MULTICRITERIA STABILITY OF THE MONETARY UNIT

by

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Abstract

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This study carries out the research on the stability of the monetary unit. We use three indicators to estimate the stabilty: exchange rate, interest rate and inflation rate relying on the (G)ARCH models. We impose maximum and average criteria to measure stability and make it comparable across time and under different policies. We also adress the stabilization question and, thus, evaluate the response of the three indicators used in stability analysis to the one period shocks by estimating the Structural VAR.. Extended New Keynesian model proposed by Leu (2004) served as theoretical background for SVAR.. We used Ukrainian data for the period of January 1996 – March 2005 for estimation. Our findings show that stability of hryvnya increased over time with the clear pattern of increasing starting from 2000. We also show that previous period shocks influence the future stability with dying out effect. Response of the indicator variables to the one period shocks meet the theory predictions

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GLOSSARY

Monetary unit – basic unit of calculation and accounting fulfilling five functions of the money.

Stability criterion – measure allowing to judge about stability in numerical values, enables comparison.

Stability indicator - figure on the basis of behavior of which one can interfere about the stability of variable of interest. For example, in our context, exchange rate, interest rate and inflation serve as stability indicators for monetary unit stability.

Chapter 1

INTRODUCTION

Stability of the monetary unit is the main function of the National Bank of Ukraine. This is defined in the Constitution of Ukraine as well as in the Law *On the National Bank of Ukraine.* However, unclear question remains about the interpretation of the term "stability" and how one can understand it. What is meant by it, is it just price stability or exchange rate stability as well, what can be said about the interest rate as the price for money? Open issue for the National Bank of Ukraine is what monetary policy instruments can and should be used to achieve this stability.

The Law of Ukraine *On the National Bank of Ukraine* does not provide the definition for 'monetary unit' (which is hryvnya) as well as for 'monetary unit stability'. It only says that monetary unit stability maintenance is the main function of the National Bank of Ukraine (NBU) with further exposure of the ways to provide it. However, the basic terms of the Law include price stability, which has to be achieved by means of monetary unit stability. In most current discussions on monetary policy price stability means the situation with low and stable inflation. (Svensson, 1999).

According to Grytsenko (2002) stability of the monetary unit is a relative invariability of value, represented by the monetary unit in circulation, which is approved by purchasing power of money. Using money one can buy goods, take a loan, or buy another currency. Thus monetary unit stability should include stability in prices, stability in the interest rates, stability in exchange rates. In the long-run perspective the central bank chooses one main target to maintain stability and achieves it by appropriate influence on the operating instruments. Central bank of Ukraine declared the sequential movement to the direct inflation targeting in 2002. By Shaling (2004) the 1990-2003 world experience has proved that inflation targeting becomes the main target of both developed and emerging countries.

Kuznetsov (2002) on the way to finding priorities of the strategic NBU policy underlines that inflation targeting is necessary in the future, but for now central bank concentrates mostly on the exchange rates, which have managed floating regime, and the interest rates.

In the thesis we would like to analyze the stability of the monetary unit relying on the three indicators of stability, that is exchange rates, interest rates and inflation rate. For this purpose the volatility specified ARCH and GARCH models are used. The author also tries to impose some numerical criteria for evaluating stability in order to make it comparable across different specifications, different time periods, which was not done before.

At the same time we understand National Bank needs to rely on the one instrument to control for stability, that is why we develop the second part of the research based on the New Keynesian Model, Taylor rule and Structural VAR analysis.

The Previous research in the sphere of the monetary unit stability was conducted mainly from the point of view of exchange rates, for example Cotter (2004) examined stability in the Euro using GARCH specification and extreme value theory. Siregar and Rajan (2003) examined exchange rate policy also relying on GARCH model.

The New Keynesian approach is broadly used in the literature for examining monetary policy issues. Leu (2004) extended the model by adding exchange rate into it. We consider this model for constructing Structural VAR.

In our research we use data of the National Bank for the period of January1996-March 2005, such as price indexes, exchange rates, interest rates, real GDP values (monthly). We examine stability for this period and estimate SVAR for 111 observations also.

The thesis includes also the following chapters. In Chapter 2 the review of the existing literature is presented, Chapter 3 include methodology according stability and stabilization techniques (theoretical model and estimating approach), in Chapter 4 data used for empirical estimation is described, Chapter 5 describes the estimated results. Chapter 6 contains the conclusions.

C h a p t e r 2

LITERATURE REVIEW

The first literature concerning monetary unit stability appeared more than the century ago concentrating much on the problems of converting currency into gold. Particularly, Mises (1923) found the equilibrium number of monetary units needed for economy without inflation in terms of both: gold value and purchasing power. He also tried to find the ways of monetary unit stabilization after rupture from the gold standard within conditions of the war crises. Mises (1923) protected exchange rates regulation and argued with the credit expansions and 'unfavorable balances of payments' maintaining.

The significant contribution to the theory brought the Quantity Theory of Money by modeling Fisher's equation for money, used till today.

Heller (1989) claimed that money could fulfill its functions only if it were a stable unit of account, stable exchange instrument and stable store of value. Stability should be supported by the asset prices, commodity prices and final goods prices. Stable monetary unit could aid rational decision making by economic agents. Sunder (2001) developed this idea by modeling the consequences of monetary instability and investigating that instability of monetary unit introduced noise in data and ineffectiveness of decision-making.

In addition to Heller's (1989) conclusions about the support of the monetary unit by price stability Grytsenko (2002) wrote that monetary unit stability is achieved by price stability for goods and services; stability of prices for the credits; stability of the exchange rates. That is why one should pay equal attention to inflation, interest rates and exchange rates. Galchynsky (2002) determined stability of Ukrainian monetary unit hryvnia as slight fluctuations in exchange rate and minor price dynamics. Most of the current discussions on price stability view it as the situation with low and stable inflation, 'low inflation' (Svensson, 1999).

As inflation framework in Ukraine is considered under the long-run perspective of inflation targeting, proclaimed in 2002, the literature regarding this issue should be considered here. The inflation targeting outlines has been subject to an increasing interest in the monetary policy literature. This literature includes the articles of Svensson (1999), Uchida and Fujiki (2003), Mishkin (2004), Ho(2004), Shaling (2004) etc, covering the experience of highly-developed countries as well as emerging countries.

Mishkin (2000) names inflation targeting as the new international trend in the monetary policy strategy, first introduced in 1990 in New Zealand. Inflation targeting has been introduced as a way of reducing inflation and with the aim to influence market expectations, after a disappointment with other targets such as monetary targets or fixed exchange rates. Svensson (2003) views monetary stabilization through supporting the inflation at a low level, which can be achieved by inflation targeting. He concludes also, that inflation targets can be used in order to overcome credibility problems. Uchida and Fujiki (2003) inspect the inflation targeting in the conditions of lacking coordination between the fiscal and monetary institutions. Mishkin (2004) raised a question whether inflation targeting can work in the emerging economies. Too much discretion in policymaker's hands can lead to poor macroeconomic outcomes. That is why strong institutional environment needs to exist before. These statements were approved by Kolodchak (2004) for Ukraine. She established initial conditions for inflation targeting such as financial market development and independence of the Central bank from the government.

In contrast to the relationship between inflation targets and the preferences of the central banks according monetary policy, a relatively undiscovered question in the literature is how to transform inflation targeting into short-term monetary policy instruments (such as interest rates, exchange rates). By Mishkin (2004) an important feature of inflation targeting is that it leads to a systematic interest rate response to inflation and greater reliance on econometric models in the conduct of monetary policy. Along with that an exchange rate target is a part of the inflation target in emerging countries (for example, Hungary). Thus, the literature concerning operating interest rate and exchange rate targets should be discussed in this topic.

A valuable article for my research by Andrade and Divino (2003) analyzes interest rate targeting versus exchange rate targeting, revealing a major role for exchange rate in explaining cyclical patterns of the interest rate.

Interest rate approach in most of the articles involves reaction function determination based on the Taylor rule.

Let us consider interest rate approach. On the one hand, there is a theoretical literature on this issue. For example, Guthrie and Wright (2004) underline that most central banks use exactly interest rate targets as operating objectives of monetary policy. In Australia, Canada, Japan, USA central banks target overnight interbank interest rates, other countries target short-term interest rates. The authors try to solve the problem of the optimal form for such interest rate targeting. The bank sets a target level of interest rates it attempts to maintain through the use of open market operations. Goodfriend (1987) supports this idea by focusing on smoothing the interest rates. Guthrie and Wright (2004) are interested in when and to what extent should the particular central bank change the target rate. Such a change involves changes in the market interest rate. Both researchers constructed a model of central bank's monitoring the target rate in time with evaluating expected total cost of this monitoring.

On the other hand, there is an empirical literature such as of Mohanty and Klou (2004), who went further in their research estimating an open economy Taylor rule for 13 emerging countries (such as India, Korea, Brazil, Chile, Mexico, Czhech Republic, Hungary and Poland etc.) Their general finding is that most central banks change interest rates systematically in response to inflation shocks, output gaps and to the exchange rates shocks. The authors went thoroughly in their research, discussing possible candidate variables for the response function, estimating reaction function, and finding monetary policy response.

Carstensen and Colavecchio (2004) considered different interpretations of the reaction function, taking the interest rate response to the lagged interest rate, the output gap and inflation as a baseline model. After that they estimated 'variations' of it by including money growth and the exchange rate as additional regressors.

