The Equilibrium Real Exchange Rate and Misalignment: the Case of Ukraine

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Abstract

The research is devoted to the question of estimating the equilibrium real exchange rate in Ukraine to find out whether the currency remains undervalued, as previous studies have shown, and whether it amplifies the rising inflation in recent years. This question has been tackled with the help of Behavioral Equilibrium Exchange Rate approach. The monthly time series from 1996 till 2007 have been employed to estimate Error Correction Model. The results show that Ukrainian currency is still undervalued and is negatively correlated with the rising inflation, thus bringing support to the view that pegged exchange rate regime is no longer appropriate. However, this conclusion should be treated under reserve and no serious inference should be made, since the results may be biased because of too short time series, structural breaks in the data, initial undervaluation of the exchange rate and fixed exchange rate regime.

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1. Introduction

The question of equilibrium exchange rate gained attention of researchers and policy makers after numerous currency attacks. Overvaluation of a real exchange rate attracts not only speculators, but also leads to the loss of competitiveness, increase of foreign debt, decline in the rate of investment and as a result inhibits economic growth (Chobanov and Sorsa 2004). Undervaluation on the one hand is attractive since it favours exporters and therefore has a positive effect on economy. But it is not a remedy for a longer period of time, since it triggers inflation and hampers effective allocation of resources by making some of the industries (export-oriented) artificially more profitable.

First attempts to estimate the real equilibrium exchange rate were made long ago and were based on Purchasing Power Parity theory. According to that the equilibrium exchange rate is stationary and all deviations from it should be treated as misalignment. However, later studies have showed that this is not the case because of the existence of real shocks and variations in capital flows. Many approaches were developed and all of them consider economic fundamentals for finding the equilibrium real exchange rate. Most of the studies (e.g. Alonso-Gamo et al. 2002, Burgess et al. 2003) use terms of trade, productivity in tradable relative to non-tradable sectors, government expenditures, fiscal debt, world real interest rates, gross savings, foreign direct investment to explain the movements in the equilibrium exchange rate.

A particular reason for being concerned about real exchange rate appreciation is possible overvaluation that leads to loss of competitiveness. On the one hand, the real appreciation may deteriorate terms of trade and lead to current account deficits. On the other hand, appreciation of the exchange rate can be caused by the growth of productivity in the tradable goods sector (Balassa Samuelson effect). In this case competitiveness will rise. Therefore, it is

important to understand what drives the equilibrium exchange rate and whether there is a need for policy intervention (Frait and Komarek 2001).

Analysis of the equilibrium exchange rate in transition economies should consider peculiarities of this period. As it was argued by Egert et al. (2005), the real exchange rate exhibited trend appreciation in these countries. One of the reasons is a significant initial undervaluation of national currencies, which was done on purpose by the policy makers to suppress growing demand for foreign currencies and to avoid overvaluation as a result of hyperinflation. This fact will bias the estimation results of OLS, since it treats the residual as fluctuating around zero mean, meaning that the misalignment of the exchange rate should be zero on average, which is not true in case of initial undervaluation (Maeso-Fernandez et al. 2005a).

There have been many studies focusing on finding equilibrium exchange rate and misalignment of real exchange rate in transition economies. But most of them concentrated on such countries as Poland, Hungary, Czech Republic, Slovak Republic, Slovenia, Lithuania, Latvia and Estonia; that is to say, on all countries that have recently joined the European Union. Such analyses are very important because all of these countries plan to adopt Euro in future and for that they need to enter ERM II and fix their exchange rate to the Euro. Both under- and overvaluation would be undesirable.

But the question of misalignment in other countries of transition is of no less importance. To my knowledge, there are very few studies that have considered the case of Ukraine. One of them that included Ukraine into country-by-country analysis was carried out by Egert 2005. In the study the researcher employed the BEER approach and, according to one class of measures, Ukrainian currency hryvnia was considerably misaligned, while another class of measures suggested that in 2003 undervaluation was corrected for. Another research was made by IMF and presented in a yearly Country Report for 2006. According to

the Macroeconomic Balance approach hryvnia was substantially misaligned until April, 2005 when a one time revaluation was made by the National Bank of Ukraine (NBU). After that it still remained somewhat undervalued.

To understand why this question is so important today a quick overview of the economic situation in Ukraine in last several years is needed. The country has had a *de facto* peg of hryvnia to U.S. dollar since 2000, meaning that the NBU has not let it fluctuate out of the range of a narrow band, while officially stating that the currency is not fixed. Until 2006 for several years in a row Ukraine enjoyed current account surpluses due to high steel prices and foreign reserves surged from the level of one week to more than 4 months of imports (figure 1 in the Appendix). At that time undervaluation of hryvnia occurred. As it was mentioned above, in 2005 it was partially corrected but the misalignment remained.

During last two years Ukraine did not have current account surplus any more (though the inflow of foreign currency did not decrease due to rise in FDI) because of the rising prices for gas, which is imported from Russia and Turkmenistan. Exports to Russia comprise 25% out of all Ukrainian exports and imports from Russia comprise 30%. Roughly two-thirds of these imports consist of gas, crude oil and petrol products. Since 2005 Russia has been increasing prices for gas which has become one of the reasons for growing inflation that hit its record high of 17% in 2007. Considering the fact that the trade occurs in U.S. dollar, keeping exchange rate fixed in case of undervaluation of hryvnia would amplify the inflation through the import channel.

The goal of this thesis has been to estimate whether Ukrainian currency is still undervalued in comparison to its equilibrium level to find out if it had its influence on rising inflation in 2007 in order to show that keeping exchange rate of hryvnia fixed to U.S. dollar is rather harmful than useful for the Ukrainian economy.

This task will be accomplished with the help of the Behavioural Equilibrium Exchange Rate (BEER) approach, which will be employed on monthly time series ranging from January, 1996 till December, 2007. The estimation of the equilibrium exchange rate will be carried out with the help of the Error Correction Model (ECM). After that the actual and total misalignments will be calculated.

The results of the research suggest that hryvnia has been undervalued almost through the whole period under study in comparison to the exchange rate of 2001, which was assumed to be in equilibrium. The correlation between misalignment and inflation is negative, supporting the fact that undervaluation amplifies the growth of prices through the import channel. Even though these results are in line with previous researches, they should be treated with care because of data limitations and pegged exchange rate regime.

The study is organized as follows. The first chapter includes literature review of studies on equilibrium exchange rate in transition economies, description of the existent approaches for equilibrium exchange rate estimation and a more detailed glance at the BEER model. The second chapter discusses the economic situation in Ukraine during the transition period with a particular attention to the exchange rate policy of the NBU. The third chapter describes the data employed, econometric background and presents the results of the ECM estimation and calculations of the misalignments. The last part concludes.

2. Theoretical Foundations for Estimating Equilibrium Exchange Rate

The following chapter presents an overview of the literature devoted to the estimation of the equilibrium exchange rate in transition economies, a short description of the methods employed by the researchers and a detailed analysis of the Behavioural Equilibrium Exchange Rate (BEER) approach that was applied in the following research. The goal of this chapter is to provide a broad picture on past research, explain why among all methods the BEER was chosen and to familiarize the reader with the expected effect of fundamentals on the equilibrium real exchange rate.

2.1. Literature Review

Empirical literature on finding equilibrium exchange rate and estimating the misalignment of the real exchange rate is vast. This issue became even more studied after the numerous currency crises of the 1980-90ies. The case of transition economies could not be really considered until recently because of data shortage. Despite this fact many studies have already been carried out during the last several years indicating the importance of this issue.

Most of the researches have been made on Central Eastern European countries and Baltic states, in particular the Czech Republic, the Slovak Republic, Hungary, Poland, Slovenia, Lithuania, Latvia and Estonia (Table 1 in the Appendix). The analyses vary according to theoretical background, econometric techniques and type of data employed (panel vs. time-series). The majority of studies employ time-series data, even though it still suffers from too short time span. Panel data cures this problem but does not allow analyzing countries individually and, moreover, it treats all of them as homogenous, which is not the case (see Maeso-Fernandez et al 2005a).

As it can be seen from Table 1, the Behavioral Equilibrium Exchange Rate (BEER) is the most popular approach for estimating real exchange rate misalignments. It is a reduced form model in which the equilibrium exchange rate is identified with a long run real exchange rate estimated by economic fundamentals. The second most applied concept is the Fundamental Equilibrium Exchange Rate (FEER). It requires first to assume the "equilibrium current account", which makes it subjective, and later to find a real exchange rate which would generate such current account. These and several other approaches applied by researchers are summarized in the papers by MacDonald (2000) and Egert et al (2005). The paper by Maeso-Furnandez, Osbat and Schnatz (2005a) provides pitfalls of existing econometric techniques for estimating equilibrium exchange rate (such as biased OLS estimates due to initial undervaluation of currencies) when they are applied for economies in transition.

A study by Egert, Halpern and MacDonald (2005) presents an overview of existing literature on equilibrium exchange rates in the Central-Eastern, South-Eastern Europe and former Soviet Union countries. It provides an analysis of available methods for estimating equilibrium exchange rate and discusses their usefulness for transition economies. The paper presents transition-specific factors, leading to faster appreciation of real exchange rate. These include: initial undervaluation, trend appreciation, demand-side factors and the Baumol-Bowen effect. The article also considers the question of data and measurement uncertainty. The conclusion of the study is that misalignments of real exchange rates in transition countries can be estimated in terms of direction of the deviation from equilibrium rather than its precise size. This outcome will be considered in the following study. Researchers also underlined that no equilibrium exchange rate approach is problem free and it is important to apply different econometric and theoretical methods for each country.

First paper which considered the question of misalignment of Ukrainian currency was written by Krajnyak and Zettelmeyer (1998). The paper rose a question whether in 1996 there was still a scope for future appreciation of currencies in several transition countries following initial undervaluation of early 1990th or it was already the time to start getting concerned about competitiveness. Considering all structural and institutional changes, which these countries were undergoing, and very short time-series available at that time researchers could not apply equilibrium exchange rate approaches used for developed countries. Therefore, they used dollar wages in the manufacturing sector as a measure for RER. The equilibrium dollar wage was estimated by productivity measures using a short panel of countries. The estimation results revealed that there was still a scope for appreciation of Ukrainian currency since the actual dollar wages accounted just for 25-30 percent of equilibrium dollar wage.

The next article that included Ukraine to the list of countries for estimating equilibrium exchange rate was written by Egert in 2005. He found that the Balassa-Samuelson effect has a partial explanation for movements in the Ukrainian currency, since the effect of productivity increase in tradable sector on rise in prices in non-tradable is not proportionate (equals less than one). The employed BEER approach showed that productivity increase is significant and leads to appreciation of RER, whereas net foreign assets cause depreciation of RER in Ukraine. Derivation of real misalignment showed that Ukrainian hryvnia was overvalued before the Russian crisis. After subsequent large adjustment the currency became undervalued. The analysis of misalignment differs with the class of measures employed. One of them suggests that hryvnia was considerably undervalued in 2003 and another – that it was close to its equilibrium value.

The third study of equilibrium exchange rate for Ukraine was carried out by the IMF and presented in *Country Report 2006* in 2007. The researchers used a different theoretical approach for finding the equilibrium exchange rate – the Macroeconomic Balance

Framework. The analysis showed that after the Russian crisis hryvnia was substantially undervalued and only in 2005 it was partially corrected by the revaluation made by the NBU. Since the misalignment remained it is important to find out whether it still exists while applying a different equilibrium exchange rate model.

2.2. Models of Equilibrium Exchange Rate

The researchers employ different methods for estimating equilibrium exchange rate. In this subchapter a brief summary of most popular methods is presented and reasons for choosing the BEER model in this study are provided.

