VOLATILITY OF ECONOMIC ACTIVITY IN TRANSITION ECONOMIES: THE ROLE OF INTEREST RATES

by

Oleg Pashkovskiy

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Abstract

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Head of the State Examination Committee: Ms.Svitlana Budagovska,
Economist, World Bank of Ukraine

The paper examines how country risk of Ukraine and international credit conditions ("risk free" real interest rates) affect the volatility of Ukrainian aggregate output. Volatility of real interest rates explains about 7% of volatility of Ukrainian GDP, while volatility of the country risk about 40% of GDP volatility. The findings confirm the results obtained by Neumeyer and Perry (2004) for Argentina's economy. In this paper, a vector Autoregression Model was estimated using three key macroeconomic variables. The difference between the interest rates on credits in USD of Ukrainian banks and the real interest rates was used as a proxy for country risk. Based on the estimated model, Impulse Response functions were constructed and Error Forecast Variance Decomposition was done. Monthly data for the period 1998:1 – 2004:3 for those three variables were used to estimate the model.

The model shows the average degree of the interrelation between the key macroeconomic variables. The results highlight the causality running from country risk and real interest rates towards aggregate output of Ukraine. The policy implications of this result are that Ukraine had high country risk during the period under study. Thus Ukrainian government should implement the policies aiming to increase the confidence of the economy, increase its credit rating, achieve the status of market economy and avoid introduction of any shocks from its side.

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Chapter 1

INTRODUCTION

From 18th century onward, economists have been interested in periodical fluctuations of economic activity and in the recurrence of cycles over time, their duration, *reasons* and economic policies in different phases of the cycle. Many economists worldwide have investigated the behavior of aggregate macroeconomic variables and to finding an answer on what causes fluctuations or breaks in their behavior.

In this thesis we want to find the answer on following question: How much will elimination of the country risk allow it to reduce the volatility of GDP in Ukraine compared to stabilization of international interest rates[1]?

The thesis is motivated to meet the following objectives. First of all, we want to analyze and document the joint behavior of aggregate macroeconomic variables of Ukrainian economy and the relation among the "risk-free" real interest rates (interest rates on the United States short-term Treasury bills adjusted for U.S. inflation). The goal is to investigate the behavior of the real interest rates and other aggregate macroeconomic variables.

Secondly, we want to introduce the notion of country risk to Ukraine which, to the best of our knowledge, has never been done before. When investors make an investment decisions of whether to invest in a particular country one of the factors they consider is the likelihood of getting their money back in accordance with the terms in which they are investing in that country. Country risk is

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[1] stabilization of real interest rates is sometimes referred to stabilization of international credit conditions.

determined by interaction of political, social, financial, institutional and economic elements ("country-specific factors") inherent in a country which can impact an entity's financial status and its ability to repay its debts on time and in full. International investors and trade partners focus not only on financial risks but also on the risk posed by country-specific factors on the flow of funds in and out of country. Country risk mainly influences the overall level of investment in a country. It also determines not only the quantity, but what is more important, the quality of investment and their stability. Countries which have low country risk attract more investment which in turn influences GDP level.

Measuring country risk is an extensive and expensive task for investors and lenders. There are many independent rating agencies such as *Moody's Investor Services, Standard and Poor's Rating Group (S&P), International Country Risk Guide (ICRG)*[2] that undertake in-depth country analysis and issue assessments in the form of a single index or a rating. However, there exists one simple measure used in empirical research which gives a quantitative measure of a country risk - a country risk premium concept[3]. It refers to an increment in interest rates that would have to be paid for loans and investment projects in a particular country compared to some standard. One way of establishing the country risk premium is to compare the interest rate that the market establishes for a standard security in the country, for example, government debt, to the comparable security in the benchmark country, say the United States. Thayer Watkins has calculated such a risk premium for Ukraine at a very high level of 6.5% which is also applied for such countries as Russia, Romania, Ecuador and Indonesia. The indicators provided in the March 2004 Issue of International Country Risk Guide suggest that Ukraine possesses moderate composite risk rating and takes 71st place among 140 countries having very high political risk in comparison to other kinds of risks.

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[2] http://www.prsgroup.com

[3] Thayer Watkins calculations, Economics Department of San Jose State University.

Finally, we want to estimate how the volatility of aggregate output responds to country risk elimination in comparison to stabilization of international credit conditions. Neumeyer and Perry (2004) in their research which was done for Argentina found that eliminating country risk lowers Argentina output volatility by 27% while stabilizing real interest rates lowers it by less than 3%. We might expect similar results for Ukraine.

Thus, we can conclude that the importance of the topic of our investigation lies in that Ukrainian economy has high economic, political and financial risks which can be captured buy so called "risk premium" demanded by investors investing in Ukrainian economy or lenders of funds to Ukrainian government. The effect of eliminating country risk and its influence on the volatility of aggregate variables will show to what extent country risk affects the economy of Ukraine. Finally, such a research for Ukraine has not been done to date.

The paper will proceed as follows: in chapter two we will provide the survey of the existing literature concerning the studies of the behavior of aggregate macroeconomic variables in different countries and parts of the world and their relationship. Also, we will point out what were the reasons of output fluctuations. Finally, we will present an overview of the models and econometric technique which can be used to investigate volatility and joint variables behavior. In chapter three we will provide statistical description of the data and will systematically document of the relationship between real interest rates and aggregate macroeconomic variables of the Ukrainian economy. In chapter four, we will provide step-by-step methodology using Vector Autoregressive Model to answer the main question of our study. Finally, in chapter five we will provide empirical estimation and the results obtained.

Chapter 2

LITERATURE REVIEW

The literature review section will proceed as follows. First of all, we present the studies devoted to joint behavior of aggregate macroeconomic variables such as Gross Domestic Product, Consumption, Investment, Government expenditures, Export and Import, Unemployment, Interest Rates and etc. Secondly, the studies aimed to find what actually causes the decline in volatilities of aggregate macroeconomic variables are highlighted. Finally, methodologies and econometric techniques which are used for analyzing and estimating of how country risk influences the economy's activity in a country are described.

There have been many studies dedicated to investigation of the behavior of aggregate macroeconomic variables. Mostly these papers documented the main stylized features concerning the behavior of aggregate macroeconomic variables in developed and developing countries and also in a number of emerging economies.

The aims of many of these studies lie in documentation of the observed facts and then construction of theoretical modes which in turn would replicate the facts that were discovered. Mendoza (1995), for example, investigating the set of developing countries, documented strong positive correlation between output (GDP) fluctuations and the terms-of-trade. Other similar studies were done by Kouparitsas (1998) and Kose and Riezman (1998).