The preceding papers were based on assumptions about the linear relationship between the variables. Shaling (2004) in his analysis found that the optimal form of the monetary policy reaction function is nonlinear (interest rate is nonlinear function of inflation rate deviation and the output gap). Mohanty and Klou (2004) tested this finding for 13 countries, obtaining the confirming results for 11 of them.

In our research we include the Taylor equation (for the interest rate response) to the New Keynesian model, broadly considered by Clarida et.al (1999), Leu(2004).

The approaches to estimation procedures differ among the papers. Basically three of them can be found. The first and the most widely used technique is the generalized method of moments (GMM), used by Carstensen and Colavecchio (2004), Andrade and Divino (2003). The second is unique and used only by Genbert and Gerlach (2004), the authors use ordinary ordered probit. However this technique is appropriate not for all data.

GMM empirical analysis does not consider adequately the properties of time series, that is there is no cointegration analysis. Andrade and Divino (2003) use VAR approach and after testing for cointegration pass to the VEC approach. This is done in order to get forcasted inflation and output gap variables of the function.

Stability estimation is based on ARCH and GARCH models developed by Engle (1982) and Bollerslev (1986) respectively.

One more issue, discussed here, however of the less volume because of the specifics of NBU policies is exchange rates framework (NBU tries to fix exchange rate). Filosa (2004) found that most central banks react strongly to the exchange rate. Mohanty and Klou (2004) point out that exchange rates are particularly important for emerging countries for the reasons of: high degree of transition characteristics before inflation targeting, financial stability maintaining. The Ukrainian central bank pays extreme attention to the exchange rates monitoring it every day. The similar situation is in Croatia discovered by Billmeier and Bonato (2004). Croatia has strict exchange rate targeting with effective results in inflation reducing, however the authors indicate this is not necessarily the best policy option for the country. They use VAR model in firs differences, identifying shocks from exchange rates changes and their effect on inflation. The long-run relationship between the exchange rate and price-level is further evaluated.

Nowadays Ukrainian monetary policy attempts to be done complexly with monitoring both interest rates and exchange rates. However, the economy needs to choose one effective anchor to deal with inflation. In my research I am going to estimate stability of the monetary unit, using three indicators (exchange rate, interest rate and inflation); this is past; and SVAR methodology to obtain forecast inflation, exchange rate and interest rate, this is future.

C h a p t e r   3

METHODOLOGY

We divide the methodology part of our work into two main blocks. The first block addresses the question about "stability", where we develop the method that allows imposing criteria for stability of the monetary unit; the second one is "stabilization" describing the theoretical background for stabilization policy.

Stability

Generally we rely on the three indicators of the monetary unit stability:

i) exchange rates
ii) interest rates
iii) inflation

We want to examine stability from the point of view of every indicator as well as cumulative effect of the three. Thus, our algorithm for imposing stability criteria is the following:

1) find the process which can describe the conditional fluctuations (volatility) for each of the indicators;
2) analyze the process found in 1) using analytical and graphical methods;
3) impose criteria for stability.

Volatility analysis of the 3 main monetary unit indicators is maid on the basis of conditional variance models, particularly Engle's (1982) Autoregressive Conditional Heteroscedastisity (ARCH) model and it's extension in the form of Bollerslev's (1986) Generalized Autoregressive Conditional Heteroscedastisity (GARCH) model.

According to Engle (1982) these models are used in order to forecast the variance of the series and are based on the violation of the assumption about constant variance. The variance, instead, is assumed to be conditional and changes over time. The first method we use in our work is proposed by Engle in 1982 and shows the possibility to simultaneously represent the mean as well as the variance of the time series using the conditional forecasts. In contrast to the constant unconditional variance the conditional variance changes over time, usually following the AR(r) process.

By Engle's (1982) methodology it is possible to test whether the disturbances u_t of the equation like

$$y_t = x_t^{'}\beta + u_t \qquad (1)$$

exhibit conditional (time-varying) heteroscedasticity using Lagrange multiplier principle. After the estimation of the regression (1) using OLS, estimated residuals $\hat{u}_t$ are regressed on the own lagged values (Hamilton(1994)), so that:

$$\hat{u}_t^2 = a_0 + a_1\hat{u}_{t-1}^2 + ... + a_r\hat{u}_{t-r}^2 + e_t \qquad (2)$$

t =1, …, T is the sample size, multiplied by R_u^2 from (2) converges in distribution to χ^2 with *r* degrees of freedom under the null hypothesis that u_t is i.i.d with normal distribution.

So, under the ARCH(*r*) specification the conditional variance takes the form of:

$$h_t = a_0 + a_1u_{t-1}^2 + a_2u_{t-2}^2 + ... + a_ru_{t-r}^2 \qquad (3)$$

The extended version of ARCH was proposed by Bollerslev in 1986 and was called GARCH model. In GARCH specification it is assumed that conditional variance follows ARMA process. The error term is described by the function:

$$u_t = v_t \sqrt{h_t} \qquad (4)$$

where v_t is i.i.d. with zero mean and variance equal to 1, and h_t changes due to the following process:

$$h_t = a_0 + a_1 u_{t-1}^2 + a_2 u_{t-2}^2 + \ldots + a_r u_{t-r}^2 + b_1 h_{t-1} + b_2 h_{t-2} + .. + b_q h_{t-q} \qquad (5)$$

Note: $Eu_t = Ev_t \sqrt{h_t} = 0$

$E_{t-1} u_t^2 = h_t$

The expression for h_t describes the conditional variance of u_t under GARCH specification.

Two requirements concerning the expression for h_t must hold for both ARCH and GARCH:

i) all the coefficients are positive;

ii) all the characteristic roots lie inside the unit circle in order h_t to be finite. For covariance stationarity the sum of coefficients excluding intercept must be less than unity. $(a_1 + a_2 + \ldots + a_r + b_1 + b_2 + .. + b_q) < 1)$

After we find the appropriate specification for describing the conditional variance of exchange rate, interest rate and inflation we construct correlograms and try to explain why at some point there was increase/decrease in conditional variance. We also look at the volatility pattern of the whole observation period and make conclusions about increase/decrease in stability. After examining all the three indicators, we compare the volatilities of their conditional variances and impose criteria.

But before doing this let us state that stability is opposite to the volatility.

The purpose of imposing criteria is to find some simple real measure of stability in order to compare stability in different periods of time, or under different policy implementations, or sometimes (but not always possible) even stability of different monetary units.

First criterion we use to measure stability is **maximum.** We look at the maximum volatility of the three indicators at every point of time.

So, Criterion 1 = K1 = max{Conditional Variance (exchange rate); Conditional Variance (interest rate); Conditional Variance (inflation)}

Such a criteria gives a possibility to conclude what indicator was the strongest contributor to the instability.

For illustrating purposes it is also useful to construct the cumulative variance based on picking up the maximum values of indicators' volatility at every period of time. Such a procedure helps to capture the maximum volatility at every period of time.

A second criterion is **average,** constructed as the average standard deviation using formula:

Criterion 2 = K2 = $\frac{1}{n}\sqrt[2]{\overline{\sigma_1^2} + \overline{\sigma_2^2} + \ldots + \overline{\sigma_n^2}}$, where n=number of indicators, $\overline{\sigma_n^2}$ is the average conditional variance of the indicator n. In our case n=1,2,3.

For example, if we want to consider only indicators, on which Central Bank can influence (using them as instruments for monetary policy) we take only 2: exchange rate and interest rate.

Alternative third criterion could be simple average of the reported standard deviations of the summary statistics. That is $\frac{1}{n}(\sigma_1 + \ldots + \sigma_n)$.

In practical estimation one can use all the three criteria.

Stabilization

After estimating the stability, one wants to know how to reach it and what stabilization policy to implement (Interesting for the Central bank in our case). In order to judge about the interdependences in the three stability criteria as well as about the possibilities to influence one criterion by means of another one we rely on the Structural Vector AutoRegression approach (SVAR).

Theoretical background for the SVAR we use is the New Keynesian model. This "New" approach is based on the standard Keynesian IS/LM framework, however distinguishes by:

- explicit derivation of the equations from the optimization problem of the households and firms;
- dependence of the economic behavior on both the present and the future course of monetary policy.

The "new" approach suggests also abstracting from investment and capital accumulation, since this does not effect the qualitative conclusions.(Clarida et.al, 1999).

The New Keynesian Model consists of two equations: IS-curve and Phillips curve: $x_t = -\lambda[i_t - E_t\pi_{t+1}] + E_t x_{t+1} + gt$ (6)

$$\pi_t = \beta E_t \pi_{t+1} + \lambda x_t + u_t, \quad (7)$$

where g_t and u_t are disturbance terms: $g_t = \mu\, g_{t-1} + g_t^{/}$

$$u_t = \varrho\, u_{t,-1} + u_t^{/}$$

$g_t^{/}$ and $u_t^{/}$ are i.i.d random variables with zero mean and variances σ^2

x_t stands for output gap, i_t is the interest rate, π_t is inflation.

(6) is the *IS curve*, relating inversely the output gap to the real interest rate.

(7) is the *New Keynesian Phillips curve* which relates inflation positively to the output gap.