The most famous and at the same time the most criticised method is the Purchasing Power Parity (PPP), which was proposed by Cassel (1916). The notion of PPP stems from the "law of one price" and argues that exchange rate is in equilibrium when nominal exchange rate is equal to price differential between domestic and foreign price levels. The empirical studies (e.g., Corbae and Ouliaris 1998; Kim 1990) showed that this theory has support only in the long run and thus requires very long time series which are usually not available. In case of economy in transition, the PPP has specific drawbacks. For example, Brissimis et al (2005) argued that PPP was a poor estimation tool when exchange rate was fixed and government intervention was present (which is true for Ukraine). The reason is that policy actions lead to biased estimates and PPP may not be empirically supported even if it exists. Thus, this method was not considered for the following research.

Another approach that should be mentioned is the Capital Enhanced Equilibrium Exchange Rate (CHEER), which is an extension of PPP theory combined with Uncovered Interest Parity. An advantage of the CHEER is that it does not require substantial amount of data and at the same time it provides a good measure for equilibrium exchange rate both in

developed and transition economies when comparing it to other approaches. On the other hand, it does not consider fundamentals (e.g. net foreign assets) except for interest rate differential, which were proved (by e.g., Braumann 1998; Karadi 2003) to influence equilibrium exchange rate. For similar reason the Balassa-Samuelson effect, which is also an extension to the PPP, was not employed in the research.

There are several other methods, which belong to the same 'group' since all of them are derived from internal-external balance framework. They are the Fundamental Equilibrium Exchange Rate (FEER), the Macroeconomic Balance Approach (MB) and the Natural Real Exchange Rate (NATREX). The first two approaches share the same weakness: an assumption about internal and external balance should be made.

In case of FEER (advocated by Williamson 1985), determining internal balance is straightforward, it mainly requires high employment and low inflation, while external balance is characterized by a 'sustainable' position of balance of payments, in particular external debt sustainability. There is no concrete rule which would help define a sustainable current account (or debt level or capital account), though it is one of the core elements of the approach, since the over- or undervaluation of the exchange rate depends on the direction of divergence of the medium-term current account from underlying current account.

A second tool, the MB, is widely used by the IMF for estimating equilibrium exchange rate both in developed and emerging economies. The MB produces a better measure of the desired capital account term, which is estimated as a difference between desired savings and investment and should be equal to current account. The equilibrium exchange rate is the one that generates such condition. This method was not employed in the following research because it still suffers from the judgmental approach (just like FEER). Another reason is that it was applied for Ukraine in 2006 by the IMF and it is more appropriate to use a different method to compare results.

The third approach from this group, the NATREX (proposed by Stein 2005), has many advantages for applying it when making a research for an economy in transition. Its main benefits are the following: it explains what the fundamental determinants of equilibrium real exchange rates are, the transmission mechanism between policies and sustainable real exchange rates, can be applied independent from the exchange rate regime a country is pursuing. The reason for not employing this method in the current research is the lack of required data, such as private consumption time series both in Ukraine and a foreign country (Russia – initially chosen for comparison since it is the main trading partner of Ukraine).

In the following research the Behavioural Equilibrium Exchange Rate (BEER) approach was applied. It has a benefit of being free from assumptions about the sustainable level of internal/ external position; a researcher rather relies on the data and lets it reveal the influence of fundamentals on equilibrium exchange rate. Another advantage of emlpoying this method is that the results can be compared to the IMF research made in 2006 using a different method. A detailed description of the BEER is presented in the next subchapter.

2.3. The Behavioural Equilibrium Exchange Rate (BEER) Approach

The BEER concept was presented by Clark and MacDonald in 1998. Its starting point is the argument that slow mean reversion found for PPP theory is caused by real factors that affect the exchange rate. As long as the systematic relationship exists between the exchange rate and fundamentals, they are cointegrated and the real equilibrium exchange rate can be obtained from the reduced form relationship (all variables are in logarithmic form):

$$q_t = q^e_{t+k} + (r_t - r^*_t) - \lambda_t,$$

where q_t is the real exchange rate in period t (usually real effective exchange rate), q^e_{t+k} is interpreted in the literature as the 'long-run' or systematic component of the real exchange rate, r_t and r^*_t are domestic and foreign real interest rates respectively and λ_t is a risk premium, which is assumed to be a function of domestic and foreign government debt. The fitted values received from estimating such equation produce equilibrium real exchange rates.

The ultimate goal of estimating the equilibrium exchange rate is to see the misalignment of real (effective) exchange rate from the first one. There are two types of such deviations usually calculated by researchers: actual and total misalignments. The actual misalignment can be computed in several ways from the residuals of the long-run estimation where all short term variables are set to zero. The total misalignment is identified the same way, except for the fact that long-run (or sustainable) values of the fundamentals are used. These are usually obtained either by Hodrick-Prescott filter or Beveridge-Nelson decomposition (e.g. Egert et al. 2005).

The choice of fundamentals which represent the q^e_{t+k} term is arguable. Typically researchers include: net foreign assets, the sectors or aggregate productivity differential, terms of trade, savings, foreign direct investment, openness and consumption. The way these variables influence the movements in real exchange rate also differ (see Table 2 in the Appendix, borrowed from Egert, Halpern and MacDonald 2005).

As it is seen from Table 2 growth of productivity was found to appreciate real exchange rate. It can be partially explained by the Balassa-Samuelson (B-S) effect: as productivity rises in tradable sector of the economy, wages rise there as well, meanwhile wages in non-tradable sector follow this trend through wage equalization, driving overall inflation up. Research of the trend appreciation in the transition economies showed that PPP does not hold in tradable sector and PPI-based real exchange rate appreciates as well. Thus B-S effect can explain only the difference between overall inflation (CPI) and inflation in tradable sector (PPI). On the

other hand, Obstfeld and Rogoff (2001) used the New Open Economy Macroeconomics model to show that rise in productivity can actually depreciate real exchange rate. This theory was not supported by empirical studies for transition economies yet but the discussion on this question is ongoing.

Another fundamental that is widely proved to influence the movements in real exchange rate is net foreign assets. Its effect on exchange rate in transition economies is ambiguous. In general, for developed countries, increase in net foreign assets means appreciation of the currency since there is inflow of capital caused by payments on debt from other counties. But the situation is different when it comes to a transition economy. Since net foreign assets are proxied by accumulation of current account balances, long periods of deficits produce net foreign liabilities. Surprisingly, this variable does not immediately lead to depreciation of the currency (e.g., Bitans and Tillers 2003). The reason is that when economic growth is high and domestic savings are not large enough to keep the corresponding pace of investment, foreign borrowing will appreciate the exchange rate. But when the desired level of investment is achieved, the exchange rate will depreciate, because of interest payments on debt (Egert et al (2004)).

Other fundamentals also produce different signs across studies as well. Most consistent is the effect of terms of trade: its improvement corresponds to the appreciation of the exchange rate. It is explained by corresponding capital inflows, which lead to higher demand for home currency and a rise in investment. Openness ratio has exhibited different effects on exchange rate. A depreciation result can be explained by the fact that when trade barriers are decreased, imports increase more than exports. On the other hand, increase in openness can reflect improvement in competitiveness of the exported goods and lead to appreciation (Egert et al, 2005). Consumption represents demand-side channel which is generally expected to

appreciate the real exchange rate. Increase of foreign direct investment and savings are also perceived as factors that appreciate exchange rate.

The influence of short-term variables, meaning interest rate differential and risk premium (λ_t), is more straightforward. As a rule, increase of interest rate differential is expected to appreciate the exchange rate. Risk premium, which is usually represented by government debt, is supposed to depreciate the exchange rate in the long run.

To draw the line, there are different fundamentals used to explain the behaviour of real exchange rates. The results of analysis often depend on their choice, which makes the conclusions of the research less firm. The fact that exchange rate can be cointegrated with different sets of fundamentals means that there are multiple channels through which it is affected (Egert et al, 2005).

The drawbacks of the BEER when applied for time series data for a country in transition are the following. First, data for transition economies is available for around 10-12 years, which is too short a span and this may lead to biases in estimated coefficients. Second, it is a rather simplistic approach, since the estimated exchange rate is assumed to be the equilibrium one, which may not be the case.

To summarize, there has been a big interest in estimating equilibrium real exchange rate in economies in transition, especially in countries that have recently joined the EU. Such analysis for former Soviet Union countries is not numerous, but the question of possible misalignment is not less important. The most recent study for Ukraine, using the MB approach, showed that the currency is undervalued. In the following research a different method, mainly the BEER, and larger time series are employed. The next chapters present the analysis of economic situation in Ukraine during the period under study and empirical results.

3. Stylized Facts: the Ukraine

In this chapter an economic situation in Ukraine during the transition period is presented. A major focus is made on the exchange rate policy of the National Bank of Ukraine (NBU). The following description is important since it is used in explaining the empirical results presented in chapter 3. The goal of this part is to argue that if Ukrainian currency is still undervalued (as it was shown by the IMF research in 2006) then in case of growing prices for imported products pegged exchange rate regime amplifies the inflation in Ukraine and it is the right time to adopt a new monetary policy, mainly to gradually move to a more flexible exchange rate regime.

After the collapse of the USSR, the fall in output in Ukraine was one of the largest among all transition economies. It was partially due to the fact that Ukraine had the highest share of the large industrial enterprises of the former Soviet Union, which in many cases ceased functioning in the beginning of 1990ies. Besides that Ukrainian industries were (and still are) energy intensive. Just as today main energy suppliers were Russia and Turkmenistan. Instead of investing money in energy-saving technologies and increasing competitiveness, state funds were used to import energy resources causing increase in state debt. Not being able to cover budget deficits in any other way, the NBU monetized them in 1993, which led to huge nominal growth of wages (3,850%), broad money (1,900%) and exchange rates (3,350%) in that year. At the same time real values fell drastically because of hyperinflation (10558%). Measures in the exchange rate policy were not successful: neither the participation in Ruble zone, nor the adoption of new currency the *Karbovanets* helped stabilize the situation (see Bas van Aarle et al. 2006).

The first macroeconomic stabilization period lasted from 1994 till the Russian crisis in 1998. As it was discussed by Petryk (2006), hyperinflation was overcome by anti-inflationary

measures of the NBU, such as introduction of government securities instead of money emission and establishment of credit ceiling. The author also underlined that fiscal adjustment played a big role: the budget deficit decreased from 15% in 1994 to 5% in 1995. In the first half of 1996, a new Ukrainian currency the *hryvnia* was introduced, which replaced the Karbovanets at a rate of 1:100 000. This time monetary reform was more successful and the currency is still in circulation.

Over its history the hryvnia has experienced three different regimes: target band, floating exchange rate and *de facto* peg to U.S. dollar. Target band of 1,80 – 2,25 UAH/USD existed from 1996 until August of 1998 - the massive devaluation and default in Russia. During that period the financial situation in Ukraine was already tense due to the deficits in current account which were strengthened by real appreciation of the exchange rate. When Russian crisis occurred, Ukrainian reserves fell to one week of imports (figure 1 in the Appendix) and the authorities were forced to devaluate the hryvnia by 50%. In 1999 the hryvnia was let to float in order to relax tension in the financial market and absorb shocks from loosening monetary policy. Hence until 2000 the hryvnia depreciated by 30% more (figure 2) (Bas van Aarle et al. 2006; Petryk 2006).

