THE IMPACT OF OIL PRICE CHANGES ON THE MACROECONOMIC PERFORMANCE OF UKRAINE

by

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Abstract

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In this research we investigate the impact of oil price changes on Ukrainian economy. Following existing literature the focus is on six macroeconomic variables: nominal foreign exchange rate, CPI, real GDP, interest rate, monetary aggregate M1 and average world price of oil. Adhering to Cologni and Manera (2008) we allow for interconnection between the variables to exist and adopt SVAR/VECM approach for this purpose. In particular, we choose between the two closely related model types based on cointegration properties of the data. We succeed in detecting long-run equilibria, estimate VECM and further perform innovation accounting. We find that oil price increases tend to deteriorate real economic activity in the short run (though with one month lag) as opposed to the long run. The reaction goes through indirect effect, namely downward demand effect, which is characterized by contraction of aggregate demand in response to adverse oil supply shock. Based on the results of IRF we further numerically confirm the validity of this channel. Finally, we check if the asymmetry effect between oil price changes and real GDP response as discovered by Mork (1989) is present in Ukrainian data. We find sustaining evidence in favor of symmetric response of real GDP to oil price increases/decreases in the short run.

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GLOSSARY

Crude oil. A naturally occurring, flammable liquid consisting of a complex mixture of hydrocarbons of various molecular weights, and other organic compounds, that are found in geologic formations beneath the Earth's surface.

Chapter 1

INTRODUCTION

Public attitude towards oil is ambiguous. Some people think that oil is the major threat to enduring economic development, social equality, environment and peace. Their viewpoint is most accurately expressed in the article by Michael Hirsh, Newsweek's national economics correspondent, where his personal perception of 'Crude World: The Violent Twilight of Oil', the hue and cry book written by Peter Maass, is given. Hirsh claims the following:

> 'Oil is the curse of the modern world; it is "the devil's excrement," in the words of the former Venezuelan oil minister Juan Pablo Pérez Alfonzo, who is considered to be the father of OPEC and thus should know. Our insatiable need for oil has brought us global warming, Islamic fundamentalism and environmental depredation. It has turned the United States and China, the world's biggest consumers of petroleum, into greedy, irresponsible addicts that cannot see beyond their next fix. With a few exceptions, like Norway and the United Arab Emirates, oil doesn't even benefit the nations from which it is extracted. On the contrary: most oil-rich states have been doomed to a seemingly permanent condition of kleptocracy by a few, poverty for the rest, chronic backwardness and, worst of all, the loss of a national soul' (Hirsh, 2009).

Others believe that the usefulness of oil in modern economic setting can not be questioned. George W. Bush, for instance, calls oil 'a fluid without which our civilization would collapse' (Hirsh, 2009). Michael Schirber sets off his article 'The Chemistry of life: Oil's many uses' by claiming that 'besides water, there's no liquid that humans rely on more than petroleum' (Schirber, 2009). And to certain extent both of them are right. Oil is the central production factor of the world economy. According to EIA estimates, between 1996 and 2006 the total share of oil as a source of commercial energy constituted 56% from total energy use. 'Black gold' powers machines and automobiles, and is the basic material for a wide range of products such as lubricants, asphalt, tars, tires, solvents, plastic, foams, bubble gums, DVDs, deodorants, crayons, to mention just a few. The amount of oil and derived products an economy consumes depends upon numerous factors. Following Bacon and Kojima (2008) such factors as the level of GDP, industrial sector structure of an economy, the availability of choices among fuels that permit substitution, level of technological progress are the most important ones. All taken together they describe the stage of economic development the country is in. It is important to realize that in principal the use of crude oil after it is removed from the ground is limited. But the situation is absolutely reversed for the products, which become available after extracted oil is refined. Oil products, mainly fuels, are important for different sectors of an economy with a special emphasis being assigned to transportation, construction, industrial and power-producing sectors. Moreover, household use of oil is overwhelmingly important for low-income countries, where the power-producing sector is in infantile phase.

Due to the fact that oil is widely used across all sectors of Ukrainian economy with no effective cost-beneficial substitute available, and taking into account that its price dynamics has been relatively volatile in recent years, I would like to investigate if the conventional hypothesis, as pioneered by Hamilton (1983), that oil price fluctuations may adversely affect country's macroeconomic performance holds for Ukraine. The variables of interest (i.e. endogenous variables) are seasonally adjusted real GDP and nominal foreign exchange rate, interest rate, monetary aggregate M1 and inflation level. The choice of variables is mainly driven by similar studies, in particular Cologni and Manera (2008) is used as a benchmark, which have been conducted for developing countries and is in accord with economic theory. The set of variables considered in this research may be decomposed into control and state ones. The former group includes M1, interest rate and foreign exchange rate, which are used as leverage by the government. In other words, their values are manipulated, so that the desirable economic effect is obtained. The latter group of variables counts the two main indicators of economy's health, i.e. inflation level and real GDP. The period under consideration is chosen to be 01/1996-12/2006 with data frequency being one month. The research differs from the others conducted on Ukrainian data in that it considers and estimates the main economic variables under study in a system framework via SVAR/VECM approach, which allows for variable's contemporaneous and lagged interconnection, whittles away endogeneity problem. In addition, we investigate if the asymmetric relationship between oil price changes and real GDP, which is characterized by unequal responses of the latter to up- and downside movements of the former variable, is present in the data. To accomplish the latter goal, approach introduced in Mork (1989) is utilized.