Kouparitsas (1998) in his paper divides the world in two parts – South and the North. As he mentions "a central feature of the North-South debate in the professional and popular press concerns the extent to which the South is dependent of the North". The paper aims at understanding the extent to which economic activity fluctuations in the Southern economies are caused by shocks which have the origin in the North. The main findings of the research are that real economic fluctuations in the South are caused by shock originating in the North. This happens due to the fact that the South is specialized in the production of primary goods and therefore relies on the North for its supply of manufactured goods and demand for its primary output. Using simulation procedures the author was able to evaluate the extent to which fluctuations in the South economy are caused by shocks originating in the North and identify the important channels of business cycle transmission between the North and the South. It was estimated that shocks taking their origin in the North explain only up to 20% of the variation in Southern output. In turn, Northern productivity shocks have much more impact on Southern expenditures, with North shocks explaining 70% of the movements in Southern consumption and 60% of the fluctuations in Southern investments.

Kose and Riezman (1998) focused on examining the role of external shocks in order to explain macroeconomic fluctuations on African countries. The shocks causing the fluctuations were external shocks which consisted of trade shocks and financial shocks, modeled as fluctuations in the world real interest rates. The researchers began the investigation by studying structural characteristics of the African economies decomposing aggregate output in expenditure shares and industrial structure and then compared them to those of G7 (Great 7 countries). The findings were that trade shocks had a significant role in driving macroeconomic fluctuations in African economies. Surprisingly, the world interest rates fluctuations had a minor effect on economic dynamics, while more than 44 % of the variations in aggregate output were explained by trade shocks.

Another set of researches focused only on the documentation of a broad set of cross-correlations among aggregate macroeconomic variables were done by, for example, Kydland and Zarazaga (1997). The striking features of Argentina's output and its components were that GDP is very volatile; the percentage standard deviation of real GDP is almost 2.5 times larger than for the United States. Although, the correlation of the cyclical component of real total consumption with that of real GDP lies within the range observed in other countries. All the statistics for investment, labor inputs, and productivity are within the range observed in the United States and European countries. Interestingly, according to Mendoza (1995) the variability of Argentina's terms of trade is twice than for the United States, which is the order of magnitude by which the variability of Argentina's GDP exceeds that of U.S. GDP.

One of the most interesting and highly relevant papers is one of Agénor and others (1991). In the paper the researchers documented the main characteristics of macroeconomic fluctuations in a number of developing countries. They presented not only cross-correlations between those countries industrial output and a large number of aggregate macroeconomic variables such as some fiscal variables, inflation, credit, trade, and exchange rates and some other variables but also analyzed the effects of economic conditions in industrial countries on output fluctuations in the sample of developing counties. The results showed that, on average, the output (GDP) fluctuations are much higher in the developing countries in comparison with the pattern observed in industrial countries. The most important discovery was that real interest rates in industrial countries show positive correlation with output fluctuations in the sample of middle-income countries. Government expenditures were found to be countercyclical.

The most recent paper is by Neumeyer and Perri (2004), who systematically documented and compared the behavior of such macroeconomic variables as

GDP, real interest rates, net export, private consumption, total consumption, investment, employment, hours of work of emerging countries to the ones of developed. The main findings were that in the set of emerging economies the correlation of GDP fluctuations with real interest rates is negative for all the emerging countries under study while it was positive for all the developed countries except for Sweden. This fact confirms the findings of Agénor and others (1991). Moreover, it was found that "the real interest rates in the set of emerging economies are countercyclical and lead the business cycle by a quarter while in the set of developed countries they are acyclical and lag the cycle by three quarters". The study also confirms that emerging economies show high, relative to developed economies volatility, which happens due to higher volatilities of output and net exports. Consumption shows greater volatility than output in emerging economies while it is roughly as volatile as output in developed economies. Finally, although net exports tend to be countercyclical in both groups, they are much more volatile in developing economies.

The question of what causes the decline in output volatility was raised in several papers. The empirical literature considers three possible explanations: good luck, good policy, and changes in the structure of the economy. The studies, for example, of the U.S. economy showed that the business cycles had become less volatile but both the nature of and the sources behind the decline in business cycle volatility were subject to controversy. In their researches, Stock and Watson (2002) and Blanchard and Simon (2001) reported that there has been a trend-decline in output volatility in the U.S., while Kim and Nelson (1999) and McConnell and Perez-Quiros (2000) observed that the reduction in U.S. output volatility in the mid-1980s were actually a discrete step-reduction. In addition, the decline in U.S. business cycle volatility has been attributed to structural shifts in the economy as suggested by Zarnowitz and Moore 1986. During the time of boom in the information technologies market developmebt the IT revolution played it role in declining of the volatility as was found by McConnell and Perez-Quiros (2000). Finally, improved monetary policy as claimed Taylor (1999) or simply 'good luck', i.e., smaller economic shocks were suggested by Blanchard and Simon (2001) and also Stock and Watson (2002).

As regards countries other than the Unites States, so far, the empirical research is relatively silent. That is why, given this ambiguity of findings and interpretations, evidence from countries other than the U.S. might yield important insights into the nature and the sources of changes in business cycle volatility. While a number of studies conclude that business cycle volatility has historically been on a decline in OECD countries (Blanchard and Simon 2001, Basu and Taylor 1999, Bergman et al. 1998, Dalsgaard et al. 2002), systematic evidence on the causes and the nature of this trend is lacking for most of these countries. The notable exceptions are studies of Simon (2001) for Australia or Debs (2001) for Canada.

Bush, Doepke and Pierdzioch (2002) studied the behavior of output volatility in Germany during 31 years from 1970:1 through 2001:1. They have found that output volatility declined during the time horizon under study but they have not found the true explanation of what was the cause of such a decline as it was in case with U.S. The conclusion was just as "… it is difficult to answer the question whether the decline in output volatility in Germany reflects good economic or monetary policy or merely "good luck".

Vector Autoregression models (VAR) are often used in studying the behavior of aggregate macroeconomic time series. Blanchard (1993) used simple VAR to find the answer on the question what caused the recession in the economy of the United States during 1990 – 1991 years. "A simple first pass is to estimate the joint behavior of the components of GDP, and look at the residuals". The model allowed to establishing that the recession was associated with large negative "consumption shocks" which had long-lasting effects on output, and that this explains why the recovery had been so slow.

The simple model proposed by Blanchard (1993) had great success in explaining what caused the 2000/01 slowdown in G7 economies ten years later. Labhard (2003) presented an analysis of shocks to G7 output components during the economic slowdown. The estimation of the model was very helpful in showing that there were actually shocks to several components and in a number of countries under the study during years 2000 – 2001. It should be pointed out that although some shocks were of the same nature across the tree largest G7 countries economies and that those shocks were consistent with sensation of a highly synchronized slowdown, all the other shocks to the economies had country-specific nature. One of the interesting results was that there were differences in the shocks which affected German economy in comparison to the other countries in the euro area. Moreover, the largest and continual shocks affected mainly business investment, inventories and net trade in 2000 – 2001.

At the early and late stages of the 2000 – 20001 slowdown large shocks occurred to private sector consumption. These shocks were much smaller in size and showed less persistence. The paper finds that "…shocks were less persistent and on average smaller (due to smaller size and offsetting signs) during the expansion, especially over a longer period. While this need not be significant, it is consistent with the common perception that expansions tend to be longer and have a slower pace than contractions."