Walsh (2003) shows the derivation of these two equations. By adding the forward-looking Taylor-rule equation for the interest rate it is possible to construct a structural VAR model and then write it in the reduced form for the purpose of estimating. However, in our thesis we also want to show the role of the exchange rate for the Ukrainian case, that is why we estimate the "extended" version of the model, proposed by Leu (2004) including exchange rate.

The model then has the form of:

$$x_t = -\lambda_1 [i_t - E_t \pi_{t+1}] + E_t x_{t+1} + \lambda_2 s_t + g_t \qquad (8)$$

$$\pi_t = \beta E_t \pi_{t+1} + \lambda x_t + u_t, \qquad (9)$$

$$i_t = \delta_\Pi \pi_t + \delta_x x_t + v_t \qquad (10)$$

where (10) is the Taylor – rule, showing the dependence of the interest rate on the output gap and inflation. And s_t is the exchange rate, explained by the interest parity condition:

$$s_t = E_t s_{t+1} - (i_t - i_t^*) + e \qquad (11)$$

i_t^* is the foreign interest rate.

For the estimation purposes we write the structural dynamic model in the form of:

$$\Gamma_o y_t = \Gamma_1 y_{t-1} + \ldots + \Gamma_q y_{t-q} + \varepsilon_t \qquad (12)$$

where $y_t = (x_t, \pi_t, s_t, i_t)'$ is the vector of endogenous variables:

Γ_i is the coefficient matrix.

The reduced form then will be:

$$y_t = N_t y_{t-1} + ... + N_{t-q} y_{t-q} + e_t \tag{13}$$

where $N_t = \Gamma_0^{-1}\Gamma_i$, $e_t = \Gamma_0^{-1}\varepsilon_t$

By Amisano and Giannini (1997) the main purpose of SVAR estimation is to obtain non-recursive orthogonalization of the error terms for impulse response analysis. So, we need to impose restrictions to identify the structural components of the error terms. We use Blanchard and Quah (1989) type of the restrictions, assuming that accumulated response to structural innovations takes the form of:

$$C = TA^{-1}B \tag{14}$$

where T is the estimated accumulated responses to the reduced form (observed) shocks. The restrictions are specified in terms of the elements of matrix T, typically they take the form of zero restrictions. For example Tij=0 restriction is treated as zero response of the i-th variable to the j-th structural shock over time. Matrices A and B impose the relationship between the shocks and stochastic elements of the unrestricted VAR model. Particularly:

$$Ae_t = B\varepsilon_t \tag{15}$$

$$E[\varepsilon'\varepsilon] = I$$

In order the system to be just identified one needs to impose $k(k+1)/2$ number of restrictions, where k is the number of variables in the model.

Before estimating the model we need to find the appropriate lag length, which can be done on the basis of Akaike and Shwarz information criteria. We should take into account the criterion for no autocorrelation as well as for ability of the model to forecast future.

In order to identify the relationship between the shock in one variable and the response of the others we will conduct an analysis of impulse response functions, taking the derivatives.

From the above analysis we expect to determine the following responses:

1) reaction of the interest rate and inflation level to the one period shock in the exchange rate;

2) response of the exchange rate and the inflation to the one period shock in the interest rate.

The above two scenarios could be conducted by the Central bank by changing interest rate or exchange rate, depending on what instrument it chooses.

As we consider inflation as one of the monetary unit criteria, we also are interested in the effect, caused by increase in inflation.

C h a p t e r   4

DATA DESCRIPTION

For the purpose of our research we use data obtained from the National Bank of Ukraine. The variables included to the model describe:

- the real sector: GDP
- inflation: CPI
- exchange rate: official NBU exchange rate (exch)
- interest rate: NBU interest rate (r)

The data is available on the monthly basis, so we will use this data to capture the effect of changes in frequently changed variables (for example, interest rate changes). The sample period is January 1996 – March 2005, and thus for the monthly case we have 111 observations.

The descriptive statistics of the variables is represented in the following table.

Table 1. Descriptive statics of the variables used for estimation

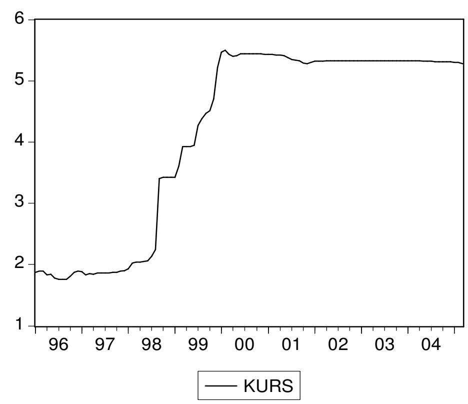
	CPI	**GDP**	**Interest rate**	**Exchange rate**
Mean	101.1901	102.0756756	29.3333333333	4.16352342342
Median	101.0000	104.1	25	5.3062
Maximum	109.4	113.6	105	5.4975
Minimum	98.2	87.4	7	1.76
Std. Dev.	1.67396942271	6.9826436282	23.7872514876	1.53272661952
Skewness	1.89658458873	-0.3587822993	1.25152020253	-0.6761428430
Kurtosis	9.19711451288	2.0430645275	4.16604933005	1.62763216389
Observations	111	111	111	111

We construct a GDP gap as the difference between the real figure and the trend of GDP. The trend is calculated using Hodrick-Prescott filter with the smoothness parameter equal 14400 (as the data is monthly).

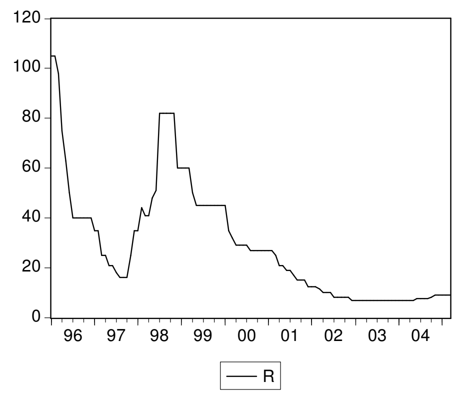
The dynamics of the variables are plotted on the following graphs (horizontal line stands for number of observations).

Figure 1. Dynamics of the series used for analysis.

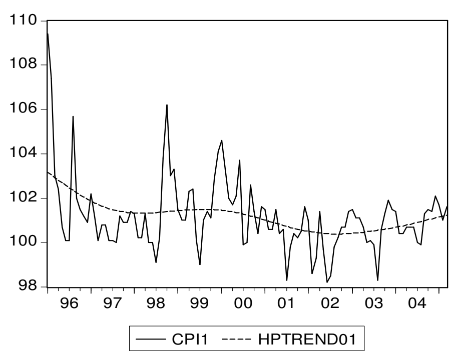
Exchange rate UAH/USD:



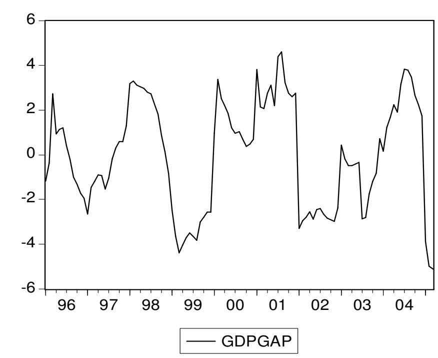
Interest rate:



CPI:



GDP Gap:



For the purpose of the further analysis we apply logarithmic transformation to the series. The models we use require data to be stationary. Visual inspection suggests exchange rate and interest rate to be nonstationary, while gdp gap and CPI to be stationary. The formal test for stationarity approves our result. The results of the Dicky-Fuller test for unit root are presented in the following table.

Table 2. Results of the Dicky-Fuller test for unit root

Test	CPI	GDP gap	Interest rate	Exchange rate
Dicky-Fuller	-4.031179	-3.887192	-1.867119	-1.491322

MacKinnon critical values for rejection of hypothesis of a unit root are:

1% Critical Value	-3.4928
5% Critical Value	-2.8887
10% Critical Value	-2.5811

After taking the first differences the unstationary series become stationary, and, thus, can be used for estimation.

Chapter 5

EMPIRICAL RESULTS

Stability analysis

i) First we analyze the stability of the exchange rates. Formally the exchange rate regime in Ukraine is called managed floating, in fact the Cenral Bank kept the exchange rate at the fixed level by means of the foreign market interventions.

After visual inspection of the plotted time series it is possible to divide the period of analysis (1996-2005) into three subperiods:
1) 1996-1998 – the period when exchange rate was fixed on almost the same level;
2) 1998-2000 – the "jump" in the exchange rate level due to financial crisis;
3) 2000-2002 – the period of the fixed exchange rate again.

The Ukrainian exchange rate is nonstationary and thus we take it in differences. However, some researches argue that the pattern that exhibit Ukrainian exchange rate allows to conclude about the stationarity of the series with two conditional means.

Let us now find the specification allowing describing the conditional variance of the exchange rate. First of all, the most appropriate AR order needs to be found. Relying on the Durbin's alternative test for autocorrelation we obtain AR (1) process, so that:

$$\text{DLNExch} = \underset{(0.095)}{0.08} + \underset{(0.004)}{0.183}\ \text{DLNExch(-1)} + u_t .$$

se (0.095) (0.004)

AR(1) coefficients are significant at 5% level and there is no serial correlation (see Appendix A for result of the Durbin's test). Increase in the previous period's exchange rate by 1 % causes relative increase in the present exchange rate value (by 18%) holding everything else constant[1].