From 2000 until today the NBU has been following a policy of stabilizing exchange rate of the hryvnia against the U.S. dollar. Until April 2005 it was not officially announced by the NBU that Ukrainian currency is pegged to the dollar. On the contrary it was stated that the NBU would maintain a floating exchange rate regime, while keeping it from large fluctuations by interventions if necessary. But the unchanging rate of 5,31-5,37 UAH/USD supported for several years made the band narrow enough to call it fixed according to the IMF classification.

Such exchange rate policy brought stability and economic growth, confidence in national currency, credibility to the NBU and substantial increase of foreign reserves. There

were several reasons for this success. First of all, depreciation of the hryvnia in 1998-1999 and later gradual depreciation of the U.S. dollar stimulated export and therefore led to accumulation of foreign reserves from the equivalent of less than 1 week of imports to more than four months in 2007. Second, current account surplus required NBU to buy dollars and sell hryvnia in order to keep the exchange rate fixed, which in case of unsterilized intervention could have led to increase of inflationary pressures. But it didn't happen at first. After several years of unchanged exchange rate, people started to trust Ukrainian currency and made savings in it (in 2004 deposits grew by 17,2%). This change led to sterilization of foreign exchange market interventions. Third, currency peg had prevented the NBU from expansionary policies and inconsistencies, since it would have jeopardized the viability of exchange rate peg. Therefore, economic agents did not expect inflation and thus set prices and wages accordingly. As a result inflation rate fell below 15%, which was a big achievement for Ukraine, though not very impressive if compared with other transition economies (figure 3) (see e.g. Bas van Aarle et al. 2006; IMF Country Report 2006).

Current account was in surplus for a long time - from 1999 till 2005 and gradually hryvnia's real value strengthened (figure 4), though nominal value did not. Suspecting a possible undervaluation, in April, 2005 NBU made a 5% revaluation of hryvnia against dollar but thereafter kept exchange rate constant at 5.05 UAH per 1 USD rate with less than 2% band. As it was mentioned in the literature review, IMF Country Report 2006 has presented analysis of real value of hryvnia. The reform in 2005 corrected undervaluation, but the currency has still remained somewhat undervalued. Keeping hryvnia undervalued may be dangerous since in case of pegged exchange rate an appreciation of a currency occurs through increase of prices.

First signs of growing inflation appeared in 2004. In previous years monetary authorities explained limited sterilization of interventions in the foreign exchange market by high

demand for national currency driven by economic growth (figure 5) and abandonment of barter operations, but these factors could not offset increase of money supply any more (figure 6) (Stelmah, Petryk 2003). Emission of money for the interventions could be avoided if the budget balance was in surplus, but it was the case only in 2000 and 2002. Sterilization was at a low level not only because in the long run such actions bring losses to the central bank, but also because there has been a positive differential between the official and market interest rates (since 2000) and therefore the demand for government bonds was low (Bas van Aarle 2006).

Since 2005 inflation has been growing and in 2007 reached its record height of 16,6% (figure 7). And there is a high probability risk that it will be more than 20% in 2008. The main reasons of inflation acceleration in recent years are the following:

- Increase in prices for imported gas and food products, which together account for 37% of all imports (figure 8).
- Strong domestic demand, fuelled by large increase in wages and social spending.
- Unsterilized continuous interventions of NBU caused by current account surpluses until 2006 and constant growth of capital inflow (figure 9).

An important change in economic situation in Ukraine (which is one of the reasons for making this research) happened in 2006. Since this year the current account was in deficit. It was primarily a result of price increase for imported gas from Russia and appreciating real effective exchange rate. Growth of these prices caused an overall increase of inflation in the whole economy. At the same time a notable increase of capital inflow occurred after 2004, when new government came to power and announced its mission to fight corruption and achieve greater transparency in economic policies. To keep the peg NBU intervened in the market (figure 10), its reserves grew, but money supply of national currency did as well, supporting the inflation growth even further. Slowdown of GDP growth and lose fiscal and

monetary policies added its contribution to the inflationary tendencies. Probable undervaluation of hryvnia (as several studies pointed out (see Egert 2005; IMF Country Report 2006)) also amplifies the inflation rate through higher payments for imports.

As it is seen from the graph during the last six years all operations of NBU in the foreign exchange market had positive balance, meaning that it bought more foreign currency than it sold in order to keep the pegged exchange rate regime. In 2006 the balance statistic was the lowest, which can be explained by the fact that it was the first year of negative current account and also since 2005 the NBU abandoned the requirement for exporters to surrender 50% of foreign currency. In 2007 the amount of bought foreign currency grew again, despite the deterioration of terms of trade. Such actions were driven by surpluses in capital account, which grew by 27% in comparison with 2006 and in absolute value largely outweighed losses from deficit in the current account.

There is another harm that the current exchange rate regime brought to the economy during last several years as it was described by the IMF Country Report 2006. In particular, attractive interest rates on foreign currency loans and stable exchange rate created a big incentive to borrow in dollars, which now accounts for 2/3 of all borrowings (figure 11) in Ukraine. This resulted in worsening of banks' portfolios since income of borrowers is not in foreign currency and loans are not hedged. The share of nonperforming loans is also relatively high. Allowing for some fluctuation in exchange rate could make its risks more apparent and thus decrease dollarization. IMF Country Report No. 07/47, 2007 emphasized that in such circumstances an information campaign to raise public awareness of exchange-rate risks would be of key importance.

Sluggish reforms in Ukraine can be explained by 'fear of floating': monetary authorities worry that unstable exchange rate would undermine the hard-earned trust in the national currency with negative balance sheet effects on the economy. But the other side of the coin is

less attractive: keeping exchange rate fixed means that goods and labor markets need to adjust flexibly to shocks in money demand and balance of payment in order to maintain external and internal stability. This regime can be still viable for Ukraine under condition that fiscal policy would be oriented toward price stability, and wages and prices would be flexible. Tight fiscal and income policies would help reduce aggregate demand therefore decreasing inflationary pressure. But this policy tool would suppress not only inflation but GDP growth as well. IMF Country Report, 2007 presented estimated differences in macroeconomic outcomes under flexible and fixed exchange rates. Forecasted cumulative loss of output for 2007-2011 is 8% if the peg is kept.

On May 22nd, 2008 there was a change in the policy: after several months of market price of Ukrainian currency being 3-10% higher than official price, monetary authorities revaluated hryvnia by 3%. There has been a big discussion in the mass media whether this decision was right or not. The biggest fears are that deficit in the current account will increase further and that people will loose money because many of them have savings in dollars (approximate loss is 1 billion U.S. dollars).

However, there are several arguments to counter these concerns. First, the main reason that pushed the NBU to make this step is growing inflation. As it was pointed out by the World Bank's adviser to Ukraine, Martin Raiser, with current surge in inflation the question of its stabilization is of biggest importance. Due to revaluation the authorities expect inflation rate to decrease by 3%. Second, a large part of exported goods has inputs which are imported from abroad. For example, the share of imported products in main export industry – metallurgy (one of the most energy-intensive industries), is approximately 40% (Petryk 2006). So partially the loss because of revaluation will be offset by decrease in import prices. Another supportive factor for Ukrainian exporters is the growth in labour productivity.

Comparison with the neighboring countries (figure 12), which are trading partners of Ukraine, shows that Ukrainian productivity growth was the highest through 2000-2004 (Petryk 2006).

The following research is conducted in order to bring more light to this issue. The side taken at the moment is for recent change made by the NBU because if the adjustment had been postponed, the income losses due to inflation could have been higher than from savings. At the same time changes in exchange rate regime are unavoidable and the later they occur the more painful they will be. The IMF has been advising to start the transition to flexible exchange rate regime as a run-up to the inflation targeting for several years. It is also supported by relatively high foreign reserves, which could be used in case of excessive fluctuations of the exchange rate. The NBU has committed to moving to a more flexible exchange rate and adopting inflation targeting afterwards, and recent revaluation can be regarded as one of the steps.

To summarize, Ukrainian currency has been fixed to the U.S. dollar for 8 years with some minor changes. Until lately this policy was very successful and brought many advantages to the economy: confidence in hryvnia, credibility of the National Bank of Ukraine, accumulation of foreign reserves stock, economic stability and growth. But recently inflationary pressures grew to very high levels and the existent exchange rate regime only amplifies it. Thus, sustaining fixed exchange rate is more harmful than fruitful and a new regime should be adopted.

4. Estimation and Empirical Results

The following chapter contains the steps of the research and the main results. After the data description, econometric method that is used for estimating the equilibrium exchange rate is presented. The next subchapter discusses the estimation results and their interpretation. The study shows that equilibrium real exchange rate is influenced by such long-term fundamentals as productivity differential and net foreign assets. The opposite effect of productivity on exchange rate behaviour signals that results should be treated with care. Taken this into account, the conclusions are drawn not about the magnitude, but the direction of misalignment and its correlation with the rising inflation.

4.1. Data Description

In the research monthly time series from January, 1996 till December 2007 are used. The primary sources are the Vienna Institute for International Economic Studies (WIIW), National Bank of Ukraine, IFS and State Statistics Committee of Ukraine. The employed variables include:

- Real effective exchange rate ($reer_t$), which was taken from IFS. Calculations were based on CPI; the exchange rate of U.S. dollar per Ukrainian currency was used, hence the increase in the index implies real appreciation and vice versa.
- Productivity differential ($prod\_diff_t$) was calculated as the difference between growth rate of industrial productivity in Ukraine and 12 countries of the Euro area. Change in productivity in other sectors was assumed to be zero. This variable did not work out well, since indices for production in industry and employment in industry in Ukraine had several jumps, which are hard to explain intuitively. For instance, there is a sharp rise in the index (where 2000 is the base year) of industrial employment in the

year of 2002, though the comparison of level data from State Statistics Committee of Ukraine shows that in this year employment in industry decreased. Unfortunately the latter data is available only from the year of 2000.

- Net foreign assets (nfa_t) were calculated following the paper by Egert (2005) as a ratio of monthly cumulated current account balances to GDP. Both variables were seasonally adjusted using Census X12 (Additive) available in Eviews. This proxy is most often used for net foreign assets in empirical studies, though it is not perfect, since it does not consider the fact that debt can be restructured or forgiven, as it is argued by Maeso-Fernandez et al. (2001).
- Government debt (g_debt_t) was obtained as a ratio of cumulative monthly balances of general government budget to GDP, just as in Egert (2005).
- NBU interventions ($NBUin_t$) were calculated as a ratio of base money to GDP. This proxy is not without drawbacks as well, since there is no information available about NBU interventions before 2002.
- Openness ($open_t$) was calculated as the average of exports and imports divided by seasonally adjusted GDP.
- Dummy (dum) was employed for the period of 1998M7-2000M6. In this period of Russian crisis, floating exchange rate regime, numerous shocks to the economy REER exhibited the highest volatility.
- The sustainable levels of productivity differential and net foreign assets were found using Hodrick-Prescott filter.

More detailed analysis of data and its sources can be found in table 2 in the Appendix.

4.2. Econometric Background

In the following research Error Correction Model (ECM) proposed by Engle and Granger (1987) was employed. It is a dynamic model, which is applied on non-stationary, but integrated of the same order and cointegrated series. To check for cointegration the long run equation should be estimated first, which has the following form:

$$Y_t = \beta_0 + \sum_{i=1}^{n} \beta_i X_{ti} + \varepsilon_t \quad (1),$$

where Y_t are the dependent series, $X_t's$ are the exogenous explanatory variables, number of which is n and ε_t are the residuals. If variables are indeed cointegrated, then OLS will produce "superconsistent" estimators of parameters β_0 and $\beta_i's$. It can be explained by the fact that nonstationary variables with a common trend (which is true when they are cointegrated) converge faster than stationary series, because there is a strong linear relationship (Enders 2004).