By contrast, Neumeyer and Perry (2004) constructed a dynamic general equilibrium model of a small open economy of Argentina with working capital in order to assess quantitatively the role of interest rates in driving business cycles.

The time horizon under study was from the year 1983 to 2001. Argentina was chosen because this country for which the longest relevant interest rate series was available. The main aim of the paper was to measure the contribution of real interest rates fluctuations to the high output volatility of this emerging economy. Their model was constructed in such a way that the interest rate faced by the emerging economy of Argentina is the sum of the following components: an international rate plus a country risk spread. The international rate relevant for emerging economies is the rate on non-investment-grade bonds in the U.S. The country risk spread was defined as the difference between the rate faced by emerging economy and the international rate. Due to high fluctuations of country risk spread there were used two polar approaches to their determination. The first one lied in that factors which are largely independent of domestic conditions drive country risk. The second approach lied in that changes in country risk are induced by the fundamental shocks to a country's economy, for example, productivity shocks. In this case, these shocks drive at the same time business cycles and fluctuations in country risk.

In this paper, we will follow Neumeyer and Perry (2004) approach to investigation of the joint behavior of Ukrainian GDP and other macroeconomic variables. Risk premium concept will be employed in order to calculate the Ukrainian economy's risk premium which investors seek making a decision of investors and lenders of whether to invest in or lend to the Ukrainian economy. Vector Autoregression Model will be constructed in order to construct impulse response function and error forcast variance decoposition and investigate the consequences of the shocks in real interest rates and country risk on the behavior of the country's aggregate output.

C h a p t e r 2

DATA DESCRIPTION

In the thesis we use standard macroeconomic data of the Ukrainian economy. The data mainly consists of the components of Ukrainian gross domestic product which are available for the public on the official sites of the governmental institutions.

The data covers a substantial time interval starting from January 1996 till August 2004 and is on a monthly basis. In total the available data range accounts for 104 observations. However, some time series are available on a shorter time interval. Thus, the analysis will be done on the basis of the available range. Nevertheless, we believe that this number of observations is enough to capture the interdependence among the variables under study and also to capture the extent of the influence of country risk and real interest rates on the gross domestic product in Ukraine. The notations of the variables and the data range available are as follows:

GDP = nominal gross domestic product of Ukraine (1996:1 – 2004:8)
NIR = nominal rate of interest on three month US T-bills (1996:1 – 2004:8)
IM = import to Ukraine in USD calculated on a FOB basis (1996:1 – 2004:8)
EX = export of Ukraine in USD calculated on a FOB basis (1996:1 – 2004:8)
NEX = EX-IM = net export of Ukraine in USD calculated on a FOB basis (1996:1 – 2004:8)
ER = USD/UAH exchange rate (1996:1 – 1996:8)
CPIUS = consumer price index of the USA (1996:1 – 2005:3)
CPIU = consumer price index of Ukraine (1996:1 – 2004:8)
C = consumption in Ukraine (1996:1 – 2004:8)
IRC = interest rate on credits in USD of Ukrainian banks (1998:1 – 2004:8)

G = percent of government expenditures in GDP (1996:1 – 2004:8)

From the variables listed above we have calculated the following variables which will be used in our analysis:

IMU = import to Ukraine in UAH calculated on a FOB basis (1996:1 – 2004:8)

$$IMU_t = IM_t * ER_t \tag{3.1}$$

EXU = export of Ukraine in UAH calculated on a FOB basis (1996:1 – 2004:8)

$$EXU_t = EX_t * ER_t \tag{3.2}$$

NEXU = net export of Ukraine in UAH calculated on a FOB basis (1996:2004)

$$NEXU_t = NEX_t * ER_t \tag{3.3}$$

INFUS = monthly inflation in % annual in the USA (1996:1 – 2004:3)

$$INFUS_t = ((CPIUS_{y+1,t} – CPIUS_{y,t}) / CPIUS_{y,t})*100\% \tag{3.4}$$

where *y* denotes year, and *t* – a particular month.

RIR = real interest rate in % annual (1996:1 – 2004:3)

$$RIR_t = NIR_t – INFUS_t \tag{3.5}$$

GE = government expenditures of Ukraine (1996:1 – 2004:8)

$$GE_t = GDPt * G_t \tag{3.6}$$

CR = country risk for Ukraine (1998:1 – 2004:3)

$$CR_t = IRC_t - INFUS_t \tag{3.7}$$

RGDP = real gross domestic product of Ukraine (1996:1 – 2004:8)

$$RGDP_t = GDP_t*100/CPIU_t \tag{3.8}$$

The CR variable is proxied by a varuabke calculated on the basis of interest rate on credits in USD of Ukrainian banks.

The table below summarizes the sources of the data and provides the units of measurement:

Table 3.1 – Data sources and units of measurement

Variable	Units of measurement	Source of information
GDP	mln. of UAH	National Bank of Ukraine official site www.bank.gov.ua
NIR	%, annual	Federal Reserve System official site www.federalreserve.gov
IM	mln. of USD	Institute for Economic Research and Policy consulting – IER official website www.ier.kiev.ua
EX	mln. of USD	Institute for Economic Research and Policy consulting – IER official website www.ier.kiev.ua
NEX	mln. of USD	Self calculation
ER	mln. of UAH	National Bank of Ukraine official site www.bank.gov.ua
CPIUS	index	U.S. Department of Labor: Bureau of Labor Statistics official site: www.bls.gov
CPIU	index	National Bank of Ukraine official site www.bank.gov.ua
C	mln. of UAH	National Bank of Ukraine official site www.bank.gov.ua
IRC	%, annual	National Bank of Ukraine official site www.bank.gov.ua
G	%, of GDP	National Bank of Ukraine official site www.bank.gov.ua
IMU	mln. of UAH	Self calculation
EXU	mln. of UAH	Self calculation
NEXU	mln. of UAH	Self calculation
INFUS	%, annual	Self calculation
RIR	%,annual	Self calculation
GE	mln. of UAH	Self calculation
CR	%, annual	Self calculation
RGDP	mln. of UAH	Self calculation