Further we find the specification for explaining conditional variance pattern. In our case it is ARCH (1) process, that takes the following form:

$$h_t = a_0 + a_1 u_{t-1}^2 \qquad (6)$$

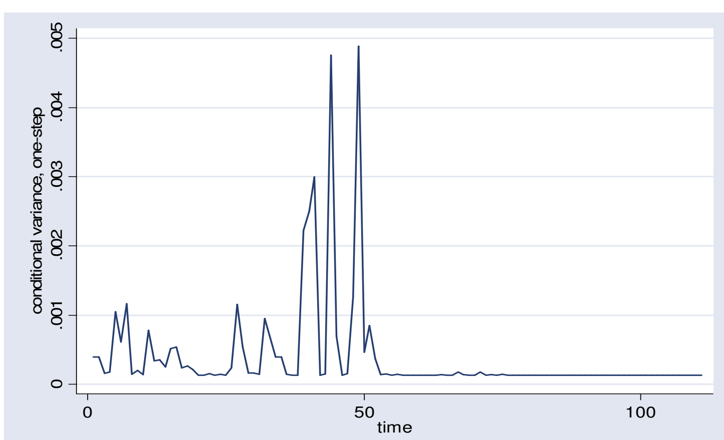
Therefore, we obtain result, that conditional variance of exchange rate is explained by the following equation:

$$h_t = 0.0001 + 0.788 u_{t-1}^2 \qquad (7)$$

se (9.20e-06) (.4065969)

The rational behind the choice of the conditional variance process is the nonnegativity of the coefficients and their significance. Moreover, the restriction about $a_1 < 1$ also holds. The current period variance for 78 % is explained by the previous heteroscedastic error. Next step is presenting the results in graphical form, so the figure 2 plots the conditional variance.

Figure 2. Conditional variance of the exchange rate for the period of January 1996 – March 2005



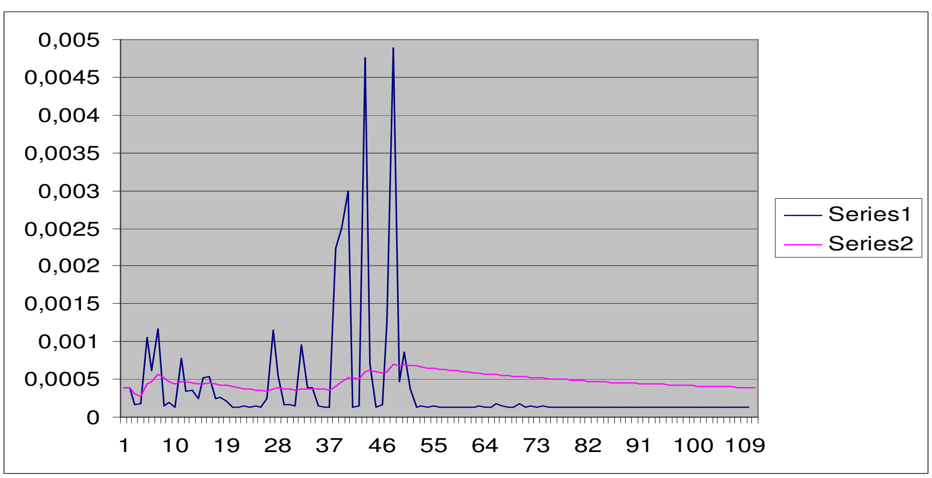
[1] $LnX_t - LnX_{t-1} = (X_t - X_{t-1})/X_{t-1}$ is relative (proportional) change in X.

As can be seen from the graph the volatility was close to zero till 1998 when the world wide financial crisis spread and hryvnya depreciated rapidly. From the point of view of stability we can clearly observe 3 subperiods again:

1. 1996-1998 – stable period with the small volatility (not bigger than 0.01 percent);
2. 1998 – the year when the world's financial crisis influenced Ukraine, which resulted in sudden depreciation of the national currency and indicated about instability that is observed till 2000;
3. 2000-2005 – volatility was close to zero. Indeed, according to the above graph one can interfere about stability, really the Central Bank kept the exchange rate at the fixed level. However, logically the stability here is rather subjective, since according to the model one can judge about stability at every point of time on the basis of comparing it with one previous period.

In order to capture the effect of the shocks in the earlier periods we perform the next step of the analysis and construct the averaged volatility, shown on the Figure 3.

Figure 3. ARCH model conditional variance versus averaged conditional variance of the exchange rate for the period of January 1996 – March 2005



Series 1 stands for conditional variance calculated by pure ARCH specification. Series 2 represents the averaged conditional variance accounting for all the previous values of the variance[2]. Now we observe increase in volatility till 2000 and gradual decrease in it after 2000. Obviously, subperiod 3 does not seem so stable as before, since the effect of the previous shock is taken into account. (Example: investors cannot believe in stability today if the day before yesterday it was crisis). However, the general pattern remains the same, stability increases over time.

ii) Second, we analyze the interest rate stability. Comparing to exchange rate it changed more frequently and more substantially. Again the 1998 financial crisis caused substantial increase in the interest rate level, which started to reduce since 1999.

We first find the appropriate AR process and this is AR (3), Durbin's alternative test shows no serial correlation for regression with 3 lags. Thus, we have:

DLNR = 0.201 DLNR(-1) + 0.21 DLNR(-2) + 0.25 DLNR(-3) + u_t.

se (0.039) (0.031) (0.794)

Every lag value increases the current value of the interest rate by approximately 20 percent.

The conditional variance of the interest rate is explained by GARCH (1,1) specification. Thus, the result is:

$$h_t = a_0 + a_1 u_{t-1}^2 + \beta_1 h_{t-1} \quad (8)$$

$$h_t = 0.00003 + 0.086 u_{t-1}^2 + 0.904 h_{t-1} \quad (9)$$

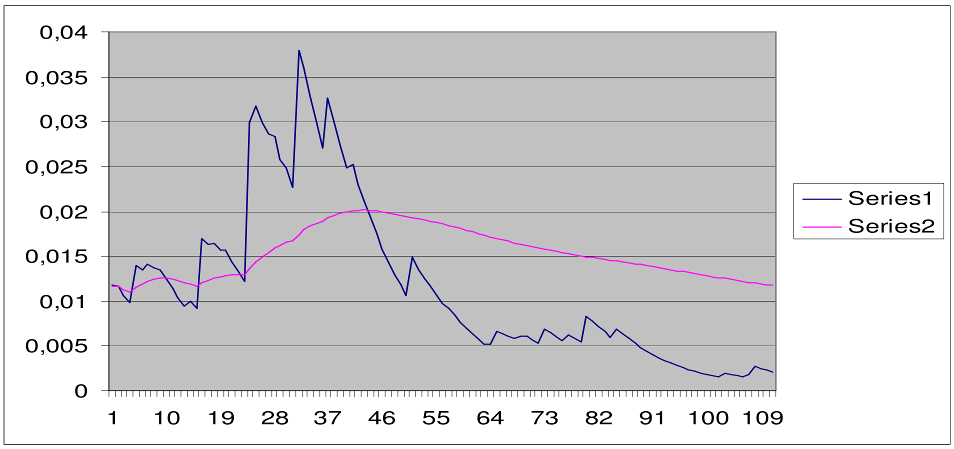
se (0.000101) (0.0360846) (0.0358113)

The coefficients are significant and meet the requirements about restrictions. The present period variance for 8 percent is explained by the past heteroscedastic error and for 90 percent by the previous period variance.

[2] at t2: average= (v1+v2)/2, at tn: average= (v1+…+vn)/n

Figure 4 represents the conditional variance of the interest rate (series 1) as well as the calculated averaged conditional variance (series 2).

Figure 4. GARCH model conditional variance versus averaged conditional variance of the interest rate for the period of January 1996 – March 2005



Comparing to exchange rate interest rate was more volatile; the shock of 1998 also has the similar impact: there was substantial increase in volatility with gradual stabilization over time. Averaged volatility captures the effect of the previous shocks and reduces when close to 2005.

iii) CPI changed over time most frequently (comparing to the previous indicators). Taking first differences of the log of the CPI gives us inflation.
On the basis of Durbin's alternative test we choose 2 lags for AR process (A3). Specification for conditional variance is GARCH (1,1). It evolves according to the formula:

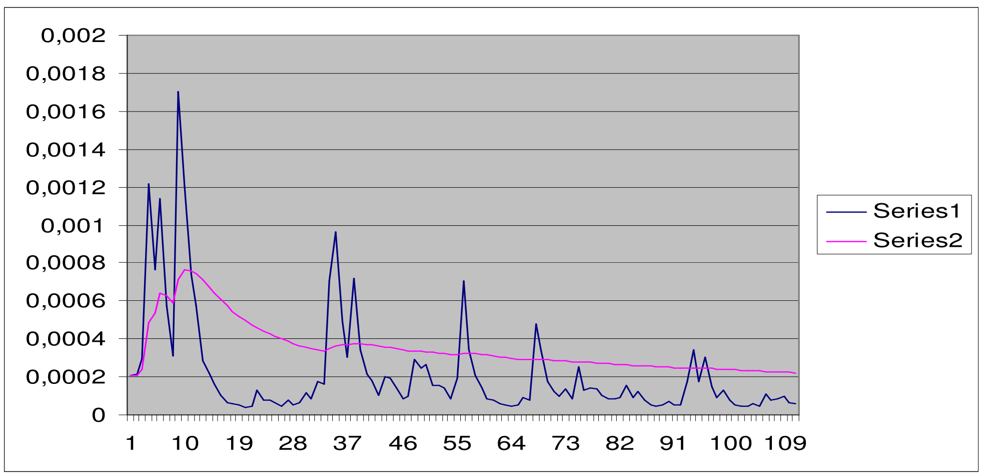
$$h_t = a_0 + a_1 u_{t-1}^2 + \beta_1 h_{t-1} \quad (10)$$

$$h_t = 0.00002 + 0.565 u_{t-1}^2 + 0.434 h_{t-1} \quad (11)$$

se (9.87e-06) (0.2007278) (0.1140582)

All the coefficients are significant at 5% critical value and meet the requirements according the restrictions. Current period variance is explained for 56 percent by the past heteroscedastic error and for 43 percent by previous period variance. Figure 5 represents the conditional variance of the inflation (series 1) and the averaged conditional variance (series 2).

