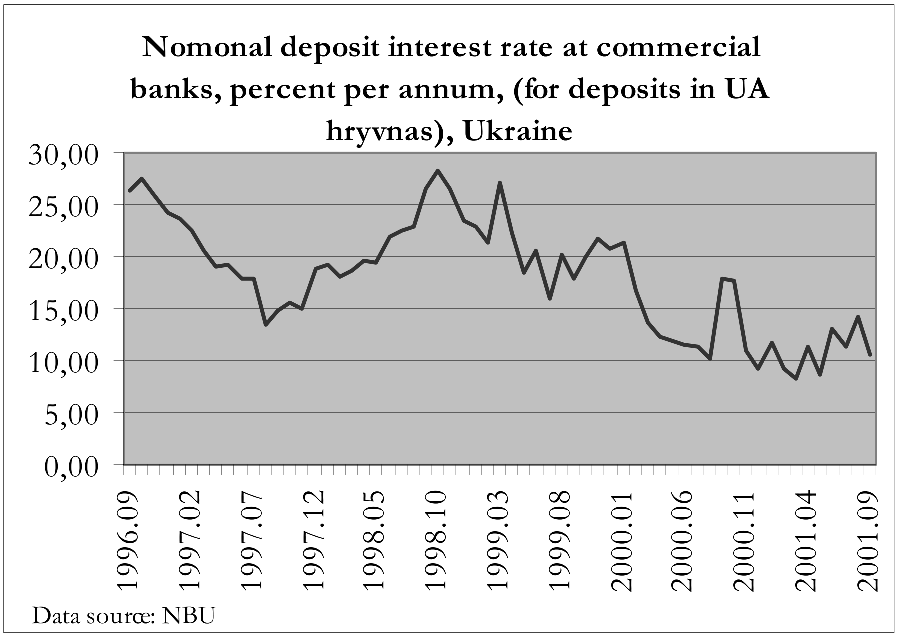
2000.01
2000.06
2000.11
2001.04
2001.09
Data source: U.S. Department of Commerce, Bureau of Economic Analysis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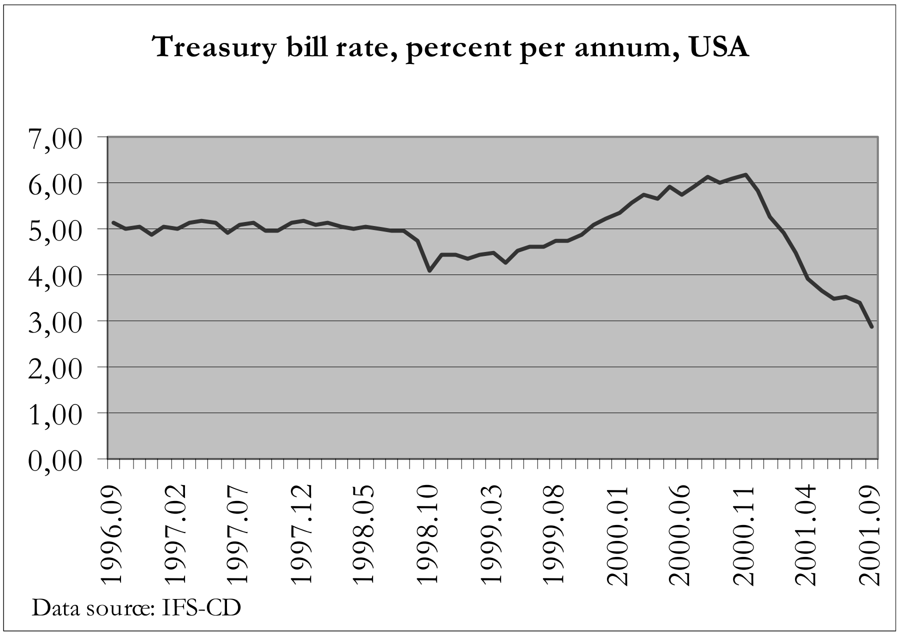
20,00
15,00
10,00
5,00
0,00
1996.09
1997.02
1997.07
1997.12
1998.05
1998.10
1999.03
1999.08
2000.01
2000.06
2000.11
2001.04
2001.09
Data source: NBU