There are two ways that can be used to find out whether cointegration exists. First, the Durbin-Watson statistic from regression (1) can be compared to cointegrating regression Durbin-Watson statistic. Second, the residual ε_t can be tested for unit root, which is usually done by applying Dickey-Fuller (when we believe there is no serial correlation in residual) or Augmented Dickey-Fuller (when we suspect serial correlation) test. Special critical values for the cointegration tests should be applied, because they take into account the fact that the residual is estimated from the regression and the true error term is unknown (Egwards 2004).

If the test shows that there is cointegration, one can proceed with the ECM. The short-run dynamic model should be specified the following way:

$$\Delta Y_t = C + \sum_{l=1}^{k} \alpha_l \Delta Y_{(t-l)} + \sum_{i=1}^{n} \sum_{l=o}^{k} \alpha_{l,i} \Delta X_{(t-l),i} + \lambda \varepsilon_{(t-1)} + v_t \quad (2)$$

As it is seen from equation (2), ECM includes lagged residual from the long run. A simple equation built on stationary time-series (e.g. differenced) would be wrongly specified, since the long-run cointegration implies that there is a short-term correction term that directs the variables back to the long-run path when they deviate. The sign on this regressor should be negative ($\lambda < 0$), because in both cases when error is positive or negative (upward or downward deviation) the correction term will bring it back to the long-run equilibrium.

4.3. Empirical Results

As it was mentioned above the ECM can be applied only when time series are integrated of the same order. So first of all the variables were checked for unit root. Table 5 presents the results.

Table 5. Integration Order of the Employed Time-Series

Level	DF-statistic	1st Difference	DF-statistic
$reer_t(10)$[1]	-2,6737	$reer_t(6)$	-3,8438
$prod\_diff_t(10)$	-1,7497	$prod\_diff_t(10)$	-5,9314
$nfa_t(12)$	-1,3297	$nfa_t(12)$	-5,9581
$g\_debt_t(2)$	-3,0093	$g\_debt_t(1)$	-17,3971
$NBUin_t(11)$	-0,9751	$NBUin_t(12)$	-4,1877
$open_t(2)$	-4,1115		
Critical values at 1, 5 and 10% accordingly	**-4,0575**	**-3,4578**	**-3,1549**

[1] The lag length is provided in parenthesis. The determination of the lag length for ADF test on the example of REER is presented in table 4 in the Appendix.

The lag length for the Augmented Dickey Fuller test was chosen using two tests. First, the standard ADF test was estimated using 12 lagged differences. The lag length was chosen depending on t-test: the first lagged difference that was statistically significant at 5% level, starting from the lag of the highest order, signalled the correct number of lag differences.

Second, the Akaike information criteria (AIC) were used. When the results from two tests differed, the lag length was chosen depending on statistic which insured there is no serial correlation.

As it seen from the table 5 all variables, except for openness, are integrated of order one, hence they can be used in the ECM. The long-run regression was estimated on the following variables:

$$reer_t = \beta_0 + \beta_1 \cdot prod\_diff_t + \beta_2 \cdot nfa_t + \beta_3 \cdot g\_debt_t + \beta_4 \cdot NBUin_t + \beta_5 \cdot dum + \varepsilon_t ,$$

where $reer_t$ stands for real effective exchange rate, $prod\_diff_t$ - industrial productivity growth rate differential between Ukraine and 12 Euro area countries, nfa_t - net foreign assets, g_debt_t - government debt, $NBUin_t$ - interventions of the NBU, dum - dummy variable from 1998M7 till 2000M6, as it was mentioned in "Data Description" subchapter. The results of the long-run equilibrium estimation are provided in table 6.

Table 6. Estimation Results: Long-Run Equilibrium

Variable	Coefficient	P-value
c	119,68	0,0000
$prod\_diff_t$	-41,44	0,0005
nfa_t	-47,29	0,0000
g_debt_t	-17,14	0,0000
$NBUin_t$	-9,94	0,0003
dum	-24,21	0,0000
R-squared	0,74	
DW	0,70	
ADF-test for the residual		
t-statistic [1]	-5,77	
p-value	0,0000	

[1] ADF cointegration test critical value at 5% level for 100 observations and 5 explanatory variables is -4,36.

To make sure there is no autocorrelation Newey-West standard errors and covariance were employed. The Durbin Watson statistic (0,70) is slightly below cointegration Durbin Watson critical value, which is 0,76 for 100 observations. But since the regression was estimated for 144 observations and critical value for 200 observations is 0,57, the second test for cointegration, mainly the ADF test with intercept, was used. It showed that the residuals are I(0) and the t-statistic is significant at 5% level for cointegration test critical value. Hence, it was concluded that the series are cointegrated of order one.

The signs of coefficients can not be interpreted as elasticities, since the variables are not taken in logarithms. It was not performed because several of them have both positive and negative values in time series. At the same time the purpose of this thesis is not to provide concrete estimates for policymakers about influence of independent variables on REER, but to rather illustrate what is their effect. Therefore, the research was carried out in levels (though the productivity differential is not in levels, but in growth rates because only such data was available).

Table 5 shows that all variables are significant at 1% level. The sign on growth rate of industrial productivity differential is unexpected, since increase of productivity is usually associated with appreciation, not depreciation of the exchange rate, as it is the case now. A possible explanation to this is the New Open Economy Macroeconomic theory which predicts growth of productivity to depreciate the exchange rate in order to balance the current account, while assuming internal balance. Since this theory is not supported by empirical research yet and the discussion is ongoing this explanation is not very reliable. Therefore, the most plausible explanation of such unexpected sign is the structural breaks in the time series for production and employment in industry indices, which were used to calculate industrial productivity. Unfortunately, no better data for Ukrainian productivity could be found for this time period.

The next fundamental that was employed to explain the movements in real effective exchange rate in Ukraine is net foreign assets. In literature the negative sign on this coefficient (meaning depreciation of the exchange rate) is expected for transition economies. These countries usually have current account deficits and cumulatively this variable produces the net foreign liabilities. Therefore when a country starts servicing the debt, its currency should depreciate in order to improve current account's imbalances. But Ukraine is exceptional in a way that it had current account surpluses from 1999 until 2005 as it was described in the previous chapter. Therefore cumulatively current account balances for the period under study do not stand for net foreign liabilities. But the explanation of negative sign on this coefficient is the same, since as Ukrainian economy grew (and revenues from exports played a big role in that) it started to service its debt. In the years of current account surplus capital account was in deficit mainly due to negative balances of "Other Investments". Main reasons for this account to be in minuses are: repayments from banks, monetary authorities, general government for borrowings that Ukraine had for many years (e.g. debt for gas), also short-term credits and long-term loans of monetary authorities and general government abroad. All of these factors imply capital outflow, hence depreciation.

As it was mentioned before, government debt is a proxy for Ukraine's risk premium. The result corresponds to the expectation that increase in a risk premium leads to the depreciation of the national currency, because the interest rate paid on the debt will be higher, which would in turn increase capital outflow. The next variable in table 5 that turned out to be significant is the ratio of base money to GDP, which is a proxy for the NBU interventions. From 2002 (the earliest data available for the NBU operations in the foreign exchange market) until 2007 the bank bought surplus of foreign currency and sold national currency in the foreign exchange market without sterilizing such operations. Hence the money supply grew substantially, as it was described in the previous chapter. With these operations the NBU

tried to depreciate the currency in order to keep the peg of hryvnia to U.S. dollar. A negative sign on this coefficient signals that nominal depreciation of hryvnia was bigger than appreciation caused by price increase (as a result of money supply growth).

One more variable was added to the regression – a dummy for the Russian crisis of 1998 and shocks that were absorbed by the exchange rate during next year. The stylized facts chapter showed that during 1998-1999 Ukraine underwent substantial changes in the exchange rate (50 and 30% depreciation accordingly). The exchange rate was stabilized in the middle of 2000. Hence, this dummy is used to correct for these shocks in the economy. The estimation result shows it has a correct negative sign. It would have been useful to estimate the influence of FDI on exchange rate dynamics also, but this data was available only since 1999 and in quarterly, not monthly time series.

There were two more variables that were initially present in the regression, but turned out to be insignificant, - interest rate differential between Ukraine and Euro area countries and government expenditures. The latter was a proxy for demand-side factor that leads to appreciation of national currency, since it drives inflation rate up. Both variables entered the regression output with the correct positive sign.

The second step of the Engle-Granger procedure is estimation of the ECM. It included differenced REER in the left-hand side, differenced lagged values of REER, differenced levels and their lags for all regressors, lagged value of the error term from the long-run equilibrium estimation and a dummy for 1998M7 to 1999M12 (period of the highest fluctuation of the differenced REER) in the right-hand side. In determining the final model general to specific approach proposed by Hendry (2000) was employed.

As the table 7 presents below, the lagged error term is significant, has a correct negative sign and a magnitude which is in line with the previous research made by Egert (2005). Among differenced level and lagged explanatory variables from the long-run estimation only

differenced level of net foreign assets is significant at 5% level. This result was not expected. Insignificance of the productivity differential growth rate can be explained by small variation in differences of this variable and at the same time existence of large outliers, which implies big variance. These factors lead to large standard errors and as a result to insignificance.

Table 7. ECM

Variable	Coefficient	P-value
c	0,34	0,1662
$d(reer_{t-1})$	0,36	0,0000
$d(reer_{t-3})$	-0,19	0,0190
$d(reer_{t-4})$	0,17	0,0406
$d(nfa_t)$	10,06	0,0403
ε_{t-1}	-0,14	0,0001
dum	-2,22	0,0070
R-squared	0,36	
DW	2,09	

The sign on net foreign assets is positive this time, meaning that increase of this variable leads to appreciation of the exchange rate in the short run. If to consider cumulated current account balances to be foreign liabilities then the explanation is in line with the view presented in previous studies (e.g. Egert, 2005): the high growth of the economy requires large investments and home savings are not large enough to satisfy this demand. Hence, foreign liabilities appreciate the exchange rate until the desired level of investment is reached. Since under period of study Ukrainian current account was not only in deficit, but in surplus as well, the appreciation can not be explained just by inflow of foreign capital through financial and capital accounts, but also through revenues from exports.

The outcome that Granger causality appeared to exist only with one variable is rather surprising. The analysis of ECM residuals shows that there is no partial or autocorrelation.

CUSUM stability test shows that the parameters are marginally stable at 5% significance lines (figure 13). The Chow breakpoint test carried out on the ECM regression without a dummy showed structural breaks in the last months of 1998 and in 1999. As it was discussed in literature review subchapter, the time series for countries in transition are still too short and suffer from structural breaks, which make the estimation results less trustworthy.

4.4. The Misalignment

Egert et al. (2005) pointed out that derivation of a precise estimate of equilibrium real exchange rate is almost impossible, since there are so many theories and the result heavily depends on the set of fundamentals chosen. The task is even harder when the estimation is performed for a transition economy. Lack of appropriate data and numerous structural breaks in it make the outcome of the research less reliable. Taking this into account the misalignment of real effective exchange rate from its equilibrium value for Ukrainian hryvnia is presented first of all to show the direction, not the magnitude of deviation.