The topic is relevant for Ukraine as Ukraine suffers from shortage of internal energy resources, including oil. This fact is supported by available statistics[1], which reveals that even now there is a huge gap between consumption and production sides of oil in Ukraine, hence to overcome these imbalances the country will still heavily rely on import, mainly from Russian Federation and Kazakhstan, and continue to be vulnerable to external factors such as oil price fluctuations, i.e. Ukraine is exposed to oil price risk. The formal proof of the above statement is provided in the study by Bacon and Kojima (2008), where the

[1] In 2008 Ukraine consumed the amount of oil (370 bpd) almost four times of what it produced (95.17 bpd) (EIA).

authors quantify oil price risk exposure of any country by referring to its vulnerability to oil price increases, which is defined as 'the ratio of the value of net oil imports (crude oil and its refining products) to GDP' (Bacon, Kojima, 2008). With regards to Ukraine, its vulnerability measure amounted to 5.2% in 1996, 5.0% in 2001, and 5.3% in 2006. In other words, during the considered years the country's average net import of oil constituted 5.1% of its GDP. It may be inferred that change in vulnerability between 1996 and 2006 constituted 0.1%. This change is decomposed via refined Laspeyres index as follows (focus is mainly on consumption effects): oil price effect through consumption is 11.7, oil share in energy effect is -1.1, energy intensity effect is -4.9, real exchange rate effect is -4.6, total consumption effect is 1.0, total production effect is -0.9. What should be emphasized is extremely high value of oil price effect through consumption if compared to other factors, which can be interpreted as a one percentage point increase in oil price will result in 11.7 percentage increase in country's vulnerability index during the considered period given other factors are held constant. This is indicative of reduced aggregate demand, further drop in output and reduced economic activity.

The rest of this research paper is organized as follows: in the next section brief overview of existing literature, methodologies used and channels representing oil transmission mechanism is given, next particular methodology applied is described, then comes data description, interpretation of the estimation results, and corollary section completes the research. To conclude, according to the theory, oil price increases are expected to negatively affect net oil importers through rising import bills, which in turn effect other prices, and lead to rising inflation, reduced macroeconomic demand (output level) and further unemployment (Bacon, Kojima, 2008). The scale of economic decline is different for different countries and varies with the extent to which countries are dependent on oil.

Chapter 2

LITERATURE REVIEW

Nowadays there exists a great mass of academic literature focusing on the economic properties of oil, its impact on the aggregate world economy and specifically on economies of different types (say, net exporters or net importers of oil, emerging or developed ones etc). Some of the papers consider the impact of oil on particular economic variables, i.e. estimate oil price pass-through into, say, exchange rate, inflation or unemployment; others estimate the system of equations via appropriate econometric techniques to account for interrelationship between the included variables as well as external (exogenous) ones and do innovation accounting, i.e. compute impulse responses to oil price shocks, evaluate its significance, determine its magnitude, speed of convergence to the long-run value as measured by the time it takes for the reaction to disappear. Another block of papers, which should be highlighted separately, is the one where the question of asymmetric relationship between the level of oil price and economic activity is investigated. There are also some studies, which focus entirely on Ukraine and thus are of particular interest. In addition, in order to justify the choice of variables mentioned in the introduction, oil transmission mechanism is considered in details. The structure of the literature review will be consistent with the aforementioned strands of existent literature, while only the most important articles will be discussed.

The vivid example of the first block of papers is a research undertaken by Chen (2009), where the author's main intention is to generalize a series of papers, which focus on the issue of declining oil price pass-through into inflation, phenomenon, which is confirmed empirically by now. Moreover, an additional step is undertaken, so that the factors, which may explain this decline, are formally determined. Employing data from 19 industrialized countries and estimating augmented Phillips curve model with error correction term, the author proceeds by checking the stability of the estimated short-run pass-through coefficients via one-time structural break test proposed by Andrews (1993). The results of the test indicate that the majority of countries under study fail to reject the null of no structural break. In the next step a dummy variable is added into the core estimation equation for the purpose of dividing the sample period into two parts: before and after the break date. This time estimation results turn out to be different, with short-run pass-through coefficients being significantly lower in the post-break period. The core innovation behind this study is that rather than assuming a discrete number of structural breaks in the pass-through[2], the author suggests accounting for its smooth change over time, i.e. treating it as a random variable following a martingale (random walk). This is a plausible assumption, since 'it would be difficult to believe that a sudden innovation or shock would exist that makes the degree of pass-through change dramatically' (Chen, 2009). Moreover, for the majority of countries it is supported by the results of Hansen stability test. The core model is modified so that it incorporates this change and is estimated via state space method. Empirical conclusion reached is that for industrialized countries under examination there appears to be a downward trend, i.e. gradual decline, in the oil price pass-through into inflation during the covered period. The major factors, which explain this phenomenon, as determined by the results of fixed effect panel regression with dependent variable being a series of short-run pass-through coefficients, are the declining share of energy consumption in the economy, favorable exchange rate movements, higher degree of trade openness and accommodative monetary policy. The first two factors are

[2] Tests proposed by Bai and Perron (2003) may be useful for this purpose.

exactly those used by Bacon and Kojima (2008) in the decomposition analysis of oil price vulnerability index and hence empirically confirm its appropriateness.