Treasury bill rate, percent per annum, USA
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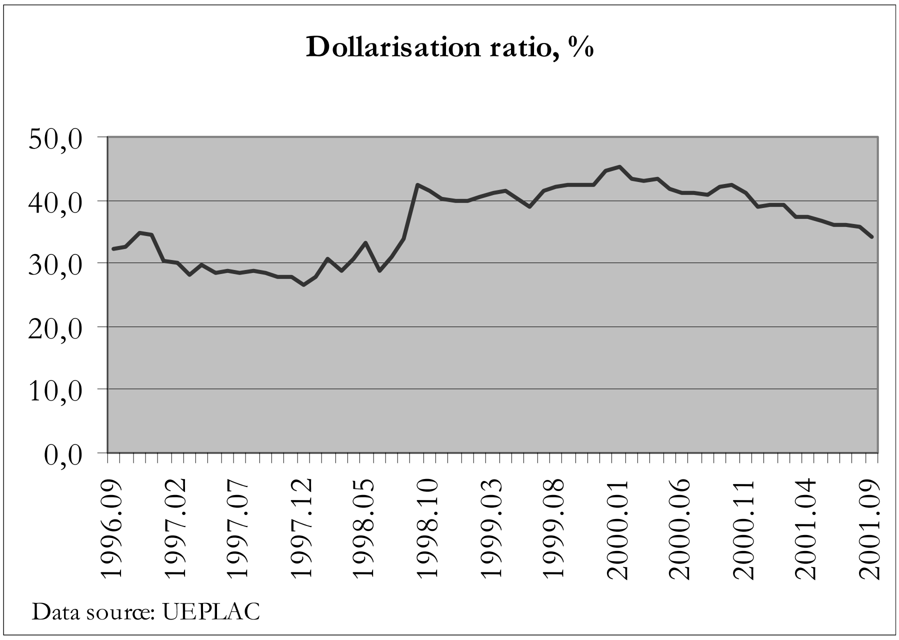
5,00
4,00
3,00
2,00
1,00
0,00
1996.09
1997.02
1997.07
1997.12
1998.05
1998.10
1999.03
1999.08
2000.01
2000.06
2000.11
2001.04
2001.09
Data source: IFS-CD


Dollarisation ratio, %
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30,0
20,0
10,0
0,0
1996.09
1997.02
1997.07
1997.12
1998.05
1998.10
1999.03
1999.08
2000.01
2000.06
2000.11
2001.04
2001.09
Data source: UEPLAC

APPENDIX 2

Table 2.1. Order of integration

Variable	Inter-sept, trend	ADF test statistic	MacKinnon critical values for rejection of hypothesis of a unit root			Serial Correlation LM Test nR^2 Probability*	Order of integration (of variables in levels)
			1%	5%	10%		
LOG(EXR)	tr, int	-1.567	-4.119	-3.486	-3.171	0.418	not 0
D[LOG(EXR)]	tr, int	-5.135	-4.122	-3.488	-3.172	0.255	1
LOG(M2)	tr, int	-2.095	-4.119	-3.486	-3.171	0.399	not 0
D[LOG(M2)]	tr, int	-6.509	-4.122	-3.488	-3.172	0.862	1
LOG(FM2)	tr, int	-2.690	-4.119	-3.486	-3.171	0.175	not 0
D[LOG(FM2)]	tr, int	-7.900	-4.122	-3.488	-3.172	0.484	1
LOG(RINC)	tr, int	-1.772	-4.122	-3.488	-3.172	0.149	not 0
D[LOG(RINC)]	tr, int	-9.011	-4.122	-3.488	-3.172	0.213	1
LOG(FRINC)	tr, int	-2.146	-4.119	-3.486	-3.171	0.249	not 0
D[LOG(FRINC)]	tr, int	-6.131	-4.122	-3.488	-3.172	0.469	1
NDR	tr, int	-2.284	-4.119	-3.486	-3.171	0.998	not 0
D[NDR]	tr, int	-6.152	-4.122	-3.488	-3.172	0.864	1
TBR	int	-1.646	-3.548	-2.913	-2.594	0.165	not 0
D[TBR]	int	-3.394	-3.546	-2.912	-2.593	0.275	1**
DR	int	-1.334	-3.544	-2.911	-2.593	0.760	not 0
D[DR]	int	-5.961	-3.546	-2.912	-2.593	0.575	1

* When probability < 0.10 we reject hypothesis that there is no autocorrelation in residuals.