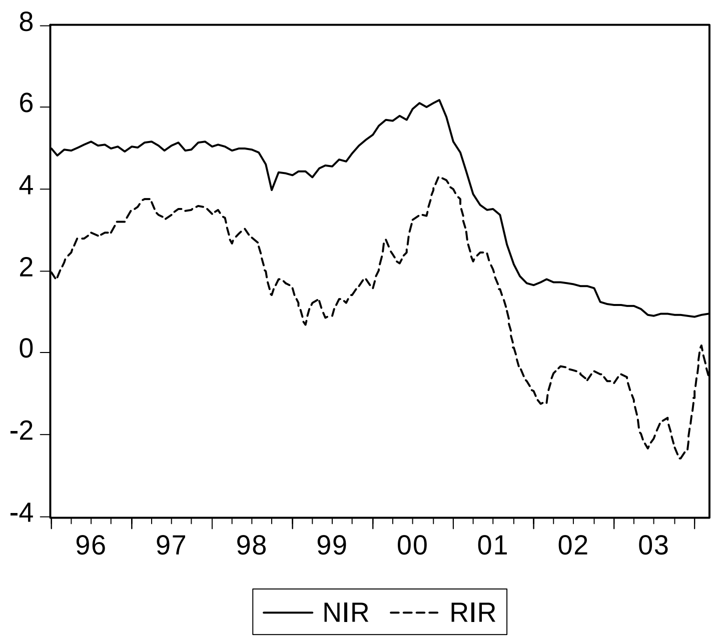
The summary statistics are presented in the table below:

Table 3.2 – Summary statistics of the variables

VARIABLE	OBSERVATIONS	MEAN	STD. DEV.	MIN	MAX
GDP	99	13444.98	6810.945	4810	37828
ER	99	4.009128	1.573838	1.76	5.5431
NIR	99	3.821919	1.752558	.88	6.17
EX	99	1321.083	386.584	730	2700.281
IM	99	1353.527	377.3566	730.2218	2676.517
NEX	99	-32.44401	202.3962	-628	393.7723
EXU	99	5582.002	3232.359	1392.936	14391.1
IMU	99	5553.496	3013.22	1385.624	14270.64
NEXU	99	28.50613	714.461	-1613.792	2099.122
G	99	29.43434	6.603171	17.5	45.8
GE	99	3753.476	1716.547	1467.111	10818.81
CPIUS	99	170.499	9.556272	154.4	187.4
INFUS	99	2.324212	.7387674	.7518797	3.757576
RIR	99	1.497707	1.881029	-2.593035	4.274538
CPIU	99	101.2071	1.758261	98.2	109.4
C	99	8521.455	5650.537	2581	23777
IRE	75	15.808	4.007148	10.8	26.5
CR	75	14.81877	3.23601	10.82516	25.10098
RGDP	99	13322.66	6813.264	4625.229	37268.96

As we observe the data range amounts up to 99 observations for all the variables except for IRE and CR. This is because IRE data is available only from the year 1998. CR mean is 14.82% which means that, on average, investor seek this high risk-premium when considering investment opportunities in the Ukrainian economy. The maximum value was reached in the year 1998 when there was economic crisis in Russia. Further in our analysis we will use different data ranges to calculate some important statistics.

Figure 3.1 – Nominal and Real Interest Rates



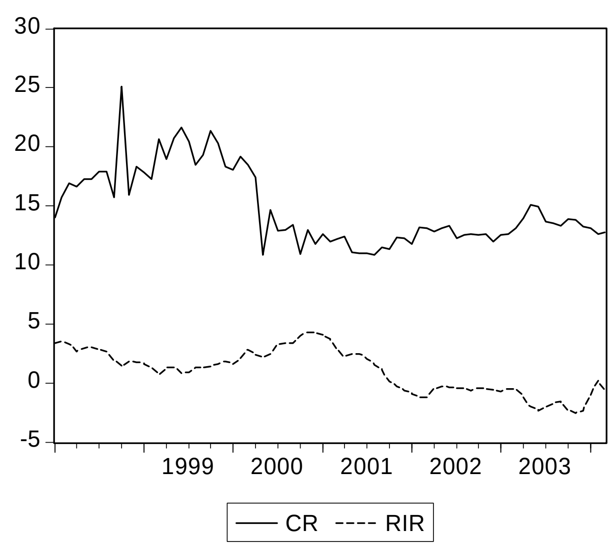
It can be observed that during the years 2000 – 2003 there was a large swing in the behavior of the nominal interest rates. Being almost stable during the years 1996 – 1998 NIR then increased sharply and reached its peak in the beginning of the year 2001 and then dropped dramatically and reached its lowest level at the end of the year 2003. The same pattern we can observe for the real interest rates but, in comparison to the nominal one, it shows a more volatile behavior with sharp increases and falls during a short period of time. Eventually, starting from the end of the year 2001 it went to be negative. As it is hypothesized in this paper, this behavior of RIR might have influenced somehow the pattern of the Ukrainian GDP. The correlation coefficients of RIR and the components of Ukrainian GDP and exchange rate are presented in the table below.

Table 3.3 – Correlation coefficients of RIR and Ukrainian GDP components and ER (1996:1 - 2003:3)

RIR							
GDP	RGDP	GE	C	EXU	IMU	NEXU	ER
-0.6399	-0.6403	-0.5681	-0.8383	-0.7193	-0.7281	-0.1837	-0.5787

As it can be observed the correlation coefficients are negative and are quite high in magnitude exempt for NEXU. This means that the variables move in opposite directions. Going further we have to analyze the behavior of RIR and country risk. The joint pattern over time is presented on the graph.

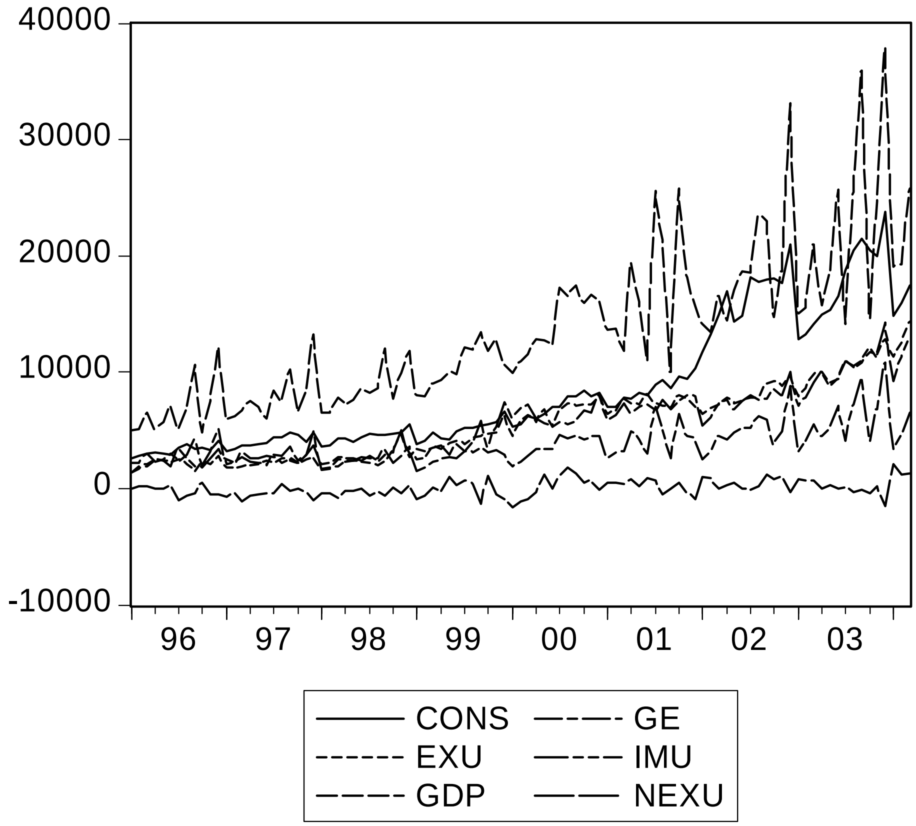
Figure 3.2 – Joint behavior of RIR and CR (1996:1 – 2003:3)



The figure reviles that country risk is more volatile than the real interest rate. In addition, on can observe that there was a dramatic increase in country risk value at the end of the year 1998. This behavior can be attributed to the economic crisis in Russia. At that time Ukrainian and Russian economies were highly interrelated and Ukraine was much more dependent on oil and gas resources. The correlation coefficient between RIR and CR is 0.17 which means that they are slightly interrelated.