Another paper, which perfectly fits into this category, is the one by Chen (2007). Relying on the fact that real shocks are the primary causes of exchange rate fluctuations as confirmed by Clarida and Gali (1994), the author considers the long-run nexus between oil price and real exchange rate using a monthly panel data for G7 countries. In other words, cointegration properties of oil price and exchange rate time series are examined using panel cointegration techniques. The reason for doing panel analysis is that country-by-country Johansen test results produce mixed evidence in favor of cointegration existence. For some countries cointegration vector may be identified (Germany, Japan), for some not (Canada, France, Italy, UK). Thus, based on these estimates, the main hypothesis, which says that the real exchange rate is positively related to the real oil price, can not be supported empirically, though theoretically it is true. To overcome this collision, the author pools the data for all countries under examination and after the implementation of the Fisher-type ADF and Phillips-Perron tests for panel unit root, runs the panel cointegration residual-based test proposed by Pedroni (2004). This time obtained statistics indicates fairly strong support for the hypothesis of cointegration relationship between the two variables. The robustness check of this result is performed via likelihood-based cointegration test proposed by Larsson (2001), which allows for the possibility of multiple cointegrating vectors and thereby provides stronger evidence of cointegration. At 1% significance level the results obtained from the Larsson test are in complete accord with those of Pedroni test. The important issue is that these results continue to hold regardless of what type of oil price measure one uses: average world oil price, Dubai oil, Brent oil or WTI oil price. Given the evidence that the two variables of interest are cointegrated, the author proceeds by estimating cointegrating coefficients and applies between-dimension panel fully modified OLS method. Estimation results suggest that for G7 countries a rise in real oil price depreciates real exchange rates in the long run. Despite the fact that the focus of this research is mainly on developed countries, one is not prohibited from extrapolating the results on developing ones, mainly those incorporating floating exchange rate regime, i.e. to state that for this group of countries oil price can adequately capture permanent innovations in the real exchange rate in the long run as well. At least the theoretical model behind this research does not distinguish between country types.

The research, which is a good example of the second block of papers mentioned above, is the one conducted by Cologni and Manera (2008), where the economic effects of oil price are estimated by means of a structural cointegrated VAR within open macroeconomic model for G7 countries. The authors pay particular attention to monetary variables and incorporate interest rate and money aggregate M1 into study in order to further understand how the latter respond to exogenous oil price shocks as well to capture the interaction between real and monetary shocks in affecting economic behavior. The authors define two long-run equilibrium conditions, i.e. cointegrating vectors, through conventional money demand function and the relationship that equates excess output, as measured by the difference between actual and potential output levels, to inflation rate, exchange rate, interest rate and the price of oil. The short-run dynamics of the model is represented via six equations, describing money market, domestic goods market equilibria, exchange rate movements and oil price shock mechanism, which is assumed to be self-generating and contemporaneously independent of any other component in the system. The authors' findings are quite predictable and indicate that for majority of countries under study one standard deviation shock in oil price on average causes inflation level to increase. In addition, output level is negatively affected, though this effect is lagged in nature. On the monetary side, interest rate increases mainly due to inflationary and real (output) types of shocks, which is an indicator of a tightening in monetary policy. Moreover, empirical results suggest that a shock in oil price does not have any contemporaneous effect on the exchange rate. To clear the issue, this finding does not fully contradict the one obtained by Chen (2007) due to different methodologies used by the researchers, i.e. Cologni and Manera consider this problem separately for each country as opposed to pooling the data and implementing the analysis on panel level. Finally, innovation accounting is performed to numerically assess the oil price pass-through into the variables under study.

Approach similar to the previous study, i.e. VECM, has been applied by Rautava (2004) in the research on the role of oil price and the real exchange rate fluctuations of rouble on Russian fiscal policy and economic performance. The results obtained indicate that the Russian oil-exporting economy is influenced significantly by fluctuations in the aforementioned variables through both long-run equilibrium conditions and short-run effects. More precisely, the author reports that 'over the long-run, a 10% permanent increase (decrease) in international price of oil is associated with a 2.2% growth (decline) in the level of Russian GDP' (Rautava, 2004). One more worthwhile example concentrates on four large energy producers and addresses the issue of the effects of oil price shocks on real exchange rate, output and inflation level via SVAR methodology (Korhonen and Mehrotra, 2009). Theoretical explanation of the empirical model is provided by a dynamic open economy Mundell-Fleming-Dornbusch model, augmented with an oil price variable. Using this approach, a set of over-identifying restrictions on the matrix of structural innovations is imposed. The authors proceed in usual fashion to estimate the model and obtain the results similar to Rautava (2004). In addition, they find that oil price shocks do not account for a large share of movements in the real exchange rate, as measured by FEVD, although for some countries under study they appear to be significant.