** Order of integration at 5 % significance level

APPENDIX 3

Table 3.1. OLS estimation of the model 1.

LS // Dependent Variable is LOG(EXR)
Sample: 1996:09 2001:09
Included observations: 61

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	7.045314	10.60602	0.664275	0.5093
LOG(M2)	0.524420	0.288369	1.818572	0.0745
LOG(FM2)	8.144880	1.206443	6.751151	0.0000
LOG(RINC)	-0.181956	0.081508	-2.232358	0.0298
LOG(FRINC)	-9.179626	1.505007	-6.099391	0.0000
NDR	0.022556	0.004322	5.218784	0.0000
TBR	0.140468	0.018479	7.601345	0.0000

R-squared	0.968871	Mean dependent var	1.192026
Adjusted R-squared	0.965412	S.D. dependent var	0.468212
S.E. of regression	0.087078	Akaike info criterion	-4.774293
Sum squared resid	0.409455	Schwarz criterion	-4.532062
Log likelihood	66.06070	F-statistic	280.1160
Durbin-Watson stat	1.004508	Prob(F-statistic)	0.000000

Table 3.2. Breusch-Godfrey Serial Correlation LM Test on residuals from OLS estimation of the model 1.

Breusch-Godfrey Serial Correlation LM Test:				
F-statistic	**0.509454**	**Probability**		**0.843004**
Obs*R-squared	**4.720591**	**Probability**		**0.786980**
Test Equation:				
LS // Dependent Variable is RESID				
Date: 05/26/02 Time: 01:03				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID1(-1)	9.271531	26.54182	0.349318	0.7284
D(RESID1(-1))	-11.69591	21.54135	-0.542952	0.5898
D(RESID1(-2))	2.699399	6.184676	0.436466	0.6645
C	0.015551	0.044186	0.351954	0.7265
RESID(-1)	2.469544	37.71579	0.065478	0.9481
RESID(-2)	-13.18995	18.77002	-0.702714	0.4858
RESID(-3)	-3.954077	6.330408	-0.624617	0.5353
RESID(-4)	-1.818664	3.222728	-0.564324	0.5753
RESID(-5)	-0.857668	1.724413	-0.497368	0.6213
RESID(-6)	-0.663987	0.925496	-0.717438	0.4767
RESID(-7)	-0.148754	0.494788	-0.300642	0.7650
RESID(-8)	-0.233430	0.320551	-0.728217	0.4702
R-squared	0.081389	Mean dependent var		9.57E-19
Adjusted R-squared	-0.138278	S.D. dependent var		0.073442
S.E. of regression	0.078355	Akaike info criterion		-4.911020
Sum squared resid	0.282417	Schwarz criterion		-4.484721
Log likelihood	72.12114	F-statistic		0.370512
Durbin-Watson stat	1.917513	Prob(F-statistic)		0.961131

Table 3.3. ADF test for unit root in residulas from the OLS model 1.

ADF Test Statistic	**-3.268376**	**1% Critical Value***	**-3.5457**
		5% Critical Value	**-2.9118**
		10% Critical Value	**-2.5932**

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
LS // Dependent Variable is D(RESID1)
Date: 05/26/02 Time: 01:12
Sample(adjusted): 1996:12 2001:09
Included observations: 58 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID1(-1)	-0.502052	0.153609	-3.268376	0.0019
D(RESID1(-1))	0.010712	0.153757	0.069670	0.9447
D(RESID1(-2))	-0.022523	0.138994	-0.162046	0.8719
C	-0.000838	0.009909	-0.084599	0.9329

R-squared	0.250392	Mean dependent var	-0.000878
Adjusted R-squared	0.208747	S.D. dependent var	0.084825
S.E. of regression	0.075454	Akaike info criterion	-5.101989
Sum squared resid	0.307440	Schwarz criterion	-4.959889
Log likelihood	69.65924	F-statistic	6.012535
Durbin-Watson stat	1.964820	Prob(F-statistic)	0.001305

Table 3.4. Error-correction model for the model 1 (the basic model).