Analyzing the behavior of the aggregate macroeconomic variables of the Ukrainian economy we can observe the following picture (1996:1 – 2004:3).

Figure 3.3 – Ukrainian economy aggregate macroeconomic variables



From the figure and from the data, it is possible to infer that Ukrainian GDP has been rising during the years under study which means that the Ukrainian economy is on the expansion part of the business cycle. GDP shows very volatile pattern in comparison to the other variables. Net export is the less volatile time series. The correlation coefficients between GDP and the other variables are presented in the table below.

Table 3.4 – Correlation coefficients between GDP and its components

GDP				
C	GE	EXU	IMU	NEXU
0.7834	0.9749	0.7729	0.7760	0.1559

As we can observe, the coefficients are very high except for NEXU. The correlation coefficient of RGDP and CR is -0.5326 for the range 1998:1 – 2004:3. This means that they actually move in opposite directions driven by investment. This is logical, because as there is economic development and growth, country risk falls.

C h a p t e r 4

VECTOR AUTOREGRESSION METHODOLOGY

In order to investigate the joint dynamic behavior of aggregate macroeconomic variables we will use Vector Autoregression Model, or VAR introduced by Sims (1980) and which is very popular nowdays in macroeconomics studies. This of model allows us to describe the dynamic behavior and evolution of a number of variables from their common history. Moreover, the VAR models are very useful because they possess a unique ability to characterize the dynamic structure of the model. VAR's allow to avoiding impositions of excessive identifying restrictions which can be associated with different economic theories. In short, VAR's doe not require any explicit economic theory for estimation. The use of VAR in macroeconomics has generated much empirical evidence, giving its fundamental support to many economic theories (Blanchard and Watson (1986) and many others).

Following the theoretical set up of the VAR models let us consider a column vector of *k* different variables, $\overline{Z}_t = [Z_{1t}\ Z_{2t} \ldots Z_{kt}]'$ and model this in terms of past values of the vector. The result is a Vector Autoregression. The VAR(*p*) process can be described by the following equation:

$$\overline{Z}_t = \overline{m} + A_1 \overline{Z}_{t-1} + A_2 \overline{Z}_{t-2} + \ldots + A_p \overline{Z}_{p-1} + \overline{\varepsilon_t} \tag{4.1}$$

or in short $$A(l)\overline{Z}_t = A + \overline{\varepsilon_t} \tag{4.2}$$

where $$A(l) = l - A_1 l - A_2 l^2 - A_3 l^3 - \ldots - A_p l^p \tag{4.3}$$

The A_i are *k* x *k* matrices of coefficients, $\overline{m}$ is a *k* x 1 vector of constants, and is $\overline{\varepsilon_t}$ a vector of white noise process, with the following properties:

$$E(\overline{\varepsilon_t}) = \overline{0} \text{ for all } t \tag{4.4}$$

$$E(\overline{\varepsilon_t}\,\overline{\varepsilon_s}) = \begin{cases} \Omega & s = t \\ \overline{0} & s \neq t \end{cases} \tag{4.5}$$

where, the Ω - covariance matrix is assumed to be positive definite. Thus the $\overline{\varepsilon_t}$'s are serially uncorrelated but may be contemporaneously correlated. Thus, in a VAR each variable is expressed as a linear combination of lagged values of itself and lagged values of all other variables in the group. Since the error terms $\overline{\varepsilon_t}$ in the above model are serially uncorrelated, an ordinary least squares (OLS) technique would be appropriate to estimate the model. However, before estimating the parameters of the model, one must limit the length of the lags in the polynomials. If l is the lag length, the number of coefficients to be estimated is $n(nl + c)$, where c is the number of constants.

Because economic theory usually does not provide any guidance to the appropriate choice of model, some additional criteria can be used to choose from alternative models that are acceptable from statistical point of view. For the purpose of the identification of the lags lengths to be included in the model the following alternative criteria's can be used:

- LR: Likelihood ratio test criteria;
- FPE: final prediction error criteria;
- AIC: Akaike information criteria;
- SIC: Schwarz information criteria;
- HQ: Hannan-Quin information criteria.

The "best" fitting model is the one that maximizes the LR, or minimizes the FPE, AIC, SIC or HQ. The most often used in empirical research criteria are AIC and SC. Both measures improve (decline) as R^2 increases, but, everything else constant, degrade as the model size increases. The measures reported by most, in particular EViews, statistical software packages are:

$$\text{AIC}(K) = \log(\frac{\overline{\varepsilon}'\overline{\varepsilon}}{n}) + \frac{2\text{K}}{n} \qquad (4.6)$$

$$\text{SC}(K) = \log(\frac{\overline{\varepsilon}'\overline{\varepsilon}}{n}) + \frac{\text{K} \cdot \log(n)}{n} \qquad (4.7)$$

Both criteria have their virtues, and neither has an obvious advantage over the other. Since AIC has some disadvantages when it is applied to VAR models (Holod, 2000), we will also use econometric theory when choosing lags number. Olivier Blanchard (1993), for example, used three lags for his macroeconomic VAR model.

Regression analysis based on time series data implicitly assumes that the underlying time series are stationary. The VAR technique requires stationary data, thus each series has to be examined for the probable order of difference stationary. Broadly speaking, "*a stochastic process is said to be stationary if its mean and variance are constant over time and the value of covariance between two time periods depends only on the distance or lag between the two time periods and not on the actual time at which the covariance is computed*" (Gujarati, 1995).