Figure 5. GARCH model conditional variance versus averaged conditional variance of the inflation for the period of January 1996 – March 2005

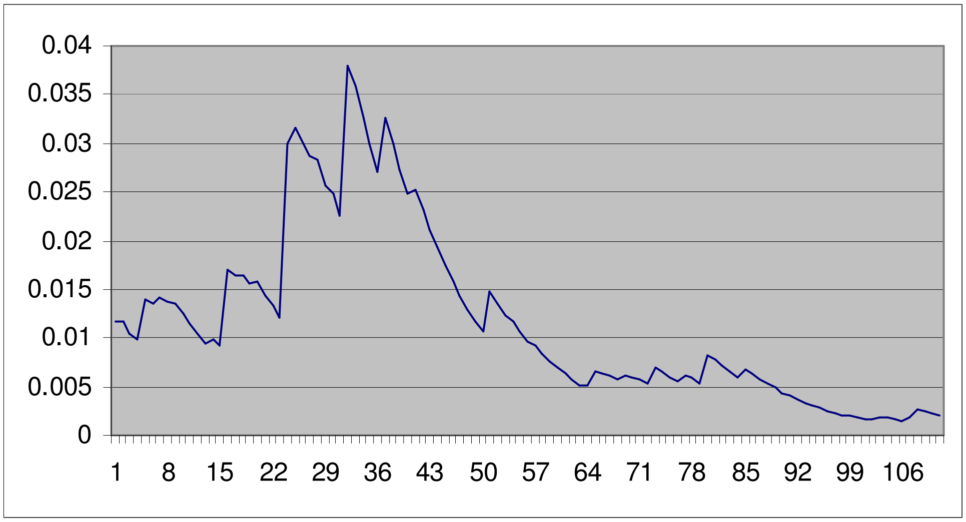


Averaged volatility shows the pattern similar to those of the previous two indicators, so that stability increases over time (starting from 2000 till 2005).

Let us now impose criteria for the monetary unit stability:

1) *Maximum.* K1 = max{Conditional Variance (exchange rate); Conditional Variance (interest rate); Conditional Variance (inflation)} We calculate this maximum value for every time period and plot it.

Figure 6. Constructed volatility based on maximum criteria



Maximum criterion allows accounting for most volatile indicator, which showed the biggest volatility at every particular point of time. For Ukraine it was interest rate. Its volatility has been maximum of the three since 1996. The pattern drawn on the Figure 6 is basically the same as that of the interest rate volatility considered previously (by taking into account the indicators separately). The reason is that the percent of volatility change was the greatest for the interest rate, not the frequency of the change. The max ever achieved during the analyzed period was 3.8 % change. The most frequent were inflation changes.

2) *Average*. On the basis of the following formula we can interfere about the stability at the end of the analyzed period, taking into account all the previous volatility changes. At the end of March 2005, the stability criterion, therefore, was:

K2 = $\frac{1}{3}\sqrt{(\overline{\sigma^2_{exch}} + \overline{\sigma^2_{ir}} + \overline{\sigma^2_{\inf}})}$ = 0.037, or 3.7 % (comparable to the previous one of 3.8%)

3) K3 = $\frac{1}{n}(\sigma_1 + ... + \sigma_n) =$ 0.003366, or 0.3%. We see that alternative third criterion value differs substantially from the two previous criteria and cannot be comparable to the first two. The author proposes to use it for informative purposes.

Thus, in the previous subsection we estimated volatilities of the three stability indicators based on Ukrainian data and observe the positive pattern for increasing stability. Now we want to look at how the change in one indicator influences the behavior of the other two. We need to estimate the SVAR for this.

SVAR model estimation

We estimate the reduced form model of:

$$y_t = N_t y_{t-1} + ... + N_{t-q} y_{t-q} + e_t$$

where $y_t = (x_t, \pi_t, s_t, i_t)'$ is the vector of endogenous variables:

x_t is the output gap, π_t is inflation, s_t is exchange rate, i_t is interest rate.

On the basis of Akaike criterion the most appropriate number of lags for our model is 4. We also include dummy variable for the crises of 1998.

After performing Granger causality test we conclude that we cannot reject the hypotheses that gdpgap does not granger cause other variables and vice versa. However, we reject the hypothesis that CPI, exchange rate and interest rate do not Granger cause each other.

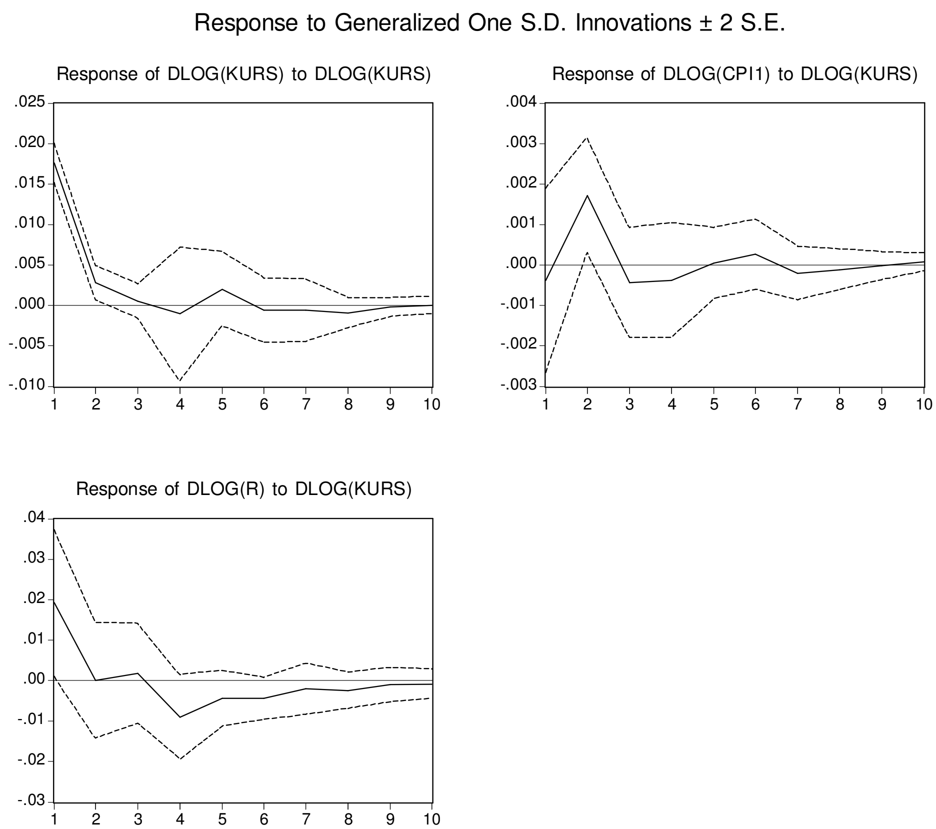
Stability test suggests that our model is stable.

Results of the estimated VAR are represented in the Appendix. F.

Next we want to estimate structural factorization, that is we impose 10 restrictions on the residuals. As can be seen from the response pattern presented in the Appendix G, the 1st shock increases inflation by 0.02% and increases interest rate by 4% in the long run. The second shock causes increase in interest rate by 0.6% in the long run. We restricted the exchange rate not to respond to the shocks since it is assumed to be fixed.