The whole thrill about this research is that in case of Venezuela linearity tests proposed by Teräsvirta (2004) produce some evidence of nonlinear relationship between the output and oil price series. The authors suggest overcoming this obstacle via estimation of a (logistic) smooth transition regression, which allows for explicit modeling of the asymmetric relationship between the variables, i.e. takes nonlinearity into account.

The whole problem of asymmetric relationship between the aforementioned variables was initiated after inability of the 1986 oil price plunge, mainly caused by preceding oil glut and unstable situation in Middle East, to produce an economic recovery as opposed to economic downturn provoked by 1973 artificial oil price surge. This phenomenon has been empirically justified by Mork (1989), who showed that if one were to extend the period under consideration by including data from 1986 oil price plunge, the oil price-macroeconomy relationship, as established by Hamilton (1983), would collapse. In fact, Hamilton[3] obtained a persistent negative correlation between oil price changes and GNP growth using the US data of 1948-1972, and claimed that 'oil shocks were a contributing factor in at least some of the US recessions prior 1972'. In principal, the conclusion reached turned out to be correct, but did not tell the whole story. The problem was that the study focused on the period in which large oil price declines did not occur, and hence one could not extrapolate its results in this kind of environment. It was not clear, if the correlation between the two variables would persist and so the ability of oil price declines to stimulate the economic activity was questioned. What Mork actually did, was that he modified Hamilton's research by separating oil price increases and decreases into different variables and re-estimated the model. This time estimation results produced mixed

[3] In his paper, Hamilton mentions an interesting observation that 'all but one of the U.S. recessions since World War II have been preceded, typically with a lag of around three-fourths of a year, by a dramatic increase in the price of crude petroleum' (Hamilton, 1983).

evidence with real oil price increases being negative and highly significant at each lag level, thus supporting Hamilton's conclusion, as opposed to real oil price decreases, which turned out to be positive though small and only marginally significant. To confirm the appropriateness of the method used, the author implemented two types of tests, accounting for the stability of model's asymmetric specification as well as pairwise equality of oil price coefficients. The tests were successfully passed and strong evidence in favor of asymmetry hypothesis was obtained. This finding has been empirically verified for a number of industrialized countries. Interested reader is encouraged to check for Mork and Oslen (1994) for additional evidence.

The asymmetry issue requires sound theoretical argumentation as well as complicates the procedure of conducting empirical studies by asking for more advanced econometric techniques to be used. As a consequence, it is worth mentioning the paper by Huang et al. (Huang, Hwang and Peng, 2005), in which multivariate (two-regime) threshold model proposed by Tsay (1998) is exploited to investigate the relationship between oil price change, its volatility component (estimated via GARCH (1,1) model), and economic activity as measured by the level of industrial production and real stock returns. The US, Canada and Japan monthly data (1970-2002) are employed for this purpose. As a reference point, the authors heavily criticize the study by Sadorsky (1999) for its inability to take into account that countries may exhibit different threshold values for an oil price impact, i.e. 'the amount of price increase beyond which an economic impact on production and stock prices is palpable' (Huang et al., 2005). Eliminating this drawback constitutes the core contribution of this article. The authors intentionally incorporate into study the aforementioned countries, since in case of USA and Japan, which are net importers of oil, the threshold value is expected to be much lower (2.58% for both) if compared to Canada, net exporter of oil (2.7%). At the first stage of the analysis, one-regime VAR model, augmented with a dummy variable, which reflects structural break date, as determined by the approach suggested in Bai et al. (1998), is estimated. Failure to take the latter into account, i.e. splitting the sample into two subgroups, may result in biased results. One-regime VAR approach, though it provides theoretically justified estimates, encounters several drawbacks, among which low explanatory power of oil price shocks, 'the average-out problem emanated from positive and negative changes in the price of oil' and inability to account for different levels of oil dependence between countries. The problem is solved via implementation of multivariate threshold autoregressive model (MVTAR). This time the value of threshold is calculated via the grid search procedure proposed by Weise (1999); estimation results confirm the presence of asymmetric relationship between the variables, which is reflected in that 'responses of economic activity are rather limited in regime I, but become much more noticeable in regime II, where oil price change exceeds the threshold level'.

Another methodology has been realized by Lardic and Mignon (2006) in the article, which studies the long-term relationship between oil price and GDP time series using data for G7 and Euro Area countries. To account for existing asymmetry, the authors adopt the approach, developed among others by Schorderet (2004), which is based on asymmetric cointegration. Intuitively, the latter may be determined after one decomposes two integrated time series into positive and negative partial sums, and further constructs a linear combination, which is stationary. This is exactly how the authors proceed in their study. As a result, they manage to affirm asymmetry hypothesis for the majority of countries. Among its possible causes, 'monetary policy, adjustment costs, adverse effect of uncertainty on the investment environment' are mentioned.

Aliyu (2009) investigates oil price shocks effect on the macroeconomic performance of Nigeria between 1980-2007 via VAR model using different asymmetric transformations for oil price variable, among which Hamilton's (1996) NOPI[4] and Mork's (1989) specification. The latter survives a number of post-estimation tests, such as Wald and block endogeneity (Granger causality), which support the significance of oil price coefficients in the model. Moreover, case of Nigeria is interesting, since on its example one may observe how the asymmetry effect is reflected in oil-exporting economy. This time, 'evidence is found of more significant positive effect of oil price increase, than adverse effect of oil price decrease on real GDP' (Aliyu, 2009).