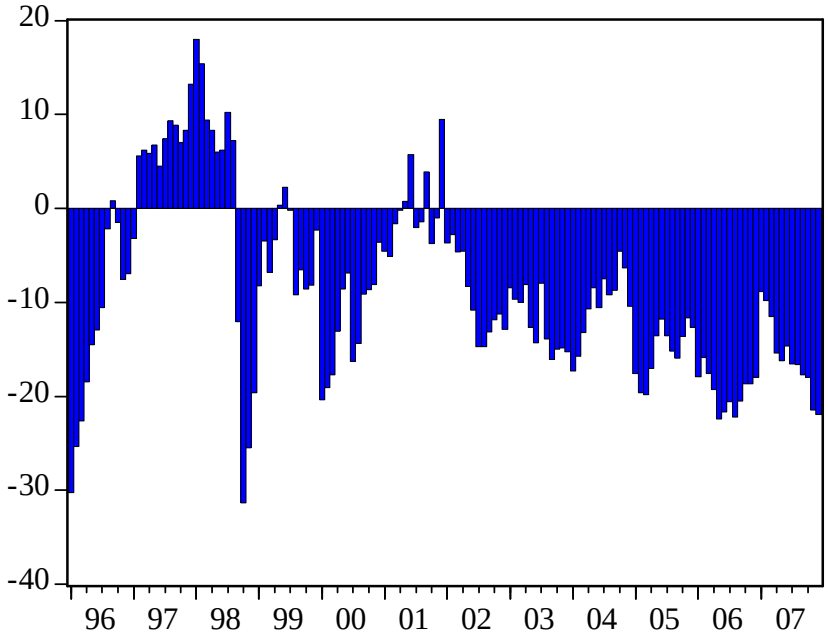
Misalignment in the whole period was calculated in comparison to the year of 2001, assuming that real effective exchange rate was in equilibrium at that time. This year was chosen for comparison because it was the first year of fixed exchange rate, which was set according to demand and supply for the currency in the market. This year was also characterized by much lower inflation levels (figure 7), higher GDP growth (figure 5) and a positive current account balance (figure 9).

The misalignment was found by eliminating the deviation of fitted values of real effective exchange rate from actual ones in 2001. This correction was made by adjusting all residuals by the average misalignment in 2001 in such a way that in this year on average the deviation was zero. Hence, the misalignment in the rest of the years is computed in comparison to this year. The residuals were initially calculated as a difference between actual

and fitted values, therefore, positive values of misalignment signal for overvaluation of hryvnia and vice versa (since the real effective exchange rate is calculated as U.S. dollar per national currency).

The first step was to find actual misalignment of Ukrainian currency. For this purpose the long-run estimation was carried out again, while setting the government debt and NBU interventions to zero. The derived misalignment is presented in figure 14.

Figure 14. Actual Misalignment

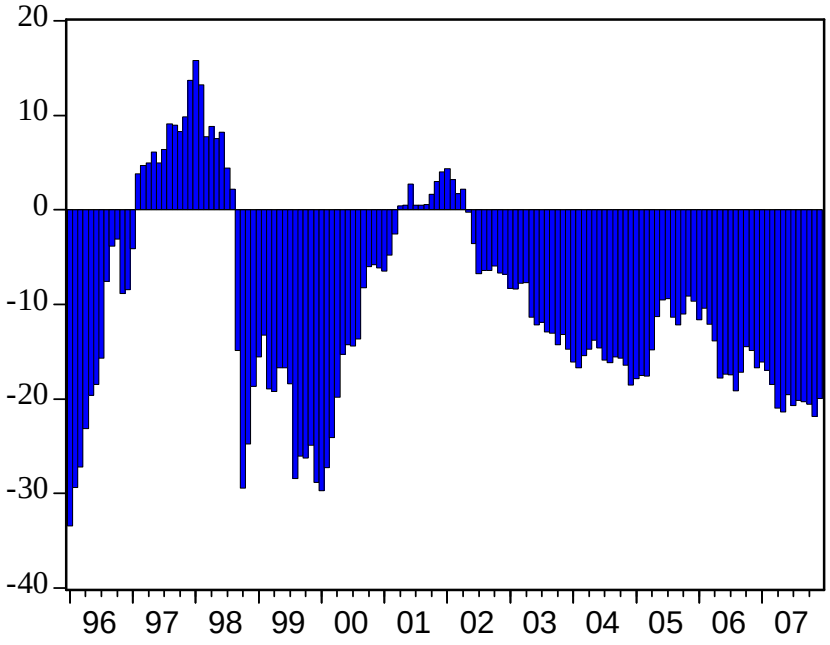


The graph shows a substantial undervaluation in comparison to the year of 2001 almost during the whole period of study, meaning that the real value of Ukrainian currency was below its equilibrium. This result is in line with previous papers (Krajnyak, 1998; Egert, 2005; IMF Country Report 2006). The whole period from 2002 till 2007 is characterized by growing undervaluation, which can be explained by efforts of the NBU to suppress the appreciation in nominal exchange rate and by gradual depreciation of U.S. dollar, which forced depreciation of hryvnia towards other currencies (in particular Euro). But considering the rising inflation, which appreciates the real exchange rate, such deviation in last several

years seems too large, thus supporting the fact that results are illustrative and provide the direction, not the magnitude of the misalignment.

The second step was to find total misalignment. The procedure is almost the same as before, but the sustainable values of the fundamentals are used in order to see the deviation from the equilibrium exchange rate. For this purpose the Hodrick-Prescott filter was employed. The result of the misalignment calculation is presented in figure 15.

Figure 15. Total Misalignment



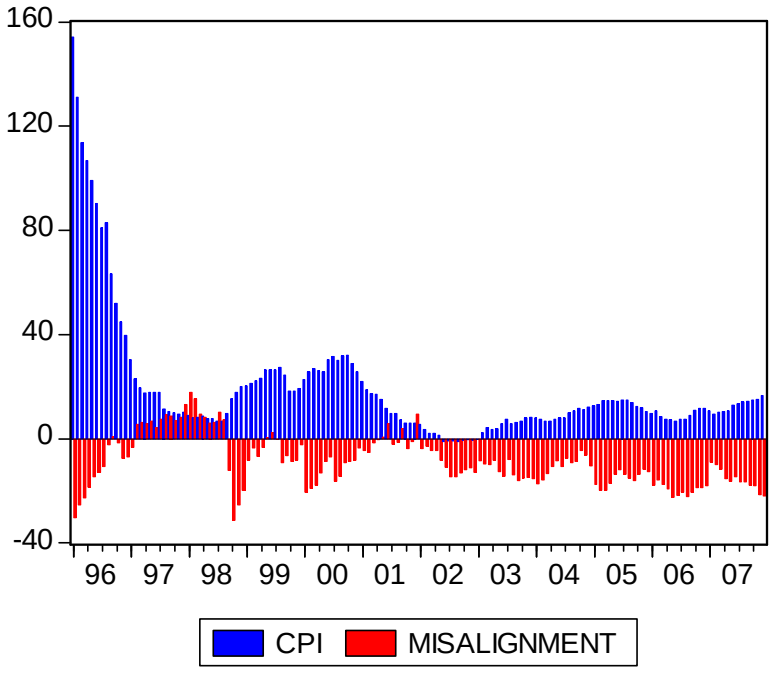
The directions of deviations are almost the same as for actual misalignment, though the periods of over- and undervaluation are more vivid now. The undervaluation of 1996 is most likely a result of huge initial undervaluation that was present at the start of transition period in most Eastern European countries. As it was argued by Egert et al (2005) the monetary authorities set the exchange rate undervalued on purpose in order to avoid future overvaluation, correct for external imbalances and suppress the demand for foreign currency.

From 1997 till the middle of 1998 the hryvnia was overvalued. At this time fiscal deficits were increasing, capital inflow was smaller than capital outflow, but the NBU still

tried to keep the currency within the band (set by managed exchange rate policy) until it almost ran out of foreign reserves (Bas van Aarle 2005). Russian crisis was the last straw and a large depreciation followed.

The next period was marked with substantial undervaluation. It happened as a result of huge nominal depreciation during the time of several shocks to the economy mentioned in the previous chapter. After 2001 Ukrainian currency was mainly undervalued. As it was argued before, the reason lies in the fixed exchange rate regime that keeps the currency at a depreciated rate since the fall of U.S. dollar's value is followed by the fall in hryvnia. At the end of 2005 beginning of 2006 the Ukrainian currency was less undervalued due to the one time revaluation made by the NBU. But the undervaluation increased afterwards again. Such situation is very harmful in case of rising prices for a large part of imported goods: gas and food. The undervaluation leads to the fact that there is additional currency tax on imported goods and this way inflation is amplified. For the illustration purpose figure 16 presents the plotted values of actual misalignment and the CPI index (calculated as annual inflation in comparison to the same month of the previous year).

Figure 16. Misalignment and Inflation



The correlation between these two variables on the whole period is -0,18, but it rises (in absolute value) to -0,84 when only the year of 2007 is considered. In general most periods of rising inflation are accompanied with the undervalued exchange rate. Hence, in today's situation the pegged exchange rate regime supports the growing inflation, a problem that has become of most importance recently.

To summarize, the results of the estimation should be treated with care, since the data contains structural breaks and estimated coefficients may be biased. Thus, the conclusions are drawn only about the direction, not the magnitude of misalignment of Ukrainian currency. The last several years are of particular interest in terms of existence of real exchange rate deviation from its equilibrium, since there is a debate in the country whether to change the exchange rate regime or not. The presented misalignment shows that hryvnia is undervalued. Since it is another source for amplifying inflation, which has been growing during last several years, the research brings some support for suggestions of the IMF to gradually change the exchange rate regime from peg to float.

5. Conclusion

The recent studies (by Krajnyak and Zettelmeyer 1998, Egert 2005, IMF Country Report 2006) of equilibrium exchange rate in Ukraine reported undervaluation of hryvnia. In the current economic situation when inflation is growing to the levels that have already been forgotten during last several years, this question has gained particular importance. Therefore, the purpose of this research has been to estimate the equilibrium real exchange rate in Ukraine to find out whether hryvnia is still undervalued and whether it has an influence on growing inflation so that to show the disadvantages for Ukrainian economy of keeping the pegged exchange rate to the U.S. dollar.

To tackle this issue the Behavioural Equilibrium Exchange Rate has been chosen among numerous theoretical methods, since it purely relies on the estimation results and does not require additional assumptions about external and internal sustainability. At the same time it has been argued by Egert et al (2005) that there is no perfect approach for estimating equilibrium exchange rate and that is why several methods should be used for the same country. Thus, the results of this study should be considered together with the outcome of research made by the IMF Country Report 2006 where Macroeconomic Balance approach was employed.

The estimation of equilibrium real exchange rate has been made by employing Error Correction Model, proposed by Engle and Granger (1987). The results of the long-run estimation show that equilibrium exchange rate is driven by such long-term fundamentals as productivity differential and net foreign assets. The sign of productivity parameter is opposite to the expected, which is most likely the result of several breaks in the time series. Net foreign assets depreciate the exchange rate in the long run, which is in line with the previous research made by Egert 2005. The ECM has a correct sign of the coefficient on lagged error term and one statistically significant long-term variable, net foreign assets, meaning that deviations of

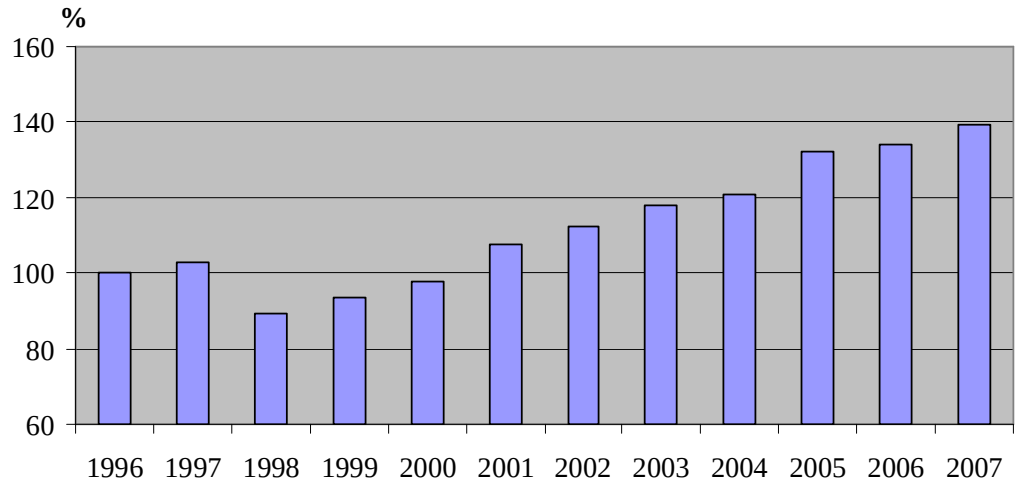
the real exchange rate and the latter from the long-run equilibrium are corrected in the short-run. In general the results suffer from too short time span of the data and possible bias because of initial undervaluation of the exchange rate. Distortions to the results have been added by the pegged exchange rate regime, which is accompanied by the interventions of the NBU and dependence on the change in value of the U.S. dollar.