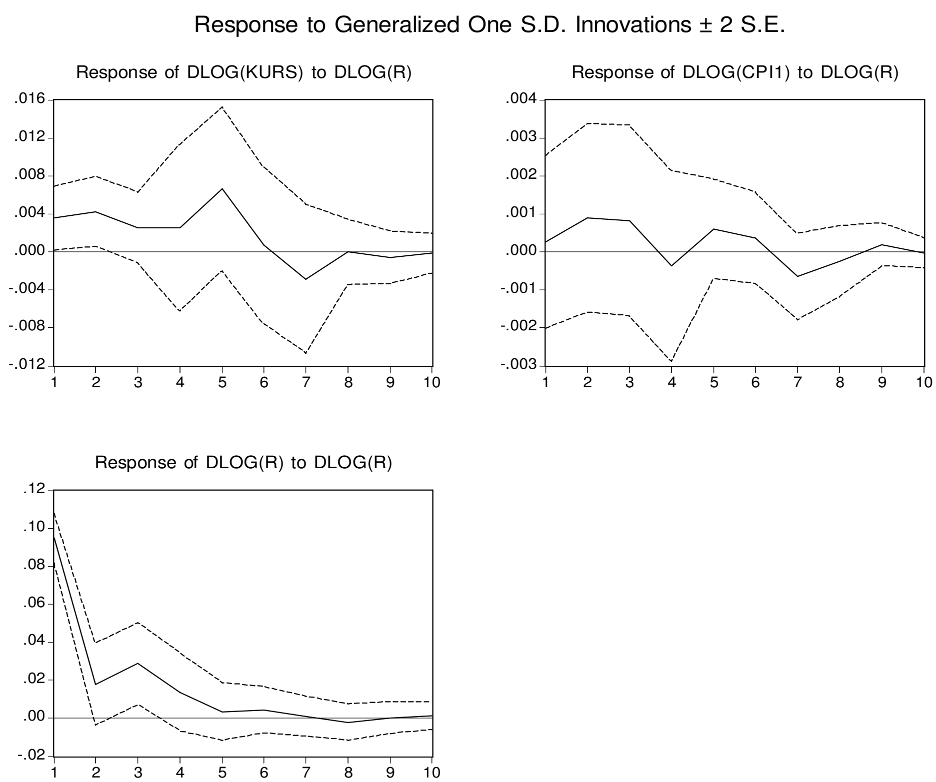
The most important part of the estimation here is the impulse response analysis. First, let us consider exchange rate shocks.

Table 3. Impulse response functions to one standard deviation exchange rate shock



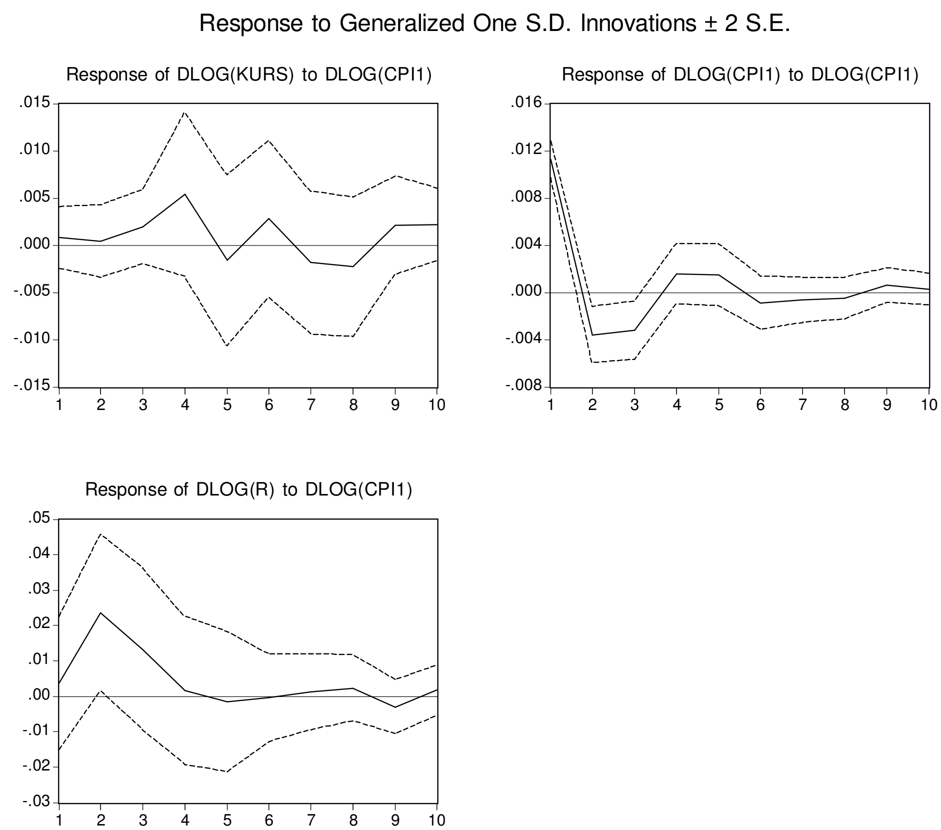
Exchange rate shock increases an inflation rate in the first period by 0.14%, and causes interest rate to fall by 1.9%, which supports the theory findings and results obtained by Leu (2004). By Taylor (2001) exchange rate effect works through the expenditure-switching effect to alter real GDP and the pass-through effect to alter the inflation rate. In the New Keynesian model a sudden depreciation of the exchange rate raises output gap that causes inflation to rise through the Philips curve.

Table 4. Impulse response functions to one standard deviation interest rate shock



Interest rate one-period shock does not influence the exchange rate, which goes in line with the Ukrainian Central Bank Policy, while rises the inflation rate by 0.06%.

Table 5. Impulse response functions to one standard deviation inflation rate shock



Inflation rate one-period shock does not have an immediate effect on exchange rate, however causes interest rate to rise by 2%, which supports the theory and the Leu (2004) findings. Once inflation increases it positively influences interest rate by Taylor rule.

Introducing white noise into the exchange rate series and letting it float does not change our results in terms of reaction to a one period shock.

Chapter 6

CONCLUSIONS

This thesis was devoted to analysis of the stability of monetary unit in Ukraine and basically addressed two issues: first, stability of hryvnya per se, and second, stabilization policy.

Among general indicators of the stability of monetary unit, the author chose three, that she considered most relevantly described Ukrainian hryvnya stability for the period of 1996-beginning of 2005. These three indicators included exchange rate, interest rate and inflation rate. Exchange rate deviations were explained by ARCH(1) specification, interest rate and inflation rate conditional volatilities followed GARCH(1,1) process. The maximum deviation in volatility showed interest rate, while the most frequent changes performed inflation rate.
Generally the period of 9 years we analyzed could be devided into three subperiods in terms of stability: before 1998 financial crisis, 1998-2000 – the period of first reaction to the world crisis, 2000-2005 – stabilization period with increasing of stability over time. We constructed averaged volatililities which allowed capturing the effect of the previous shocks and showed the gradual increase in stability in terms of all the three indicators.

The author suggested that stability could be measured numerically at every point of time as well as at the end of some period of interest. We imposed several criteria for measuring the stability of the monetary unit, basically relying on maximum or average. Author's calculations showed that these two approaches provide similar comparable results and serve for analyzing the stability issue from different angles: the biggest contributor to instability and the influence of all the three indicators simultaneously.

Stability question bothers all the economic agents as well as government. Increased monetary unit stability should be a positive signal for investors and business entities, as well as for foreign partners of Ukraine.

Including of the exchange rate into the New Keynesian model and Structural VAR estimating enabled the author to determine the interdependences between the exchange rate, interest rate and inflation in Ukraine. Our estimated results go in line with the theory as well as with the findings of the similar research, particularly that of Leu (2004). One period shock in exchange rate causes increase in inflation and fall in the interest rate, inflation increases the interest rate and interest rate increase follows by increase in inflation. Letting exchange rate float introducing the white noise into the model does not change the short-run immediate results of response to the one-period shock. The author predicts, however, that persistent shock would increase the magnitude of the results suggested by the one-period shock approach, and advises this question for further research.

Main policy implications for the National Bank of Ukraine from the author's point of view are the following:

1. Increased monetary unit stability is obviously a very positive sign for the economy that is why monetary policy should be further conducted with this aim in mind.
2. In order to achieve stability Central Bank can influence one of the two targerts: either interest rate, or exchange rate. Letting exchange rate float should be opposed by interest rate response for stabilizing the situation.

3. Stability is an important factor for formulating the expectations about the future, even if the stable period lasts for a definite period of time the past crisis opposes belief in stability in the people's mind. So, Central bank policy should avoid unexpected sudden "jumps", that create panic. (Concluded by the author after constructing average volatilities).
4. Important question is including the definition of the monetary unit stability to the Law of Ukraine *On the National Bank of Ukraine,* for example that one proposed by Grytsenko (2002) adapted to the law terminology.

Finally, the author proposes own definition of the monetary unit stability as the state of the low fluctuations in the monetary unit indicators, or monetary target. The set of the monetary unit indicators could very, we rely on the three proposed by Grytsenko (2002). The set includes {exchange rate, interest rate, inflation rate}. As from the point of view of Central Bank instruments the set could include { exchange rate, interest rate }, could be extended by monetary aggregates.

Further research the author views in using the criteria for the monetary unit stability for comparison of the different time periods and also different models. Simulations about the floating exchange rate regime and persistent shocks would be of particular interest.