In general, economists come up with different explanations of the asymmetry phenomenon. For example, Lee et al. (Lee, Ni and Ratti, 1995) conduct a research study, where they claim that 'an oil price change is likely to have greater impact on real GNP in an environment where oil price movements have been stable, than in an environment where oil price movements have been frequent and erratic'. In other words, one should account for the variability of real oil price movements prior to assessing the relationship between the two variables. The authors propose to augment the VAR model of Hamilton (1983) and Mork (1989) with the unexpected oil price shock variable normalized by a measure of oil price variability. 'This ratio can be thought of as being an indicator of how different given oil price movement is from its prior pattern'. To construct this variable changes in real oil price are assumed to be exogenous to any other variable present in the model, and thus depend entirely on its own lagged values with error term following GARCH (1,1) process. The variable is then defined as the ratio of the 'unexpected part of the rate of change in real oil price' to the square root of conditional variance of the error term. In other words, given that certain value of the unexpected part (numerator) is calculated, its impact on real economic activity will diminish the higher is the value of conditional variance

[4] NOPI=max{0, o(t)-max{o(t-1), o(t-2), o(t-3), o(t-4)}}. Main focus is on oil price increases (Aliyu, 2009).

(denominator), i.e. it will be treated as a temporary change. To draw an analogy, one may think of conditional variance as something describing general environment of some geographical area, say the desert of Judea, and the unexpected part representing average number of rainy days during the year. If the latter figure is trifling, it will not make one change the common perception that desert is an arid place. On the other hand, assume that rainy weather prevailed during the whole year, undoubtedly, one will be puzzled with this observation and his/her perception may be affected. The authors provide the following economic justification of their approach: 'a rise in real oil price that is large relative to the observed volatility will result in reallocation of resources and the lowering of aggregate output, but during periods of high volatility, since current oil price contains little information about future, rational agents will be reluctant to reallocate resources in the presence of real costs of doing so, thus aggregate output remains unchanged' (Lee et al., 1995). The empirical results support this line of reasoning. Moreover, if one distinguishes between positive and negative normalized oil price shocks the issue of asymmetry arises: the coefficients on positive ones are all strictly negative and highly significant, the coefficients on negative ones are of different signs and insignificant. The model proposed by Lee et al. survives a number of robustness checks, including the one proposed by Hamilton that 'the relationship between the impulse response of real GNP growth obtained from a nonparametric kernel estimate and normalized unexpected oil price shock be examined'.

Addressing the issue of oil price uncertainty, I would like to briefly overview the research by Elder and Serletis (2009). In this paper the authors investigate the effects of oil price uncertainty in Canada via two-variable (industrial output and oil price) structural VAR model, assuming, as in the previous study, that error terms are heterosc(k)edastic and follow GARCH (1,1) process. The proposed measure of uncertainty is a conditional standard deviation of oil, i.e. 'a standard deviation of the one-month ahead forecast for oil price, obtained from the multivariate variance function, in which the volatility of industrial production and the volatility of oil price depend on their own lagged squared errors and lagged conditional variance' (Elder, Serletis, 2009). The VAR model is constructed in such a way that oil price uncertainty, which is treated as an exogenous variable in the system, enters the equation for industrial production only. The model is estimated by maximum likelihood (joint maximization over conditional mean and variance parameters). The estimation results say that the coefficient in front of oil price uncertainty measure is negative and statistically significant, proving that oil price volatility has tended to depress industrial output in Canada during the considered period. Moreover, this term brings about asymmetry, in the sense that 'unanticipated oil shocks, whether positive or negative, will tend to increase the conditional standard deviation of oil, which will tend to depress output growth' (Elder, Serletis, 2009). In other words, abrupt oil price declines may lead to contraction of output due to increased uncertainty. Finally, the relevance as well as explanatory power of the uncertainty measure is revealed after implementation of innovation accounting. In particular, impulse-response analysis indicates that the latter variable 'strengthens negative response of output to oil price shock'. Though this study considers the problem of asymmetry from slightly different angle, the results obtained are in complete accord with those of Lee et al. (1995) and Mork (1989).

Thus far the studies, which mainly used relatively homogeneous econometric techniques to account for asymmetric relationship between oil price shocks and output level, were considered. Another way to think about asymmetry is to explicitly assume that the relationship between the two variables is nonlinear. This issue has been thoroughly investigated by Hamilton (1999), where he developed a new framework for determining whether a given relationship is nonlinear, what the nonlinearity looks like, and whether it is adequately described by a particular model. What is unusual about the proposed approach is that at the first stage the nonlinear part of the regression equation is not defined explicitly, remains unknown and is treated as the outcome of a random process. In the further research, Hamilton applies the methodology he proposes to US historical data, and estimates the relation between oil price and GDP growth (see Hamilton (2003)). The results, he obtains, prove the appropriateness of the method used, as well as the nonlinearity hypothesis. Just to mention that the same methodology has been used by Zhang in his research on Japan, where he shows that once a nonlinear asymmetric effect is accounted for, a considerably larger coefficient on the oil shocks can generally be obtained, providing evidence of misspecification of a simple linear regression model (D. Zhang, 2008).