Taking this into account, the computed misalignment should be treated with care. Therefore, the estimation results are not used to compute the magnitude of the deviation. In best case they capture the direction of misalignment, which has been calculated for the whole period in comparison to the year of 2001, assuming that in this year exchange rate was in equilibrium. The outcome supports the results presented by the previous researches that Ukrainian currency was mostly undervalued during the period of study, except for the time before the Russian crisis. The computed correlation between misalignment and annual CPI is negative, supporting the view that undervaluation amplifies the inflation. Hence, this thesis brings some support to the previous conclusions made by the IMF Country Report 2006 about the undervaluation of hryvnia and the need to change exchange rate regime.

A more valid and reliable results will be possible to find in future if Ukraine continues to show steady growth rates it has today, gradually moves to a more floating exchange rate regime and no major shocks occur in the economy. With longer time series not only ECM results will be more trustworthy, but other more sophisticated econometric techniques will be possible to apply (e.g. the Johansen Procedure). It would also be valuable to estimate equilibrium exchange rate employing the NATREX model, which has proved to be satisfactory for both developed and transition economies, floating and fixed exchange rate regimes and useful for policy implications (Stein 2005).

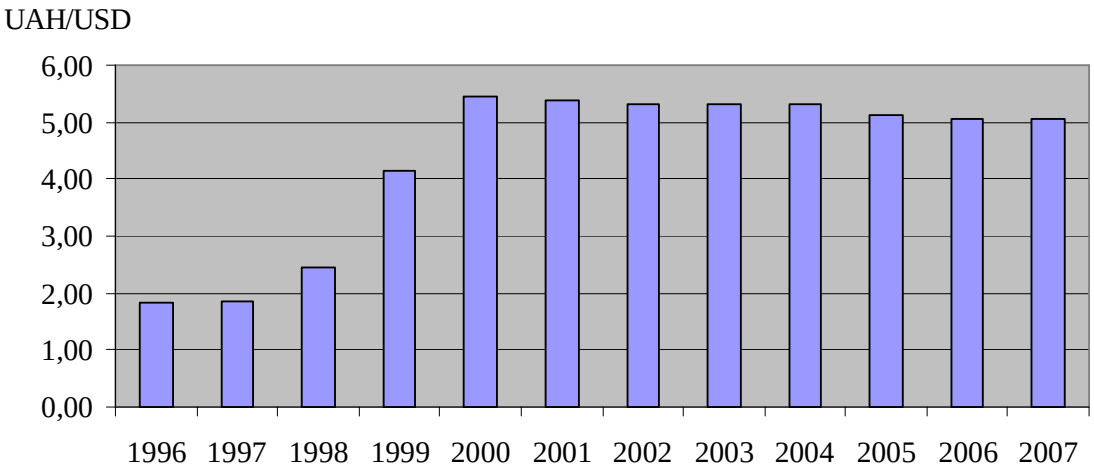
6. Appendices

Figure 1. Foreign Reserves (1996=100)



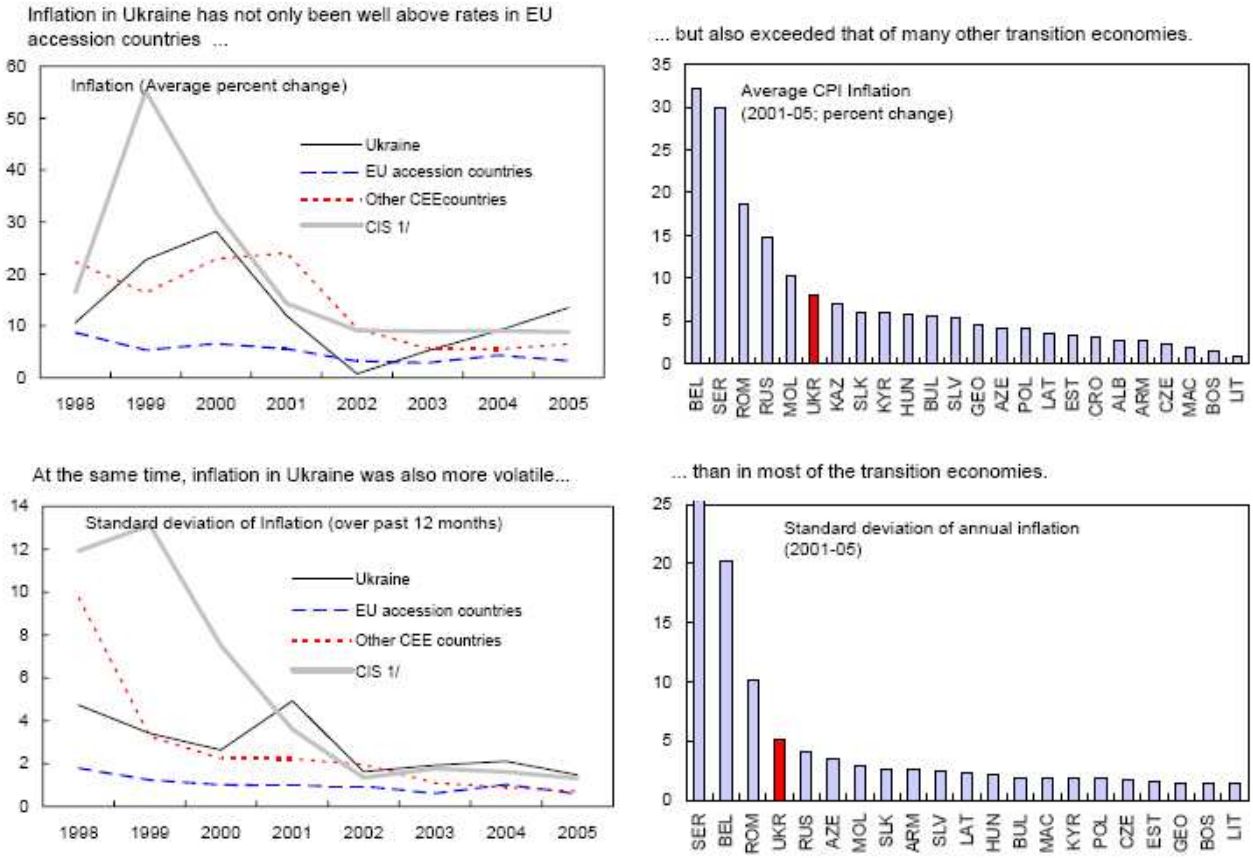
Source: National Bank of Ukraine www.bank.gov.ua

Figure 2. Nominal Exchange Rate (Hryvnia per U.S. Dollar)



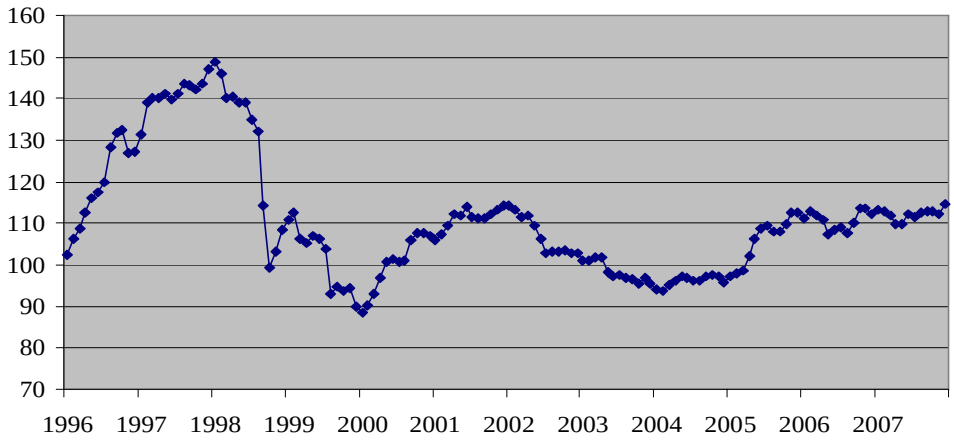
Source: IFS Statistics www.imf.org

Figure 3. Comparison of inflation in Ukraine and other countries



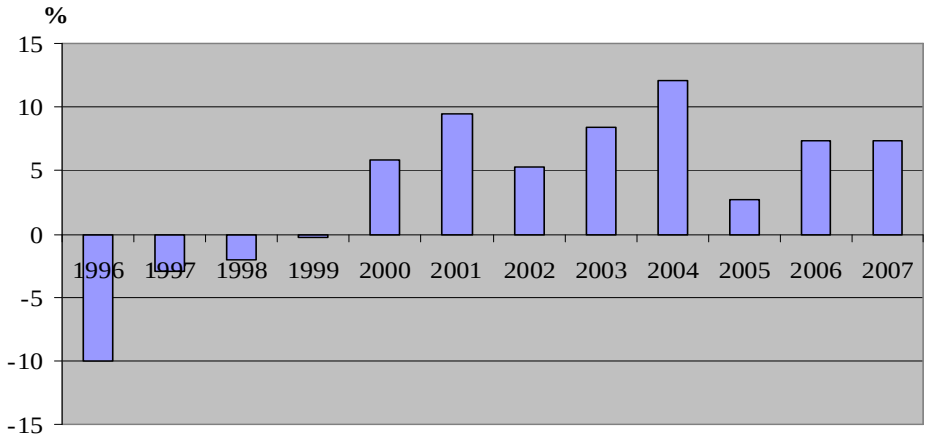
Sources: National Bank of Ukraine; State Statistics Committee; and staff estimates.
1/ CIS countries excluding Tajikistan, Turkmenistan, and Uzbekistan.

Figure 4. Real Effective Exchange rate



Source: IFS Statistics; REER is CPI based, increase implies appreciation.

Figure 5. Real GDP Growth Rate (yoy)



Source: NBU Statistics

Table 6. Base money targets (percent change)

	Original Targets 1/	Revised Targets 2/	Outcome
2005 3/	20-26	38-43	53.9
2004 4/	26-32	51-56	34.1
2003	17-20	38-42	30.1
2002	11-13	32-36	33.6
2001	12	18-19	37.4

Sources: National Bank of Ukraine; and IMF *International* Financial Statistics.