One simple test of stationarity is based on the so-called *autocorrelation function* (ACF). Since in practice we only have a realization (sample) of a stochastic process, it is only possible to compute the *sample autocorrelation function,* $\hat{\rho}_k$:

$$\hat{\rho}_k = \frac{\hat{\gamma}_k}{\hat{\gamma}_0} \qquad (4.8)$$

where

$$\hat{\gamma}_k = \frac{\sum (Z_t - \overline{Z})(Z_{t+k} - \overline{Z})}{n} \qquad (4.9)$$

$$\hat{\gamma}_0 = \frac{\sum (Z_t - \overline{Z})^2}{n} \qquad (4.10)$$

where *n* is sample size and $\overline{z}$ is the sample mean. Then one can construct a plot of $\hat{\rho}_k$ against *k* which is known as the *sample correlogram*. A simple decision rule is that if time series is stationary then its autocorrelation at any lag greater than zero is zero. The statistical software also reports Q statistic developed by Box and Pierce and also Ljung-Box (LB) statistic:

$$Q = n\sum_{k=1}^{m} \hat{\rho}_k^{\,2} \qquad (4.11)$$

where *n* is sample size and *m* is lag length.

$$LB = n(n+2)\sum_{k=1}^{m}\left(\frac{\hat{\rho}_k^{\,2}}{n-k}\right) - \chi^2 \qquad (4.12)$$

An alternative and the most widely used test is the Augmented Dicky-Fuller Unit Root Test. This test includes a constant but no time trend. In addition, before the test is run in EViews it is necessary to define the lag length which is equal to *p-1,* where *p* is the lag length to be included in the model determined by minimized AIC criteria. If the obtained statistics is less then the critical values reported at different levels of significance, then one can make a conclusion that the series are stationary.

If the series are not stationary, a standard econometric technique is applied, namely first differencing. If all the variables are stationary in first differences this means that they are integrated of order one, e.g. I(1). If this is the case, then one can conclude that they are cointegrated.

The test used for testing for cointegration is Johansen's cointegration test. The test reports the number of cointegration equations which is then used in construction of Vector Error Correction Model (VECM).

The next step is actual estimation of VAR of VECM and testing for stability. If the system is stable, the there exists long-run relationship among the variables included in the model.

Finally, impulse response function is constructed and the error forecast variance decomposition procedure can be run. Based on the results of the graphs, it is possible to infer about the interrelation of the variables under the study and to characterize theirs interdependence.

Although VAR models have a lot of advantages, there are some critical issues due to the following problems associated with VAR:

- VAR is a theoretical model because it uses less prior information. Thus, inclusion or exclusion of a variable significantly influences the model's identification;
- VAR models are less suited for the policy analysis as they are primarily used for forecasting;
- Lag length determination is arbitrary and usually is not followed by the tests results. Thus, estimation of many parameters will consume a lot of degrees of freedom.
- Many problems arise if the series are integrated of different orders;
- Coefficients are very difficult to interpret.

Summarizing all the procedures required to estimate VAR we will follow the following steps in our empirical section:

1. Selection of the variables which will be included in the model;
2. Identification of the lag length;
3. Selection of the model variables in levels or differences;
4. Testing for cointegration;

5. Testing for causality using Granger Causality Test;
6. Estimating Vector Autoregression model if there are no cointegration equation or equations, otherwise estimation of Vector Error Correction Model;
7. Testing VAR for stability;
8. Introduction of shocks and investigation of their influence on the behavior of the variables included in the VAR using Impulse Response Function;
9. Estimation of Forecast Error Variance Decomposition in order to determine to what extent variability in one variable can explain volatility of the other.

Chapter 5

EMPIRICAL ESTIMATION AND RESULTS

The procedure described above will be followed in this section. The variables which will be included in our model are: RGDP – real gross domestic product of Ukraine, CR – country risk of Ukraine, RIR – "risk free" real interest rate.

First of all, it is necessary to define the number of lags to be included in the model. Usually the series are converted in logarithm form but in our case, as RIR has negative signs we will proceed without such a transformation. Thus, we run VAR including different lag numbers in order to determine how many lags should be included in the model. This approach was used by Holod (2000). The decision will be based on the AIC statistic, which should be minimized. Appendix 1 presents the obtained results for the following lag numbers: 1, 2, 3, 4, 5. Table 5.1 summarizes the obtained AIC static's for the defined above lag numbers:

Table 5.1 – AIC for different lag lengths

Lags	1	2	*3*	4	5
AIC	25.42606	25.28393	*24.93012*	25.28808	25.61012

Alternative approach results are presented in Table 5.2 below. The results support our findings mentioned in the table above.

Table 5.2 - VAR Lag Order Selection Criteria

VAR Lag Order Selection Criteria
Endogenous variables: RGDP RIR CR
Exogenous variables: C
Sample: 1998:01 2004:03
Included observations: 68

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-986.3735	NA	8.71E+08	29.09922	29.19714	29.13802
1	-853.0105	251.0362	22482833	25.44149	25.83316	25.59668
2	-832.9890	35.92092	16287177	25.11732	25.80276	25.38891
3	-806.9958	44.34132*	9922721.*	24.61752*	25.59672*	25.00551*
4	-802.9703	6.511902	11576526	24.76383	26.03679	25.26822
5	-799.4883	5.325458	13789923	24.92613	26.49284	25.54690
6	-792.5748	9.963469	14941555	24.98750	26.84796	25.72467
7	-788.0236	6.157555	17488223	25.11834	27.27257	25.97191

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

It is clear that AIC is minimized when the number of lags is 3. Thus in our model we will use 3 lags, in other words we will run VAR(3).

As the lag length is defined, the next step is testing the data for stationarity using the ADF testing procedures. In EViews 4.0 it is necessary to specify the number of lagged differences to be included. "The common procedure is to include *p-1* lagged differences in the ADF equation. Here *p* is the number of lags used in the model" stated Holod (2000). The number of lagged differences to be included in ADF test specification is, thus, 2 because the optimal lag length is 3. We will include an intercept (without trend) in the ADF equation. The results show that of all time series are non-stationary; that is, the null hypothesis of the unit root can not be rejected even at 10% significance level. The results of the tests and the series graphs in levels are presented in Appendix 2. As the time series are all non-stationary, they should be differenced until they become stationary. The ADF test of first differences and the graphs are presented in Appendix 3.

As can be seen, from the ADF test statistics in Appendix 3, the first differences of all time series are stationary. This means that all time series are I(1). So we can run the VAR's in first differences rather than in levels. Table 5.3 summarizes the statistic's for ADF tests in levels and first differences and the critical values:

Table 5.3 – ADF tests statistics

Variable	Levels				First difference			
	Statistics	1% cr.v.	5% cr.v.	10% cr.v.	Statistics	1% cr.v.	5% cr.v.	10% cr.v.
RGDP	-1.433464	-3.5226	-2.9017	-2.5879	-6.963603	-3.5239	-2.9023	-2.5882
RIR	-1.057629	-3.5226	-2.9017	-2.5879	-4.321279	-3.5239	-2.9023	-2.5882
CR	-1.134990	-3.5226	-2.9017	-2.5879	-6.266157	-3.5239	-2.9023	-2.5882

Now we have to define whether time series are cointegrated. The results of Johansen Cointegration Test are shown in Appendix 4. The test reveals that the time series are not cointegrated at both 1% and 5% levels of significance. Thus we can run the usual VAR in differences.

Following the VAR estimation procedure, we use Granger causality test to assess whether the history (i.e. lagged observations) of such variables as CR and RIR help to predict the future values of RGDP. The results are presented in Table 5.4.