Alternatively, it should be mentioned that not all economists believe in the existence of asymmetric (nonlinear) oil price shock effect. In particular Tatom (1988) blames monetary policy for the asymmetric response of aggregate economic activity to oil price shocks, implying that in fact economy responds symmetrically.

As it was already mentioned, there exist some studies, which investigate the impact of oil price fluctuations on Ukrainian economy. One example is a research carried out by Myronovych (2002). The author adopts methodology proposed by Gisser and Goodwin (1983) and estimates three separate St. Louis-type equations[5], where oil price simultaneously with monetary and fiscal policy variables influence real GDP, inflation and unemployment. The estimation method used is error correction mechanism (ECM) with Newey-West standard errors, which are used for the purpose to eliminate serial correlation and heterosc(k)edasticity problems. Clear dependence between oil price fluctuations

[5] St. Louis-type equations describe the impact monetary and fiscal policies have on economic activity (Cologni, Manera, 2008)

and the first two macroeconomic indicators (GDP and inflation) is found, though the impact on unemployment level is not statistically significant at any lag length. Moreover, the study reports that in case of GDP monetary policy has the largest positive counterbalancing effect among all the regressors, though it is lagged in nature. This finding is also supported by the observation made in Peersman and Robays (2009). Finally, Myronovych reports that one percent increase in the growth rate of real oil price will likely decrease next quarter GDP growth rate by 0.126 percents and its effect is still increasing after. In addition, contemporaneous increase in the quarterly growth rate of inflation by 0.27% will also take place.

To conclude the literature review section and to justify the choice of macroeconomic variables chosen for this research, I consider the channels through which oil price fluctuations may affect economy of a given country. Following the existing literature, I refer to those channels as oil transmission mechanism. According to Peersman and Robays (2009) oil price increases are accompanied in the first place by a rise in consumer price index, which conventionally includes energy goods such as petroleum, heating fuels etc. This effect is known as direct or short-run effect and its magnitude depends on the weights assigned to energy goods in aggregate CPI. Direct effect is assumed to be rapid and complete, though the question of completeness may be distorted in case of high level of competition in retail energy sector. Indirect effect comes next and is more persistent and considerably larger in magnitude. It captures long-run increases in CPI, which on purpose excludes energy prices. Indirect effect is more relevant for policy makers, because monetary policy, whose effect is delayed in nature, is pursued with the reference to aggregate CPI changes. This effect may be decomposed into cost effect, second-round and demand effects. The intuition behind the cost effect, which is measured by changes in import deflator, is that higher price of oil inevitably pulls production costs and terminal goods' prices up, finally resulting in increased CPI. Second-round effect occurs since rising CPI is associated with decreasing purchasing power of money, hence employees become worse off and have an incentive to demand higher nominal wages to restore their real income. This is possible to accomplish through wage indexation mechanism. As a result, firm's costs are subject to even further increase. The firms respond to it via additional increase in prices, which again will lead to an increase in CPI, and so on and so forth. It turns out that second-round effect is cyclical and may result in even higher inflation level. As Peersman and Robays (2009) mention correctly: 'the existence of second-round effects will depend on supply and demand conditions in the wage-negotiation process and the reaction of inflation expectations'. Turing to demand effect, one is supposed to remember the conventional textbook supply-demand graphs. Exogenous oil price shock shifts supply curve upward along aggregate demand curve. This results in an increase in the price level and decrease in output. The more elastic the demand curve is, the lower the impact of oil price shock on the price level will be. Moreover, for the country, which is a net oil importer, oil price increases are accompanied by the downward shift in the aggregate demand curve, which reflects reduced composition of demand and even additional drop in output. The latter is associated with the following sub-channels: precautionary savings, uncertainty and monetary policy effect. As regards monetary policy effect, its legitimacy is supported by the results of Leduc and Sill (2001) study, where the authors construct a DSGE monetary model within monopolistic competition framework, and find out that 'easy inflation policies are seen to amplify the impacts of oil price shocks on output and inflation' (Leduc, Sill, 2001). This conclusion is supported empirically in the study by Hamilton and Herrara (2000). Finally, oil price increases are also expected to negatively affect country's terms of trade through negative current account. As a result, the Central bank will not be able to intervene into foreign exchange market endlessly to meet demand, and will have to let the exchange rate to depreciate.

Chapter 3

METHODOLOGY

As opposed to the research conducted by Myronovych (2002), I am inclined to estimate the system of equations via SVAR/VECM framework, which allows for contemporaneous and lagged interconnection between the variables of interest to exist, thus should provide more qualitative estimates. All the series are considered in levels as opposed to growth rates. The advantage of using SVAR/VECM approach is that both enable a researcher to perform innovation accounting (IRF and FEVD), i.e. to numerically assess how one standard deviation shock in the error term of oil price variable will affect a set of endogenous variables included in the model as well as determine what proportion of the forecast error variance of a particular variable is due to oil price shock.