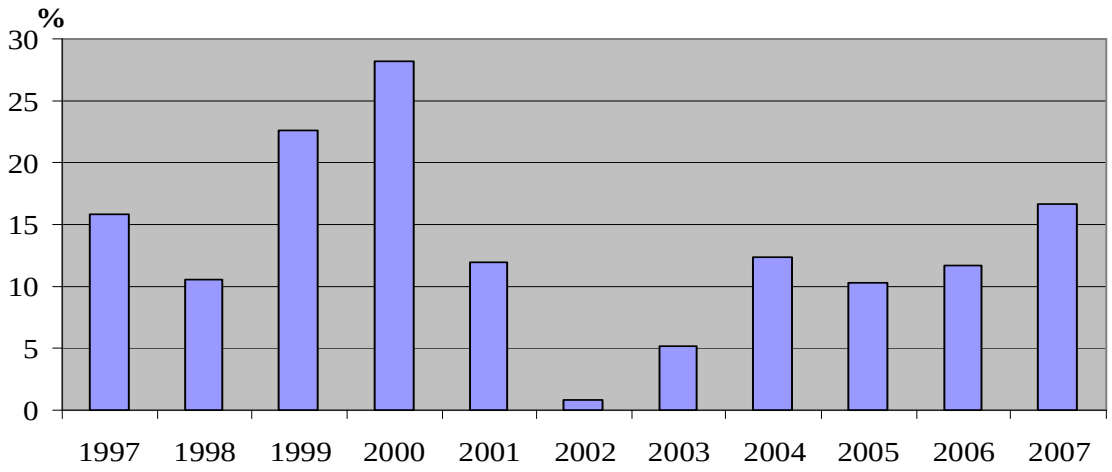
1/ Set in *Monetary Policy Guidelines* in Sept. of previous year.

2/ Revised in Sept. of current year.

3/ Revision in Nov. 2005 to 50-55 percent.

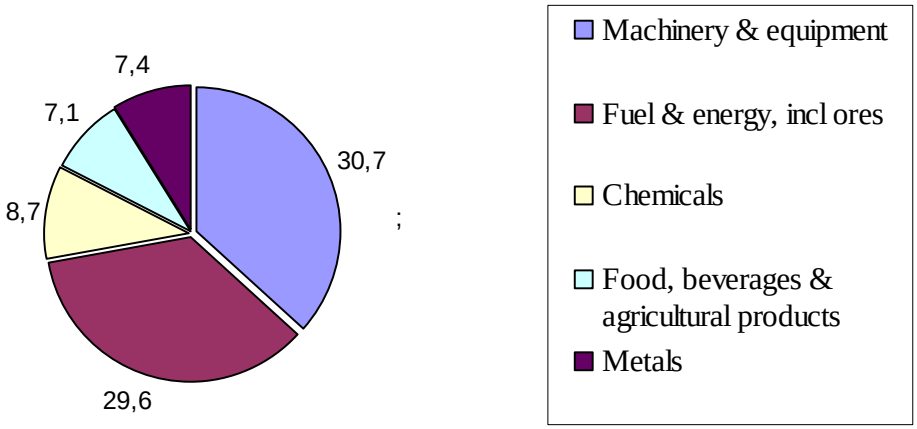
4/ Revision in Dec. 2004 to 34-40 percent.

Figure 7. CPI (yoy)



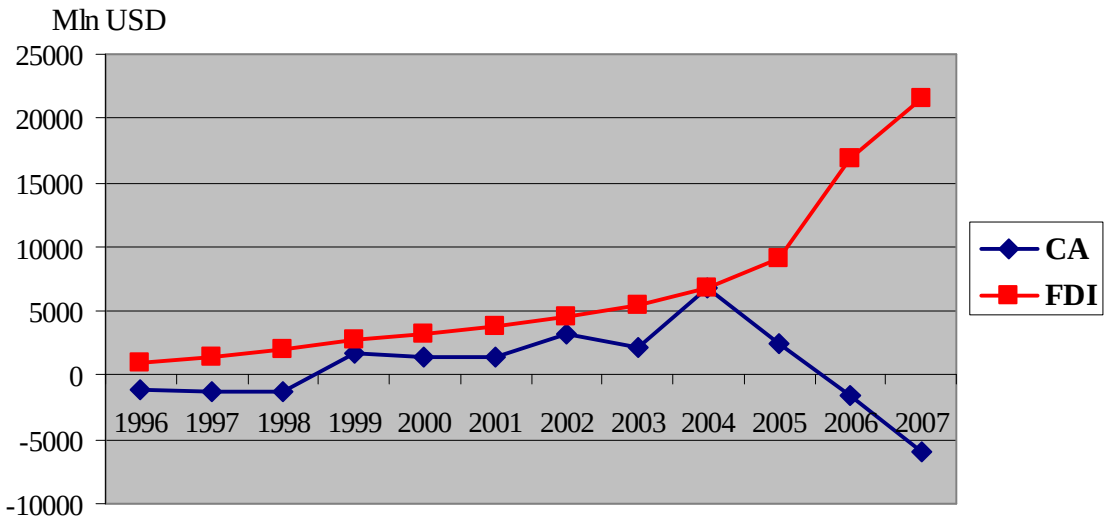
Source: NBU Statistics;
Note: CPI in 1996 was 80,2%; this statistic is an outlier and therefore was not included in figure 7.

Figure 8. Principal Imports 2006



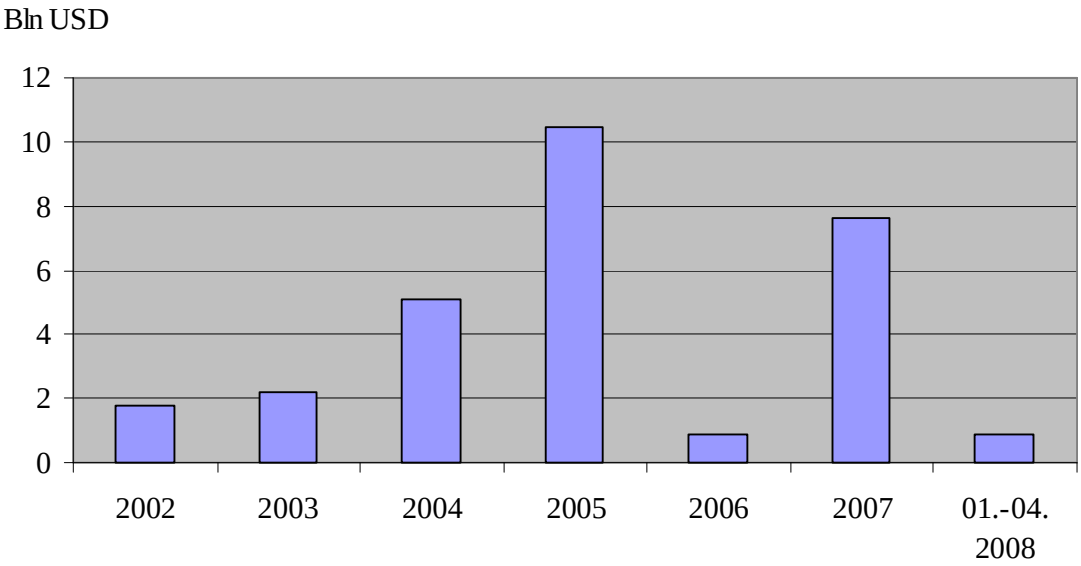
Source: Economic Intelligence Unit

Figure 9. Current Account and Foreign Direct Investment Balances



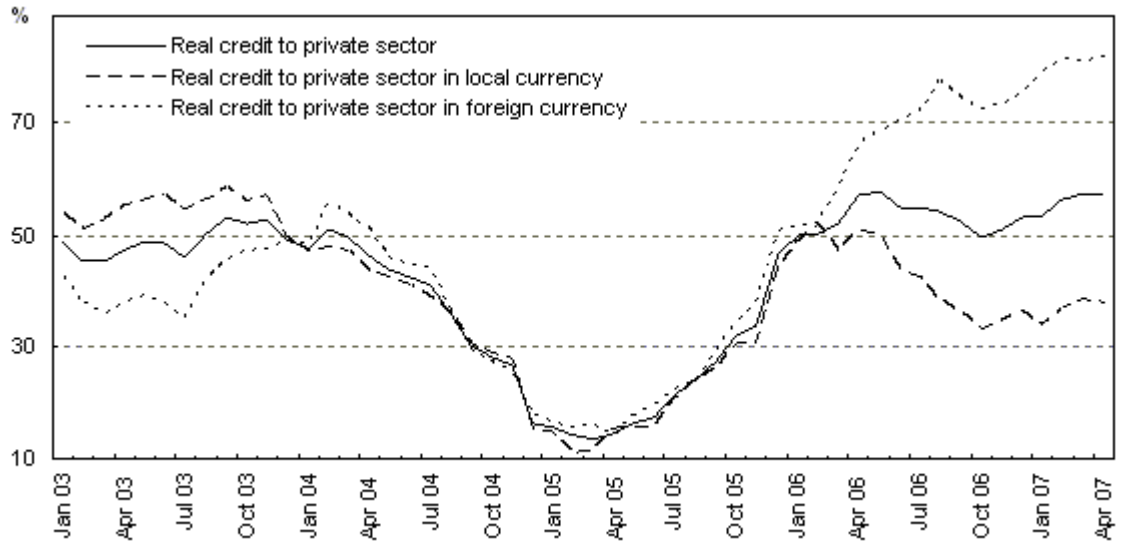
Source: Statistics of NBU

Figure 10. Balance of NBU Foreign Exchange Market Interventions



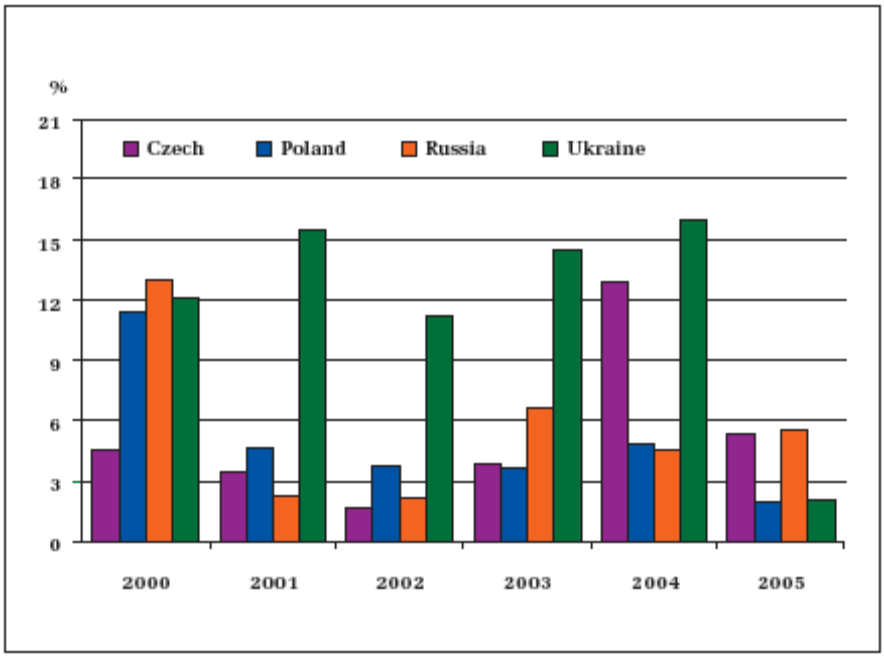
Source: NBU Statistics

Figure 11. Credit growth (yoy)



Source: IMF Country Report: Ukraine, 2006.