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Appendix A

Estimation output for choosing the lag length for the exchange rate

```
------------------------------------------------------------------------------
D.LNEXCH     |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
LNEXCH       |
          LD |   .1826594   .0950876     1.92   0.057    -.0058406    .3711594
_cons        |   .0076795   .0042163     1.82   0.071    -.0006787    .0160378
------------------------------------------------------------------------------

. durbina

Durbin's alternative test for autocorrelation
---------------------------------------------------------------------------
    lags(p)  |          chi2               df                 Prob > chi2
-------------+-------------------------------------------------------------
       1     |          0.066               1                   0.7970
---------------------------------------------------------------------------
                        H0: no serial correlation
```

Appendix B
Estimation output for ARCH model of exchange rates

ARCH family regression -- AR disturbances

Sample: 2 to 111		Number of obs	=	110
		Wald chi2(2)	=	65.66
Log likelihood =	309.6919	Prob > chi2	=	0.0000

D.LNEXCH		Coef.	OPG Std. Err.	z	P>|z|	[95% Conf. Interval]	
LNEXCH							
dummy		.3892298	.0527376	7.38	0.000	.2858659	.4925936
_cons		.0028183	.0031113	0.91	0.365	-.0032798	.0089163
ARMA							
ar							
	L1	.6008976	.1570819	3.83	0.000	.2930227	.9087726
ARCH							
arch							
	L1	.7883437	.4065969	1.94	0.053	-.0085716	1.585259
_cons		.0001356	9.20e-06	14.73	0.000	.0001176	.0001537

In order to account for shock in 1998 we include dummy variable for it.

sum variance

Variable	Obs	Mean	Std. Dev.	Min	Max
variance	111	.0003659	.0006909	.0001356	.0046693

Appendix C

Estimation output for choosing the lag length for the interest rate

```
. reg  d.LNR l.d.LNR l2.d.LNR  l3.d.LNR

      Source |       SS       df       MS              Number of obs
=     107
-------------+------------------------------           F(  3,   103)
=    4.64
       Model |  .162839659     3  .054279886           Prob > F
=  0.0044
    Residual |  1.20404738   103   .01168978           R-squared
=  0.1191
-------------+------------------------------           Adj R-squared
=  0.0935
       Total |  1.36688704   106  .012895161           Root MSE
=  .10812

----------------------------------------------------------------------
---------
D.LNR        |      Coef.   Std. Err.      t    P>|t|     [95% Conf.
Interval]
-------------+--------------------------------------------------------
---------
LNR          |
          LD |   .2012964   .0962045     2.09   0.039     .0104975
.3920952
         L2D |   .2102219   .0962578     2.18   0.031     .0193173
.4011266
         L3D |   .0251431   .0961136     0.26   0.794    -.1654755
.2157617
_cons         |  -.0099195   .0108394    -0.92   0.362    -.0314169
.0115779
----------------------------------------------------------------------
---------

. durbina

Durbin's alternative test for autocorrelation
----------------------------------------------------------------------
------
    lags(p)  |          chi2               df                 Prob >
chi2
-------------+--------------------------------------------------------
------
       1        |                   0.671                           1
0.4126
----------------------------------------------------------------------
------
                        H0: no serial correlation
```

Appendix D

Estimation output for GARCH model of interest rates

```
ARCH family regression -- AR disturbances

Sample:  2 to 111
Waldog likelihood =  103.0782         Number of obs =110


OPG
D.LNR              Coef.   Std. Err.      Z P>z     [95% Conf.
LNR
_cons          -.0110915   .0212253    -0.52 0.601 -.0526924

ARMA
ar
L1    .2440614   .1206782     2.02     0.043       .0075364
L2    .0928512   .1164395     0.80    0.425        -.135366
L3    .1458613   .1378639     1.06    0.290        -.1243468

ARCH
arch
L1    .0856347   .0360846     2.37    0.018       .0149102
garch
L1    .9038428   .0358113    25.24    0.000        .8336538
_cons .0000295    .000101     0.29    0.770      -.0001684




. sum volatility

    Variable |         Obs           Mean      Std. Dev.          Min
Max
-------------+--------------------------------------------------------
-
  volatility |          111       .0117489       .0091255     .0014964
.0379051
```

Appendix E

Estimation output for choosing the lag length for the inflation and summary statistics for inflation conditional volatility

```
. reg  d.LNCPI l.d.LNCPI l2.d.LNCPI

      Source |       SS       df       MS              Number of obs =     108
-------------+------------------------------           F(  2,   105) =    4.57
       Model |  .001459515     2  .000729758           Prob > F      =  0.0125
    Residual |  .016765942   105  .000159676           R-squared     =  0.0801
-------------+------------------------------           Adj R-squared =  0.0626
       Total |  .018225457   107  .000170331           Root MSE      =  .01264

------------------------------------------------------------------------------
D.LNCPI      |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
LNCPI        |
          LD |  -.1303454   .0897983    -1.45   0.150    -.3083988    .0477081
         L2D |   -.245294    .089177    -2.75   0.007    -.4221155   -.0684725
_cons        |  -.0003666   .0012187    -0.30   0.764     -.002783    .0020498
------------------------------------------------------------------------------

. durbina

Durbin's alternative test for autocorrelation
---------------------------------------------------------------------------
    lags(p)  |          chi2               df                 Prob > chi2
-------------+-------------------------------------------------------------
       1     |          2.366               1                   0.1240
---------------------------------------------------------------------------
                        H0: no serial correlation



sum vol

            Variable Obs Mean Std. Dev.  Min Max

            Vol      111 .0002226 .0002805 .0000419 .0017007
```

Appendix F
Vector Autoregression Estimates

Vector Autoregression Estimates
Sample(adjusted): 1996:06 2005:03
Included observations: 106 after adjusting endpoints
Standard errors in ( ) & t-statistics in [ ]

	DLOG(KURS)	DLOG(CPI1)	DLOG(R)	GDPGAP
DLOG(KURS(-1))	0.166275	0.088331	-0.220174	-0.098829
	(0.10823)	(0.03026)	(0.27713)	(3.15177)
	[1.53631]	[2.91865]	[-0.79448]	[-0.03136]
DLOG(KURS(-2))	-0.004681	-0.007110	-0.199642	0.932676
	(0.11457)	(0.03204)	(0.29337)	(3.33650)
	[-0.04086]	[-0.22193]	[-0.68051]	[0.27954]
DLOG(KURS(-3))	-0.005224	0.023482	-0.617507	-1.005004
	(0.10515)	(0.02940)	(0.26925)	(3.06214)
	[-0.04968]	[0.79860]	[-2.29344]	[-0.32820]
DLOG(KURS(-4))	0.107635	-0.060351	0.224397	-2.707785
	(0.10738)	(0.03003)	(0.27496)	(3.12710)
	[1.00235]	[-2.00987]	[0.81611]	[-0.86591]
DLOG(CPI1(-1))	-0.131609	-0.302160	1.848857	0.255510
	(0.36721)	(0.10268)	(0.94027)	(10.6936)
	[-0.35840]	[-2.94264]	[1.96630]	[0.02389]
DLOG(CPI1(-2))	-0.298965	-0.408912	1.410756	-2.370422
	(0.37588)	(0.10511)	(0.96246)	(10.9460)
	[-0.79538]	[-3.89046]	[1.46578]	[-0.21656]
DLOG(CPI1(-3))	-0.372221	-0.139940	0.423778	4.193765
	(0.35773)	(0.10003)	(0.91600)	(10.4176)
	[-1.04050]	[-1.39894]	[0.46264]	[0.40257]
DLOG(CPI1(-4))	-0.389660	-0.044698	0.030692	0.256782
	(0.33817)	(0.09456)	(0.86591)	(9.84793)
	[-1.15225]	[-0.47268]	[0.03544]	[0.02607]
DLOG(R(-1))	0.034805	-0.001752	0.152618	1.440891
	(0.04177)	(0.01168)	(0.10696)	(1.21649)
	[0.83317]	[-0.14996]	[1.42682]	[1.18446]
DLOG(R(-2))	0.179083	0.017947	0.270539	0.619740
	(0.04097)	(0.01146)	(0.10491)	(1.19318)
	[4.37073]	[1.56645]	[2.57866]	[0.51940]
DLOG(R(-3))	-0.042186	0.002067	0.075830	-0.238684

	(0.04501)	(0.01259)	(0.11525)	(1.31077)
	[-0.93724]	[0.16419]	[0.65794]	[-0.18209]
DLOG(R(-4))	0.010794	-0.014114	-0.108402	0.095522
	(0.04466)	(0.01249)	(0.11436)	(1.30066)
	[0.24167]	[-1.13005]	[-0.94786]	[0.07344]
GDPGAP(-1)	-0.003412	0.000834	-0.010180	1.018991
	(0.00359)	(0.00100)	(0.00919)	(0.10456)
	[-0.95017]	[0.83079]	[-1.10725]	[9.74570]
GDPGAP(-2)	0.003737	-0.001174	0.018057	-0.099515
	(0.00514)	(0.00144)	(0.01315)	(0.14957)
	[0.72754]	[-0.81738]	[1.37306]	[-0.66536]
GDPGAP(-3)	-0.000978	-9.20E-05	0.003190	0.098045
	(0.00529)	(0.00148)	(0.01355)	(0.15411)
	[-0.18475]	[-0.06219]	[0.23541]	[0.63620]
GDPGAP(-4)	-0.000949	0.000377	-0.008560	-0.208564
	(0.00395)	(0.00110)	(0.01012)	(0.11506)
	[-0.24018]	[0.34123]	[-0.84608]	[-1.81272]
C	0.011070	-0.000482	-0.002645	0.027747
	(0.00495)	(0.00138)	(0.01268)	(0.14416)
	[2.23623]	[-0.34824]	[-0.20865]	[0.19247]
DUM	-0.022932	0.006191	0.069249	0.331880
	(0.04507)	(0.01260)	(0.11540)	(1.31241)
	[-0.50884]	[0.49123]	[0.60009]	[0.25288]
R-squared	0.250710	0.336754	0.258138	0.802654
Adj. R-squared	0.105961	0.208627	0.114823	0.764530
Sum sq. resids	0.151935	0.011880	0.996158	128.8460
S.E. equation	0.041552	0.011619	0.106395	1.210024
F-statistic	1.732034	2.628285	1.801199	21.05396
Log likelihood	196.6229	331.6979	96.95882	-160.7520
Akaike AIC	-3.370244	-5.918827	-1.489789	3.372678
Schwarz SC	-2.917962	-5.466545	-1.037507	3.824960
Mean dependent	0.009941	8.39E-05	-0.018358	-0.030484
S.D. dependent	0.043945	0.013061	0.113086	2.493599
Determinant Residual Covariance		3.60E-09		
Log Likelihood (d.f. adjusted)		428.7587		
Akaike Information Criteria		-6.731295		
Schwarz Criteria		-4.922167		