Following the theory, we choose between the following two closely related types of models: SVAR and VECM. Decision criterion is order of integration of the series at hand and the presence of long-run equilibria, which are supposed to be stationary[6]. To decide between the two options available, stationarity properties of the data are examined first. Phillips-Perron (PP) and Augmented Dickey-Fuller (ADF) tests are employed for this purpose. The two are almost identical with the only difference being the approach used to tackle a problem of serial correlation in the residuals: the former test (PP) uses Newey-West standard errors while the latter augments the core equation with lagged values of the dependent variable.

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[6] Stochastic process, which has finite mean and variance (1st and 2nd moments, respectively) is called covariance stationary. Additional condition is the dependence of covariance between two time periods on the distance or lag between those periods and not on the actual time at which the covariance is computed (D. N. Gujarati)

In case the variables are found to be I(0), SVAR model is preferred and estimated. But if the variables turn out to be I(1), we may not directly proceed by estimating SVAR in differences, since there may be a linear combination between the variables, which is stationary. In this case, the variables are referred to as CI(1,1) and the coefficients in front of them constitute cointegrating vector, which in turn determines long-run equilibrium relationship[7]. Cointegrating vector is not unique and in general if there are n variables in the model, integrated of the same order, one may expect to get at most n-1 stationary combinations, which constitute cointegrating rank. If cointegration is detected, it should be incorporated into the model, since its omission entails misspecification error. As Enders (2004) points out: 'a principal feature of cointegrated variables is that their time paths are influenced by the extent of any deviation from long-run equilibrium. After all, if the system is to return to the long-run equilibrium, the movements of at least some of the variables must respond to the magnitude of the disequilibrium'. In other words, system's short-run dynamics is determined, among others, by its steady state, and hence the latter should be incorporated into the model exogenously. We proceed by checking for the existence of cointegration (long-run equilibria) employing Johansen procedure[8] (in particular, $\lambda_{trace}(r) = -T\sum_{r+1}^{n}\ln(1-\hat{\lambda}_i)$ and $\lambda_{\max}(r, r+1) = -T\ln(1-\hat{\lambda}_{r+1})$ statistics are considered) and if successful, i.e. the variable are CI(1,1), further estimate VECM. Otherwise, we convert the CI(1,0) variables into the first differences, which is generally speaking not desirable, and estimate SVAR.

7 Be reminded that for economic theorists and econometricians the meaning of the word 'equilibrium' is different. In particular, the latter group understands it as 'any long-run relationship among nonstationary variables' (Enders, 2004)

8 Engle-Granger approach is burdensome in this case since the number of endogenous variables is larger than two

It is worth of emphasizing that one may obtain VECM representation of the conventional SVAR model using the following transformation (in fact, another name for VECM is 'near VAR'):

$$AY_t = \mu + \sum_i \Gamma_i Y_{t-i} + B\varepsilon_t \text{ (structural VAR)}, \quad (1)$$

$$Y_t = \alpha + \sum_i Z_i Y_{t-i} + Q\varepsilon_t \text{ (reduced form VAR)},$$

For simplicity assume that the number of lags equals three as well as $Q = A^{-1}B = I$:

$$Y_t = \alpha + Z_1 Y_{t-1} + Z_2 Y_{t-2} + Z_3 Y_{t-3} + \varepsilon_t,$$

$$Y_t = \alpha + Z_1 Y_{t-1} + (Z_2 + Z_3) Y_{t-2} - Z_3 \Delta Y_{t-2} + \varepsilon_t,$$

$$\Delta Y_t = \alpha + (Z_1 + Z_2 + Z_3 - I) Y_{t-1} - (Z_2 + Z_3) \Delta Y_{t-1} - Z_3 \Delta Y_{t-2} + \varepsilon_t,$$

$$\Delta Y_t = \alpha + \Pi Y_{t-1} - \Pi_1 \Delta Y_{t-1} - \Pi_2 \Delta Y_{t-2} + \varepsilon_t$$

Generalization of the above result yields the following expression for ΔY_t:

$$\Delta Y_t = \alpha + (\sum_i^n Z_i - I) Y_{t-1} - \sum_i^{n-1} (\sum_{j=i+1}^n Z_j) \Delta Y_{t-i} + \varepsilon_t, \quad (2)$$

where $\Pi = \sum_i^n Z_i - I = \eta\beta^T$, $\Pi_i = \sum_i^{n-1} (\sum_{j=i+1}^n Z_j)$, ($\eta, \beta$ are adjustment and cointegration matrices respectively[9]).

Irrespectively of model type estimated, the order of variables assumed throughout the research is as follows: $Y_t = (oil_t \quad fx_t \quad cpi_t \quad rgdp_t \quad i_t \quad m1_t)^T$. The order of variables is important mainly for innovation accounting. In case of SVAR the matrix of contemporaneous effects is defined in fashion similar to Cologni and Manera (2008) by A^{SVAR} and in case of VECM conventional

[9] Number of long-run equilibria is exactly the rank of matrix Π

Cholesky restrictions, $A^{CHOLETSKY}$, are imposed, i.e. its elements satisfy the following the following condition: $\{a_{ij} = 0\} \in A^{CHOLETSKY} : i < j$.