Figure 12. Labour Productivity Growth in Selected Countries



Source: Petryk O. (2006)

Table 1. Summary of Real Exchange Rate (RER) Studies in Transition Countries

Authors	Countries	Methodology	Key findings on RER
Alonso-Gamo et al. (2002)	Lithuania	BEER/PEER	RER moves with stock of net foreign assets and relative sectoral prices between countries; slightly undervalued in 2001
Beguna (2002)	Latvia	BEER	RER was overvalued by 2% comparing to fundamentals
Bialluch and Schularik (2005)	Visegrad countries		RERs were undervalued in all countries except for Hungary in 2005, caused by foreign investments
Braumann (1998)	Republic of Slovakia	BEER	No significant misalignment, appreciation of RER in 1990-97 was largely due to fundamentals
Burgess et al. (2003)	Baltic states	BEER/PEER	Real appreciation of equilibrium exchange rate was caused by productivity growth and capital inflows; no misalignment found
Chobanov and Sorsa (2004)	Bulgaria	BEER and NATREX	No misalignment in 2003; RER driven by productivity, terms of trade, world real interest rates, gross savings, FDI
Coudert and Couharde (2002)	Hungary, Poland, Slovenia, Slovak and Czech Republics	FEER	Very small misalignment found; response of foreign trade to small changes in exchange rate is high because of high degree of openness and large export price elasticities
Dibooglu-Kutan (2000)	Hungary, Poland	BEER	Nominal shocks explained movements in RER in Poland and real shocks – in Hungary
Egert and Lommatzsch (2003)	Hungary, Poland, Slovenia, Slovak and Czech Republics	BEER	Overvaluation was found for Po, Hu and Cz. Results are sensitive to econometric method, model and period
Egert (2005b)	Bulgaria, Croatia, Romania, Ukraine, Russia, Turkey	BEER	RER is driven by productivity, net foreign assets, openness, public debt and expenditures
Filipozzi (2000)	Estonia	BEER	RER appreciation occurred parallelly with appreciation of equilibrium RER; slightly overvalued in 2000

Authors	Countries	Methodology	Key findings on RER
Fischer (2002)	Bulgaria, Romania	BEER	RER explained by fundamentals: productivity, real world interest rates, consumption
Frait and Komarek (2001)	Czech Republic	BEER and NATREX	RER determined by productivity, terms of trade, world interest rates and FDI
Genorio and Kozamernik (2004)	Slovenia	FEER	No misalignment found and extrapolation showed that it is not expected in future
Halpern, Wyplosz (1997)	Hungary, Poland, Slovenia, Slovak and Czech Republics	BEER	In 1996 initial undervaluation was not completely reversed; future appreciation was expected
Karadi (2003)	Hungary	BEER/NATREX	In 2002 RER was expected to appreciate as net foreign assets and capital stock adjust to steady-state level
Kim, Korhonen (2005)	Hungary, Poland, Slovenia, Slovak and Czech Republics	BEER	Currencies were overvalued in 2002, but converging to long run fundamentals
Krajnyak and Zettelmeyer (1998)	15 transition economies of CEE and former SU	BEER	Equilibrium dollar wages appreciated steadily in Baltic states and CEE, but remained flat in former SU in 1996
Lommatzsch and Tober (2004)	Hungary, Poland, Czech Republic	BEER	RER appreciation is driven by productivity increases; such appreciation can be viewed as equilibrium phenomenon
Rahn (2003)	Czech Republic, Hungary, Poland, Slovenia, Estonia	BEER/PEER	RER is overvalued in all countries. Productivity differential and net foreign assets influence RER.
Smidkova et al. (2002)	Czech Reublic, Slovenia, Hungary, Poland, Estonia	FEER/FRER	Signs of overvaluation except for Slovenia, RER do not move in the same direction in all countries
Stein (2005)	Poland, Bulgaria, Czech Republic, Hungary	NATREX	Increase in government consumption appreciates RER in the medium-run, but depreciates in the long-run; rise in productivity always appreciates RER
Vetlov (2002)	Lithuania	BEER	Slight undervaluation in 2001, RER moves with productivity differential, openness, interest rate differential, oil price

Source: Egert et al. (2005), Chobanov and Sorsa (2004), own collection

Table 2. Signs of the Estimated Coefficients

	dependent variable	explanatory variables									
Time series		**PROD**	**CAPITA**	**NFA**	**OPEN**	**TOT**	**GOV**	**PRIV**	**RIR**	**INV**	**FDEBT**	**REGD**
Alberola (2003)	REER(CPI)	+ (LP)		+/-								
Alonso-Gamo et al. (2002)	REER(CPI)	+ (CPI/PPI)		-								
Avallone and Lahrèche-Révil (1999)	REER(CPI)		+		-	+	+	+				
Beguna (2002)	REER(CPI)				+	+	+					
Bitans (2002)	REER(CPI,PPI) EU	+ (LP)			-		-					
Bitans and Tillers (2003)	REER(PPI) EU		+	+		-						
Braumann (1998)	REER(CPI, PPI)	+ (RWAGE)			+		-			-		
Burgess et al. (2003)	REER(CPI)	+ (CPI/PPI)		-								
Csajbók (2003)	REER(CPI)	+ (LP)		+	+	+	+		+			
Darvas (2001)	RER (DEM)	+ (LP)		+					+/- (1)			
Égert and Lahrèche-Révil (2003)	REER(CPI)	+ (CPI/PPI)										
Égert and Lommatzsch (2003)	RER(CPI,PPI) DEM,EUR	+ (LP)			-				+/-		+/-	+
Filipozzi (2000)	REER(CPI)	+ (LP)								+		
Frait and Komárek (1999)	REER(CPI)	+ (real GDP)				+						
Hinnosar et al. (2003)	REER(CPI)	+ (LP)		+		+						
Kazaks (2000)	REER(CPI)	+ (LP)			-							
Lommatzsch and Tober (2004)	REER(PPI)	+ (LP)		-					+			
Rahn (2003)	REER(CPI)	+ (CPI/PPI)		+								
Randveer and Rell (2002)	REER(CPI)	+ (LP)				+						
Rawdanowicz (2003)	RER(CPI) EU	+ (LP)				+			+			
Rubaszek (2003a)	REER(PPI)			+					+			
Vetlov (2002)	REER(PPI)	+ (LP)			-				-			
Panel												
Begg et al. (1999)			+		+		+					
Coricelli and Jazbec (2004)	P(t)/P(nt)	+ (LP)					+	+ (2)				
Coudert (1999)	RER(CPI) US	+ (CPI/PPI)									-	
De Broeck and Sløk (2001)	REER(CPI)	+ (LP)			-							
Dobrinsky (2003)	RER(CPI) EU	+ (TFP)	+				+					
Égert and Lommatzsch (2003)	RER(CPI,PPI) EU	+ (LP)			+				+		+/-	+
Fischer (2004)	REER(CPI)	+ (LP)				-	+		+/-			
Halpern and Wyplosz (1997)	RER(CPI) US	+ (GDP/worker)	+				+					
Kim and Korhonen (2005)	REER(CPI); RER(CPI) US		+		-		+			+		
Krajnyák and Zettelmeyer (1998)	RER(CPI) US		+									
MacDonald and Wójcik (2004)	REER(CPI)	+ (LP)		+/-					+			+ (3)
Maurin (2001)	REER(CPI)		+				+		+		-	

Note: + (-) means that an increase (decrease) in the given variables gives rise to an appreciation (depreciation) of the real exchange rate; REER(CPI) = real effective exchange rate based on the CPI; REER(PPI) = real effective exchange rate based on the PPI; RER(CPI) EU; RER(CPI) EUR; RER(CPI) U.S. = real exchange rate against the EU, the euro and the U.S., respectively; P(t)/P(nt) = the internal real exchange rate.

Explanatory variables: PROD=a measure of labour productivity, CAPITA: GDP per capita, OPEN=measure of openness, TOT=terms of trade, GOV=government consumption over GDP, PRIV=private consumption to GDP, RIR= real interest differential, FDEBT=foreign debt to GDP, REGD=regulated price differential

(1) the foreign real interest rate

(2) the share of non-tradable consumption in private consumption

(3) regulated prices in the home country

Source: Egert, Halpern and MacDonald (2005)

Table 3. Data Description

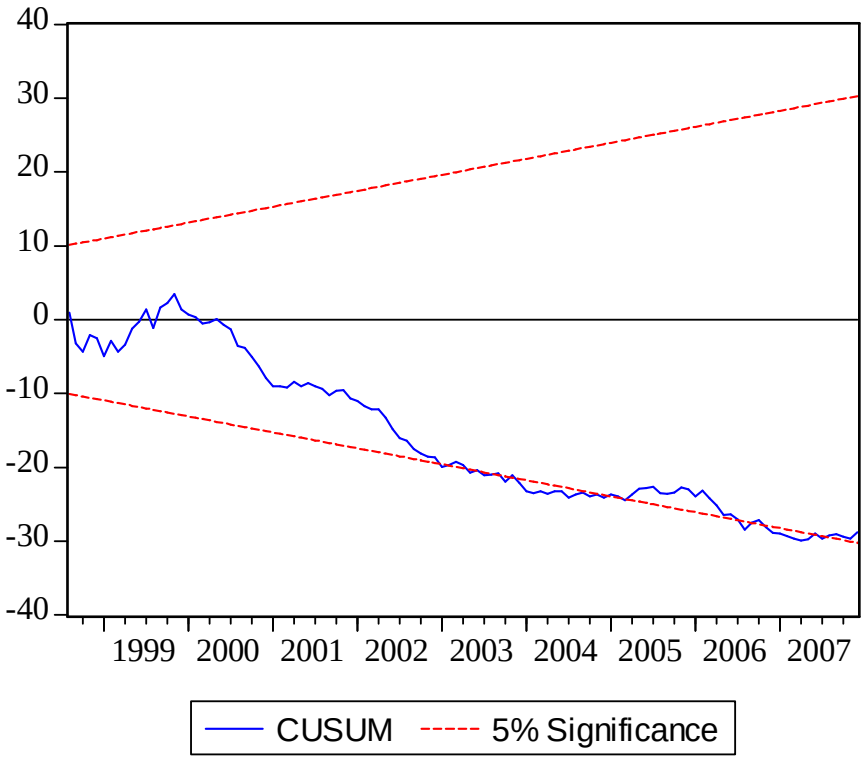
Variable	Source	Note
Real effective exchange rate	IMF Statistics	CPI based; U.S. dollar per hryvnia
Consumer price index	State Statistics Committee of Ukraine	Annual index in comparison to the previous month of the same year
Index of industrial production in Ukraine	IMF Statistics	The index was transformed from 2000 base to CCPY[1]
Index of employment in industry in Ukraine	WIIW	The index was transformed from previous month base to CCPY
Index of industrial production in EU 12	Eurostat	EU 12 includes: Belgium, Denmark, Greece, Spain, France, Italy, Luxembourg, Netherlands, Austria, Portugal, Finland and Ireland. The indices were transformed from 2000 base to CCPY
Index of employment in industry in EU 12	Eurostat	
Current account balances	WIIW	Quarterly series were interpolated to monthly using Quadratic Match Sum and seasonally adjusted through Census X12 options available in Eviews
General government balances	WIIW	
GDP	National Bank of Ukraine	Seasonally adjusted using Census X12
Base money	National Bank of Ukraine	

[1] CCPY – corresponding cumulated period of previous year

Table 4. Determination of the Lag Length for ADF test (example for $reer_t$ level)

Lag-length	Coefficient	t-statistic	AIC	SIC
12	0,021	0,235	4,951	5,280
11	0,095	1,083	4,935	5,241
10	0,229	2,694	4,922	5,205
9	0,005	0,052	4,984	5,244
8	-0,028	-0,323	4,961	5,197
7	0,078	0,909	4,938	5,152
6	0,120	1,388	4,965	5,157
5	0,158	1,843	4,962	5,131
4	0,196	2,322	4,965	5,113
3	-0,041	-0,482	4,987	5,113
2	-0,162	-1,919	4,976	5,081
1	0,408	5,298	4,981	5,065

Figure 13. CUSUM Stability Test



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