Estimation Proc:
===============================
LS 1 4 DLOG(KURS) DLOG(CPI1) DLOG(R) GDPGAP @ C DUM

VAR Model:
===============================
DLOG(KURS) = C(1,1)*DLOG(KURS(-1)) + C(1,2)*DLOG(KURS(-2)) + C(1,3)*DLOG(KURS(-3)) + C(1,4)*DLOG(KURS(-4)) + C(1,5)*DLOG(CPI1(-1)) + C(1,6)*DLOG(CPI1(-2)) + C(1,7)*DLOG(CPI1(-3)) + C(1,8)*DLOG(CPI1(-4)) + C(1,9)*DLOG(R(-1)) + C(1,10)*DLOG(R(-2)) + C(1,11)*DLOG(R(-3)) + C(1,12)*DLOG(R(-4)) + C(1,13)*GDPGAP(-1) + C(1,14)*GDPGAP(-2) + C(1,15)*GDPGAP(-3) + C(1,16)*GDPGAP(-4) + C(1,17) + C(1,18)*DUM

DLOG(CPI1) = C(2,1)*DLOG(KURS(-1)) + C(2,2)*DLOG(KURS(-2)) + C(2,3)*DLOG(KURS(-3)) + C(2,4)*DLOG(KURS(-4)) + C(2,5)*DLOG(CPI1(-1)) + C(2,6)*DLOG(CPI1(-2)) + C(2,7)*DLOG(CPI1(-3)) + C(2,8)*DLOG(CPI1(-4)) + C(2,9)*DLOG(R(-1)) + C(2,10)*DLOG(R(-2)) + C(2,11)*DLOG(R(-3)) + C(2,12)*DLOG(R(-4)) + C(2,13)*GDPGAP(-1) + C(2,14)*GDPGAP(-2) + C(2,15)*GDPGAP(-3) + C(2,16)*GDPGAP(-4) + C(2,17) + C(2,18)*DUM

DLOG(R) = C(3,1)*DLOG(KURS(-1)) + C(3,2)*DLOG(KURS(-2)) + C(3,3)*DLOG(KURS(-3)) + C(3,4)*DLOG(KURS(-4)) + C(3,5)*DLOG(CPI1(-1)) + C(3,6)*DLOG(CPI1(-2)) + C(3,7)*DLOG(CPI1(-3)) + C(3,8)*DLOG(CPI1(-4)) + C(3,9)*DLOG(R(-1)) + C(3,10)*DLOG(R(-2)) + C(3,11)*DLOG(R(-3)) + C(3,12)*DLOG(R(-4)) + C(3,13)*GDPGAP(-1) + C(3,14)*GDPGAP(-2) + C(3,15)*GDPGAP(-3) + C(3,16)*GDPGAP(-4) + C(3,17) + C(3,18)*DUM

GDPGAP = C(4,1)*DLOG(KURS(-1)) + C(4,2)*DLOG(KURS(-2)) + C(4,3)*DLOG(KURS(-3)) + C(4,4)*DLOG(KURS(-4)) + C(4,5)*DLOG(CPI1(-1)) + C(4,6)*DLOG(CPI1(-2)) + C(4,7)*DLOG(CPI1(-3)) + C(4,8)*DLOG(CPI1(-4)) + C(4,9)*DLOG(R(-1)) + C(4,10)*DLOG(R(-2)) + C(4,11)*DLOG(R(-3)) + C(4,12)*DLOG(R(-4)) + C(4,13)*GDPGAP(-1) + C(4,14)*GDPGAP(-2) + C(4,15)*GDPGAP(-3) + C(4,16)*GDPGAP(-4) + C(4,17) + C(4,18)*DUM

VAR Model - Substituted Coefficients:
===============================
DLOG(KURS) = 0.1662751637*DLOG(KURS(-1)) - 0.004681089144*DLOG(KURS(-2)) - 0.005223607544*DLOG(KURS(-3)) + 0.1076351705*DLOG(KURS(-4)) - 0.1316087509*DLOG(CPI1(-1)) - 0.2989648353*DLOG(CPI1(-2)) - 0.3722211024*DLOG(CPI1(-3)) - 0.3896598591*DLOG(CPI1(-4)) + 0.03480451605*DLOG(R(-1)) + 0.1790830709*DLOG(R(-2)) - 0.04218600973*DLOG(R(-3)) + 0.01079374519*DLOG(R(-4)) - 0.003411561214*GDPGAP(-1) + 0.003736633156*GDPGAP(-2) - 0.0009777327713*GDPGAP(-3) - 0.000948942278*GDPGAP(-4) + 0.01107001992 - 0.02293234728*DUM

DLOG(CPI1) = 0.08833054793*DLOG(KURS(-1)) - 0.007110162108*DLOG(KURS(-2)) + 0.02348158454*DLOG(KURS(-3)) - 0.0603511278*DLOG(KURS(-4)) - 0.3021603886*DLOG(CPI1(-1)) - 0.4089120528*DLOG(CPI1(-2)) - 0.1399396628*DLOG(CPI1(-3)) - 0.04469780415*DLOG(CPI1(-4)) - 0.001751727653*DLOG(R(-1)) + 0.01794732523*DLOG(R(-2)) + 0.002066511498*DLOG(R(-3)) - 0.01411351625*DLOG(R(-4)) + 0.0008341115483*GDPGAP(-1) - 0.001173890319*GDPGAP(-2) - 9.202529888e-05*GDPGAP(-3) + 0.0003769896356*GDPGAP(-4) - 0.0004820472888 + 0.00619059081*DUM

DLOG(R) = - 0.2201743893*DLOG(KURS(-1)) - 0.1996423765*DLOG(KURS(-2)) - 0.6175074208*DLOG(KURS(-3)) + 0.2243972538*DLOG(KURS(-4)) + 1.848857168*DLOG(CPI1(-1)) + 1.41075628*DLOG(CPI1(-2)) + 0.4237783836*DLOG(CPI1(-3)) + 0.03069213496*DLOG(CPI1(-4)) + 0.1526182045*DLOG(R(-1)) + 0.2705391507*DLOG(R(-2)) + 0.07582958982*DLOG(R(-3)) - 0.1084022886*DLOG(R(-4)) - 0.01017959903*GDPGAP(-1) + 0.01805718635*GDPGAP(-2) + 0.003189949518*GDPGAP(-3) - 0.008559504309*GDPGAP(-4) - 0.002644732066 + 0.06924891339*DUM

GDPGAP = - 0.09882916879*DLOG(KURS(-1)) + 0.9326755767*DLOG(KURS(-2)) - 1.005003716*DLOG(KURS(-3)) - 2.707785078*DLOG(KURS(-4)) + 0.2555104563*DLOG(CPI1(-1)) - 2.370421781*DLOG(CPI1(-2)) + 4.193764869*DLOG(CPI1(-3)) + 0.2567816805*DLOG(CPI1(-4)) + 1.440890684*DLOG(R(-1)) + 0.6197397798*DLOG(R(-2)) - 0.2386838048*DLOG(R(-3)) + 0.09552232784*DLOG(R(-4)) + 1.018991058*GDPGAP(-1) - 0.09951512325*GDPGAP(-2) + 0.09804548437*GDPGAP(-3) - 0.2085640643*GDPGAP(-4) + 0.02774651434 + 0.3318801957*DUM

Appendix G

Structural VAR Estimates

Structural VAR Estimates
Sample(adjusted): 1996:06 2005:03
Included observations: 106 after adjusting endpoints
Estimation method: method of scoring (analytic derivatives)
Convergence achieved after 12 iterations
Structural VAR is just-identified

Model: Ae = Bu where E[uu']=I
Restriction Type: long-run pattern matrix
Long-run response pattern:

C(1)	0	0	0
C(2)	C(5)	0	0
C(3)	C(6)	C(8)	0
C(4)	C(7)	C(9)	C(10)

	Coefficient	Std. E	z-Statistic	Prob.
C(1)	0.05003707	14.56022	0.0000	
C(2)	0.002248	0.000612	3.674238	0.0002
C(3)	0.036098	0.015079	2.393871	0.0167
C(4)	-1.628163	0.668410	-2.435873	0.0149
C(5)	0.006096	0.000419	14.56022	0.0000
C(6)	0.019518	0.014814	1.317576	0.1876
C(7)	0.278870	0.658712	0.423357	0.6720
C(8)	0.151890	0.010432	14.56022	0.0000
C(9)	3.153155	0.621801	5.071004	0.0000
C(10)	6.001022	0.412152	14.56022	0.0000
Log likelihood	428.7587			

@e1 for DLOG(KURS) residuals
@e2 for DLOG(CPI1) residuals
@e3 for DLOG(R) residuals
@e4 for GDPGAP residuals