LS // Dependent Variable is DLOG(EXR)				
Sample(adjusted): 1996:10 2001:09				
Included observations: 60 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.017244	0.011823	1.458583	0.1507
DLOG(M2)	0.177293	0.288311	0.614938	0.5413
DLOG(FM2)	0.908549	1.013057	0.896839	0.3739
DLOG(RINC)	-0.001112	0.051226	-0.021703	0.9828
DLOG(FRINC)	-2.181290	1.658248	-1.315418	0.1941
D(NDR)	0.006287	0.002343	2.684030	0.0097
D(TBR)	0.006129	0.033017	0.185642	0.8534
RESID1(-1)	-0.158626	0.084594	-1.875156	0.0664
R-squared	0.177546	Mean dependent var		0.018495
Adjusted R-squared	0.066831	S.D. dependent var		0.045761
S.E. of regression	0.044206	Akaike info criterion		-6.114228
Sum squared resid	0.101616	Schwarz criterion		-5.834982
Log likelihood	106.2905	F-statistic		1.603631
Durbin-Watson stat	1.001711	Prob(F-statistic)		0.155206

APPENDIX 4

Table 4.1. OLS estimation of the model 2.

LS // Dependent Variable is LOG(EXR)				
Sample: 1996:09 2001:09				
Included observations: 61				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	7.160085	6.119978	1.169953	0.2474
LOG(M2)	0.508235	0.168077	3.023820	0.0039
LOG(FM2)	3.746141	0.815404	4.594217	0.0000
LOG(RINC)	-0.035898	0.049385	-0.726900	0.4705
LOG(FRINC)	-4.991945	0.951845	-5.244493	0.0000
NDR	0.001931	0.003268	0.590901	0.5571
TBR	0.029280	0.015005	1.951305	0.0564
DR	0.031031	0.003000	10.34245	0.0000
DUMMY	-0.020675	0.021335	-0.969074	0.3370
R-squared	0.990093	Mean dependent var		1.192026
Adjusted R-squared	0.988569	S.D. dependent var		0.468212
S.E. of regression	0.050059	Akaike info criterion		-5.853646
Sum squared resid	0.130308	Schwarz criterion		-5.542205
Log likelihood	100.9809	F-statistic		649.6120
Durbin-Watson stat	1.630869	Prob(F-statistic)		0.000000

Table 4.2. Breusch-Godfrey Serial Correlation LM Test on residuals from OLS estimation of the model 2.

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	**0.634020**	**Probability**	**0.744976**
Obs*R-squared	**5.760189**	**Probability**	**0.674074**

Test Equation:
LS // Dependent Variable is RESID
Date: 05/26/02 Time: 01:40

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID2(-1)	-2.218822	3.74995	-0.591694	0.5570
D(RESID2(-1))	2.271185	1.776832	1.278222	0.2076
D(RESID2(-2))	0.617450	1.422786	0.433973	0.6663
C	-0.001449	0.007256	-0.199676	0.8426
RESID(-1)	-0.061852	2.227146	-0.027772	0.9780
RESID(-2)	1.708286	1.260844	1.354875	0.1821
RESID(-3)	0.992052	1.223645	0.810735	0.4217
RESID(-4)	-0.017561	0.298428	-0.058844	0.9533
RESID(-5)	-0.181100	0.223765	-0.809333	0.4225
RESID(-6)	-0.137709	0.162601	-0.846911	0.4014
RESID(-7)	0.039889	0.151972	0.262478	0.7941
RESID(-8)	-0.082355	0.151498	-0.543602	0.5893

R-squared	0.099314	Mean dependent var	-5.98E-20
Adjusted R-squared	-0.116068	S.D. dependent var	0.045637
S.E. of regression	0.048213	Akaike info criterion	-5.882253
Sum squared resid	0.106928	Schwarz criterion	-5.455955
Log likelihood	100.2869	F-statistic	0.461105
Durbin-Watson stat	2.022342	Prob(F-statistic)	0.917497

Table 4.3. ADF test for unit root in residulas from the OLS model 2.