Table 5.4 – Granger Causality test for first differences

Pairwise Granger Causality Tests
Sample: 1998:01 2004:03
Lags: 3

Null Hypothesis:	Obs	F-Statistic	Probability
DRGDP does not Granger Cause DCR	71	0.38409	0.76481
DCR does not Granger Cause DRGDP		0.24641	*0.86360*
DRIR does not Granger Cause DCR	71	1.28868	0.28590
DCR does not Granger Cause DRIR		2.69294	0.05343
DRIR does not Granger Cause DRGDP	71	0.15536	*0.92586*
DRGDP does not Granger Cause DRIR		1.17460	0.32642

Looking at the p-values we do not reject the following hypothesizes:

- DCR does not Granger Cause DRGDP;
- DRIR does not Granger Cause DRGDP;

If we continue to run VAR in first differences then the effect we are interested in will not be captured. Thus, we have decided to run Granger Causality Test for the data in first differences and in levels. The following result was obtained using the data in levels and specifying 2 lags. Table 5.5 summarizes the findings.

Table 5.5 - Granger Causality test in levels

Pairwise Granger Causality Tests
Sample: 1998:01 2004:03
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Probability
RIR does not Granger Cause RGDP	*73*	*3.66559*	*0.03077*
RGDP does not Granger Cause RIR		0.00789	0.99214
CR does not Granger Cause RGDP	*73*	*3.30994*	*0.04249*
RGDP does not Granger Cause CR		1.16628	0.31768
CR does not Granger Cause RIR	73	2.06369	0.13486
RIR does not Granger Cause CR		0.54019	0.58512

As this new test reveals, we can reject the following hypothesizes, namely:

- DCR does not Granger Cause DRGDP;
- DRIR does not Granger Cause DRGDP;

Thus, we will run VAR in levels with 2 lags included in the model. Now we have to redo the ADF test for the stationarity for the data in levels specifying the number of lagged differences as 1, because we will include 2 lags in our model. Appendix 5 summarizes the findings. The test shows that RGDP is stationary at 5% level of significance while CR and RIR are not. The ADF for the first differences is presented in Appendix 6. Table 5.6 summarizes the findings.

Table 5.6– ADF tests statistics for 2 lags

Variable	Levels				First difference			
	Statistics	1% cr.v.	5% cr.v.	10% cr.v.	Statistics	1% cr.v.	5% cr.v.	10% cr.v.
RGDP	*-3.333315*	-3.5213	*-2.9012*	-2.5876	-19.22772	-3.5226	-2.9017	-2.5879
RIR	-1.626798	-3.5213	-2.9012	-2.5876	-6.846474	-3.5226	-2.9017	-2.5879
CR	-1.451527	-3.5213	-2.9012	-2.5876	-9.350001	-3.5226	-2.9017	-2.5879

Now, again we have to run Johansen cointegration test in order to investigate whether the series are cointegrated or not. The results are presented in Appendix 7. The test shows that again there are no cointegration equation at both 1% and 5% levels of significance. This means that the VAR should be estimated in first differences but as all the variables have a unit root I(1) and are not cointegrated, then, asymptotically, VAR in levels or first differences makes no difference (Sims, Stock, Watson, 1990), but 1st differences is better in small samples (Hamilton, 1994). As we have a "small" sample, we might use first differences in our VAR model. Nevertheless, we will follow (Sims, Stock, Watson, 1990) due to the Granger test results. Moreover, we will follow Eltony (2002) who in his paper wrote the following:

"…the VAR technique requires stationary data, thus each series should be examined for the probable order of difference stationarity. However, in transforming a variable, a usual

question arises as to whether one should do an appropriate differencing to identify the stationarity structure of the process. In this context, Doan (1989) noted that differencing a variable is 'important' in the case of Box-Jenkins ARIMA Modeling. However, he also observed that it is not desirable to do so in VAR models. As a matter of fact, Fuller (1976) has shown that differencing the data may not produce any gain so far as the 'asymptotic efficiency' of the VAR is concerned 'even if it is appropriate'. Furthermore, Fuller (1976) has argued that differencing a variable 'throws information away' while producing no significant gain. Thus, following Doan and Fuller, the level rather than the difference was preferred."

Testing data for stationarity Eltony (2002) found that 3 series out of 7 were not stationary in levels but all 7 variables were stationary in 1st difference. As it is mentioned above the author run his VAR model in levels. Thus we will follow the same procedure.

The results of the VAR model and the estimates are presented in Appendix 8. Although the estimates of individual coefficients in VAR do not have a straightforward interpretation, a glance at the table generally shows that 5 of 21 estimates are significant at conventional levels. By far, the higher R^2, F-statistics and Log-likelihood level belong to the RIR equation. The estimation results can be analysis as follows. First of all, one can observe high R^2 in both RIR and CR equations which are correspondingly equal to 95% and 75%, with a low R^2 in RGDP equation which equals 0.49%. This means that the lagged values of RIR and CR together with lagged RGDP itself can explain only a half of the variation in RGDP in that equation.

As the model has been estimated we will test the system for stability. The results are presented in the Table 5.7 below.

Table 5.7 – VAR Stability Test

Roots of Characteristic Polynomial
Endogenous variables: RGDP RIR CR
Exogenous variables: C
Lag specification: 1 2

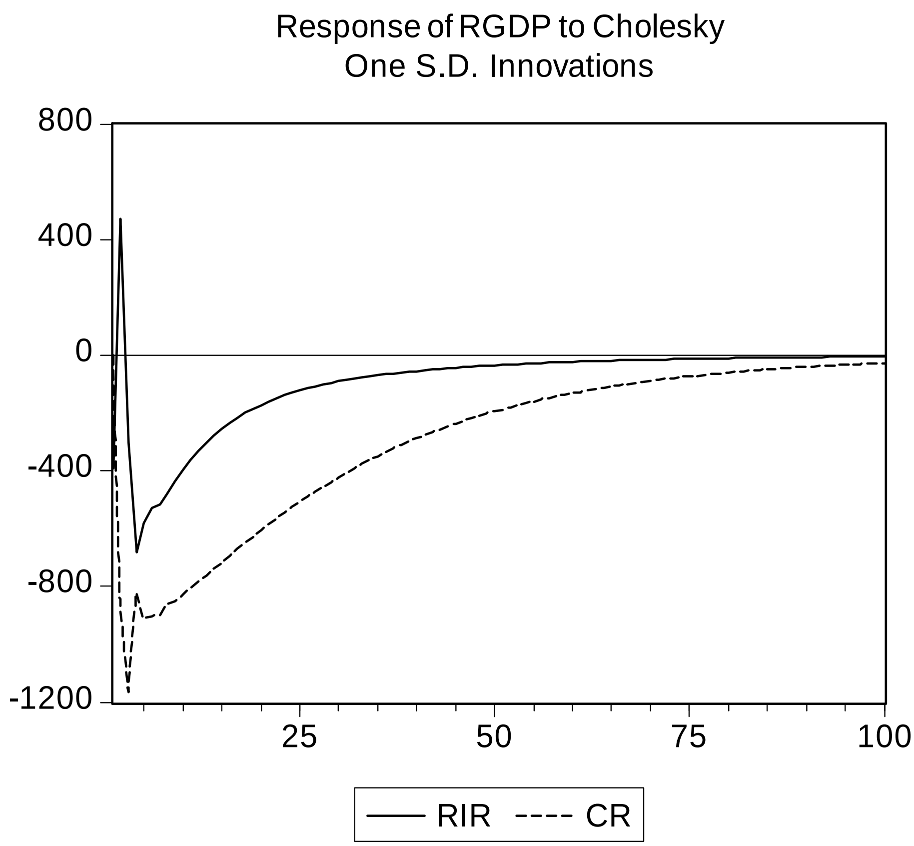
Root	Modulus
0.961632	0.961632
0.873702	0.873702
-0.547110	0.547110
0.479164	0.479164
-0.063827 - 0.434807i	0.439466
-0.063827 + 0.434807i	0.439466