ADF Test Statistic	**-4.356034**	**1% Critical Value***	**-3.5457**
		5% Critical Value	**-2.9118**
		10% Critical Value	**-2.5932**

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
LS // Dependent Variable is D(RESID2)
Date: 05/26/02 Time: 01:43
Sample(adjusted): 1996:12 2001:09
Included observations: 58 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID2(-1)	-0.953257	0.218836	-4.356034	0.0001
D(RESID2(-1))	0.162987	0.175000	0.931354	0.3558
D(RESID2(-2))	-0.008900	0.137759	-0.064607	0.9487
C	-0.000558	0.006168	-0.090542	0.9282

R-squared	0.429916	Mean dependent var	0.000704
Adjusted R-squared	0.398244	S.D. dependent var	0.060444
S.E. of regression	0.046888	Akaike info criterion	-6.053517
Sum squared resid	0.118718	Schwarz criterion	-5.911417
Log likelihood	97.25356	F-statistic	13.57428
Durbin-Watson stat	2.003764	Prob(F-statistic)	1.00E-06

Table 4.4. Error-correction model for the model 2.

LS // Dependent Variable is D(LOG(EXR))
Sample(adjusted): 1996:10 2001:09
Included observations: 60 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.000811	0.007208	-0.112451	0.9109
D(LOG(M2))	0.287895	0.161262	1.785256	0.0803
D(LOG(FM2))	0.836209	0.606283	1.379239	0.1740
D(LOG(RINC))	-0.010066	0.028915	-0.348142	0.7292
D(LOG(FRINC))	-1.083160	0.973155	-1.113040	0.2710
D(NDR)	0.002408	0.001330	1.810010	0.0763
D(TBR)	-0.005831	0.019000	-0.306884	0.7602
D(DR)	0.008387	0.002037	4.116431	0.0001
DUMMY	0.055472	0.010293	5.389544	0.0000
RESID2(-1)	-0.375918	0.092676	-4.056246	0.0002

R-squared	0.737836	Mean dependent var	0.018495
Adjusted R-squared	0.690647	S.D. dependent var	0.045761
S.E. of regression	0.025452	Akaike info criterion	-7.190885
Sum squared resid	0.032391	Schwarz criterion	-6.841828
Log likelihood	140.5902	F-statistic	15.63562
Durbin-Watson stat	1.567415	Prob(F-statistic)	0.000000

Table 4.5. Breusch-Godfrey Serial Correlation LM Test on residuals of ECM 2.

Breusch-Godfrey Serial Correlation LM Test:				
F-statistic	**0.929792**	**Probability**		**0.502341**
Obs*R-squared	**9.027409**	**Probability**		**0.339989**
Test Equation:				
LS // Dependent Variable is RESID				
Date: 05/26/02 Time: 02:06				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.001623	0.007936	-0.204501	0.8389
D(LOG(M2))	0.045949	0.176153	0.260850	0.7955
D(LOG(FM2))	0.007176	0.639446	0.011222	0.9911
D(LOG(RINC))	-0.003619	0.033406	-0.108342	0.9142
D(LOG(FRINC))	0.010380	1.056032	0.009829	0.9922
D(NDR)	0.000169	0.001378	0.122587	0.9030
D(TBR)	0.011427	0.022474	0.508428	0.6138
D(DR)	0.000328	0.002086	0.157308	0.8758
DUMMY	0.004394	0.011738	0.374368	0.7100
RESID2(-1)	-0.051578	0.102514	-0.503131	0.6175
RESID(-1)	0.297540	0.174033	1.709676	0.0947
RESID(-2)	-0.135939	0.184162	-0.738151	0.4645
RESID(-3)	0.109697	0.163054	0.672764	0.5048
RESID(-4)	-0.015797	0.168730	-0.093622	9.26E-01
RESID(-5)	-0.222722	0.165784	-1.343448	0.1863
RESID(-6)	-0.071469	0.177563	-0.402496	0.6894
RESID(-7)	0.063839	0.170580	0.374246	0.7101
RESID(-8)	0.091745	0.164381	0.558124	0.5797
R-squared	0.150457	Mean dependent var		3.12E-18
Adjusted R-squared	-0.193406	S.D. dependent var		0.023431
S.E. of regression	0.025596	Akaike info criterion		-7.087275
Sum squared resid	0.027518	Schwarz criterion		-6.458972
Log likelihood	145.4819	F-statistic		0.437549
Durbin-Watson stat	2.042872	Prob(F-statistic)		0.966218