No root lies outside the unit circle.
VAR satisfies the stability condition.

The results show that the system is stable, which means that the system is not explosive and the shocks will die out with time.

The next step is to introduce shocks in the model. As we are interested in the behavior of RGDP due to shocks in RIR and CR we will construct impulse response functions to capture the effect. We use the Cholesky degrees of freedom adjusted decomposition method. The results are presented on Figure 5.1.

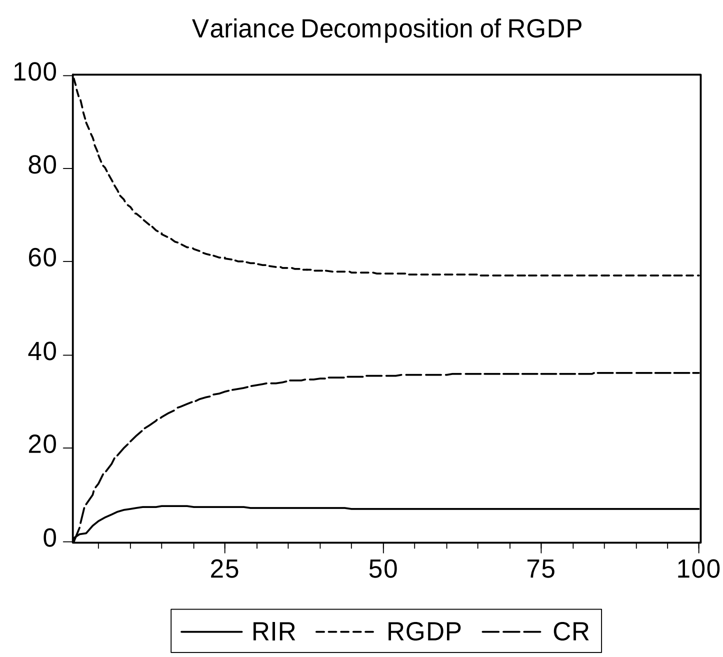
Figure 5.1 – Impulse Response Function



As we can see from the Figure 5.1, the response of RGDP to Cholesky one standard deviation innovation in CR influences RGDP more then the one of RIR. Both effects diminish as time horizon increase. Thus, we can infer that increase in country risk variable leads to decrease in RGDP growth. In other words, an increase in country risk reduces RGDP volatility. Concerning the RIR, after a Cholesky one standard deviation innovation, we observe first a sharp increase in RGDP. After 5 months, however, the growth of RGDP goes negative and stays there. Eventually, after 100 month, the effect of the shock is gone. All this increases the volatility of RGDP. By contrast, concerning the country risk, we observe a sharp decrease in RGDP. After 5 months the decrease begins to lessen but the growth of RGDP falls and effect of the shock is gone. This also increases volatility of RGDP.

In order to identify how volatility in one variable can explain volatility in another, we will use the Forecast Error Variance Decomposition procedure. While impulse response functions trace the effects of a shock to one endogenous variable on to the other variables in the VAR, variance decomposition separates the variation in an endogenous variable into the component shocks to the VAR. Thus, the variance decomposition provides information about the relative importance of each random innovation in affecting the variables in the VAR. The variance decomposition results are presented in Figure 5.2.

Figure 5.2 – Variance Decomposition



The figure presents RGDP variance decomposition for the 100 months forecast. From the results obtained we can infer that, indeed, the variability or, in other words, volatility of CR and RIR explain volatility of RGDP of Ukraine. First, we see that over 50% (53% to be precise) of RGDP volatility is explained by itself. Of the remaining 47% we can infer that the country risk volatility explains the volatility of RGDP by four times as much as RIR. This means that eliminating the volatility of CR will reduce the volatility of RGDP by 40% while the reduction of volatility in RIR will reduce the volatility of RDP of Ukraine by only 7%. Our findings parallel those obtained by Neumeyer and Perry (2004).

C h a p t e r 6

CONCLUSIONS

The primary goal of the thesis was to examine the volatility of economic activity in Ukraine and the role of interest rates. To be precise, we investigated how real gross domestic product of Ukraine reacts to fluctuation in international credit conditions, namely real interest rates and country risk, measured by the spread between the interest rates Ukrainian banks charge on their credits and real interest rates.

Many Vector Autoregression model studies have showed there exists interrelationship among aggregate macroeconomic variables in different countries and in international financial markets. That is why we used VAR in order to investigate for how much reduction of volatility of real interest rates and country risk will improve the volatility of Ukrainian GDP. The VAR estimation technique was chosen because it does not require introducing aeconomic theory or structure in the model and also has two key devices through which the dynamic structure of the model is characterized, namely Impulse Response function and Forecast Error Variance Decomposition.

After the VAR model was specified and estimated, we found that shocks in RIR and CR affect the gross domestic product of Ukraine but CR affects it by a greater magnitude. The answer on the main question of our study is that stabilization of international credit conditions will reduce the volatility of Ukrainian GDP by almost 7% while reduction of volatility of country risk will reduce GDP's volatility by almost 40%. The results support recent findings of Neumeyer and Perry (2004) for Argentina. We can conclude that Ukrainian economic activity is more dependent of RIR fluctuations and that country risk explains GDP volatility by 17% more then in case of Argentina.

There are some important policy implications of our study. First of all, it should be mentioned that real interest rates can not be influenced by any country exempt for the USA. This variable is taken as given. This means that volatility of RIR can not be influenced by the Ukrainian government. By contrast, the government can and should influence the country risk indicator of Ukraine if it wants to reach stable and continuing economic growth.

The policy implications of the obtained results are that, first of all, government should increase the trust of foreign and domestic investors to the economy. Secondly, both fiscal and monetary policies should implement stability in economic development of the country without shocks from the government side. Thirdly, political situation should be stabilized and the trust of population in the government gained. Finally, Ukrainian economy should receive the status of the market economy.

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