$$A^{SVAR} = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ . & 1 & 0 & 0 & 0 & 0 \\ . & . & 1 & 0 & 0 & 0 \\ . & . & . & 1 & 0 & 0 \\ . & . & . & . & 1 & 0 \\ 0 & 0 & . & . & . & 1 \end{pmatrix}, \quad A^{CHOLETSKY} = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ . & 1 & 0 & 0 & 0 & 0 \\ . & . & 1 & 0 & 0 & 0 \\ . & . & . & 1 & 0 & 0 \\ . & . & . & . & 1 & 0 \\ . & . & . & . & . & 1 \end{pmatrix}$$

According to the information filed in A^{SVAR}, the variables, which have contemporaneous effect on the demand for money balances $(M1)^d$ are assumed to be interest rate, real GDP and inflation rate; interest rate dynamics is described via real GDP, inflation level, exchange rate and oil price variables; real GDP is dependent upon inflation level, exchange rate and oil price changes; inflation level is influenced by exchange rate and oil price movements; exchange rate is directly influenced by oil price shocks; finally, oil price is considered as contemporaneously exogenous to any other variable in the system. As regards $A^{CHOLETSKY}$, it is used in case of VECM estimation, since due to software limitations we are not able to manually define contemporaneous coefficients' matrix. But in fact, the difference between the two is not that crucial and constitutes only two additional variables added to explain demand for money balances, $(M1)^d=(M1)^s$ in equilibrium. In case of A^{SVAR} we have $(M1)^d$ advocated by Keynes' liquidity preference theory, $M1 = f(i, rgdp, cpi)$, and in case of $A^{CHOLETSKY}$ we have more extended version of the former, $M1 = g(i, rgdp, cpi, fx, oil)$. The logic behind adding extra variables in the demand for money equation is the call to control for foreign influence given that Ukraine is a small, open, highly dollarized economy. Both matrices are theoretically elegant and hence, the difference between the two will not crucially undermine final estimations. Estimation method applied to both SVAR and VECM is OLS, which said to be efficient one. After any model is estimated, a number of tests are performed to check the model adequacy. In particular the following ones are of primary concern: Lagrange-multiplier (LM) test for autocorrelation in the residuals, Jarque-Bera test for normally distributed residuals, in addition for VECM we perform eigenvalues stability test and check if the predicted values of the cointegrated equations, as determined by Johansen procedure, are stationary. Based on these tests' results we either accept or reject the model in favor of its competitor. As soon as appropriate model is determined, we implement innovation accounting and provide its further interpretation within the considered framework.

Finally, asymmetry issue between oil price shock and real GDP response is investigated. Following the study by Mork (1989), oil price variable is divided into two separate ones, which reflect oil price increases and decreases. The two variables are defined as follows: 1) $\Delta oil>0$: $\{\Delta oil\}$ if $\Delta oil>0$, $\{0\}$ otherwise; 2) $\Delta oil<0$: $\{\Delta oil\}$ if $\Delta oil<0$, $\{0\}$ otherwise. Next step is to re-estimate SVAR/VECM model replacing oil price variable with one of the two just defined. By means of impulse-response analysis we further will be able to check if the magnitude of real GDP response to a one standard deviation shock in the error term of $\Delta oil>0$ and $\Delta oil<0$ is asymmetric or not.

Though a little bit involved, alternative approaches in dealing with asymmetry exist and include multivariate threshold model (Huang et al., 2005), Markov-switching VAR (Krolzig, 1997) and logistic smooth transition VAR (Weise, 1999). They all may serve as good robustness checks to the results obtained using Mork's (1989) approach.

DATA DESCRIPTION

The data necessary for practical realization of this research have been mainly obtained from IMF STATISTICS DATABASE[10] and include seasonally adjusted[11] nominal exchange rate (UAH-EUR) and real GDP, monetary aggregate M1, annual lending rate, CPI and average world oil price monthly series, which cover the period 01/1996-12/2006. The period under consideration excludes pre-crisis years (2007-2008) to avoid spurious results. For CPI and real GDP the base year is 1996. Summary statistics as well as contemporaneous correlation matrix are presented below:

Table #1. Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Oil, (USD)	132	30.2	15.5	10.4	72.5
Fx, (UAH/100EUR)		471.2	161.2	194.8	691.8
Cpi, (%)		263.7	90.6	109.4	438.0
Rgdp, (mil. UAH)		7671.6	1963.7	4320.2	17361.2
I, (%)		36.7	21.4	14.3	110.9
M1, (mil. UAH)		36515.3	32383.7	4378.0	123276.0
Δoil>0, (USD)	131	1.1	1.5	0	7.0
Δoil<0, (USD)		-0.8	1.5	-9.8	0

[10] Source of data: http://www.imfstatistics.org/imf

[11] Seasonal adjustment has been performed for Rgdp and Fx series only by means of BV4.1 freeware available at: http://www.destatis.de Refer to Appendix 1 for further clarification and series decomposition results

Table #2. Contemporaneous correlation matrix

Variable	Oil	Fx	Cpi	Rgdp	I	M1
Oil	1	-	-	-	-	-
Fx	0.7096	1	-	-	-	-
Cpi	0.8531	0.9244	1	-	-	-
Rgdp	0.8107	0.6824	0.8161	1	-	-
I	-0.6602	-0.8042	-0.8748	-0.6992	1	-
M1	0.9429	0.7867	0.9154	0.89	-0.758	1

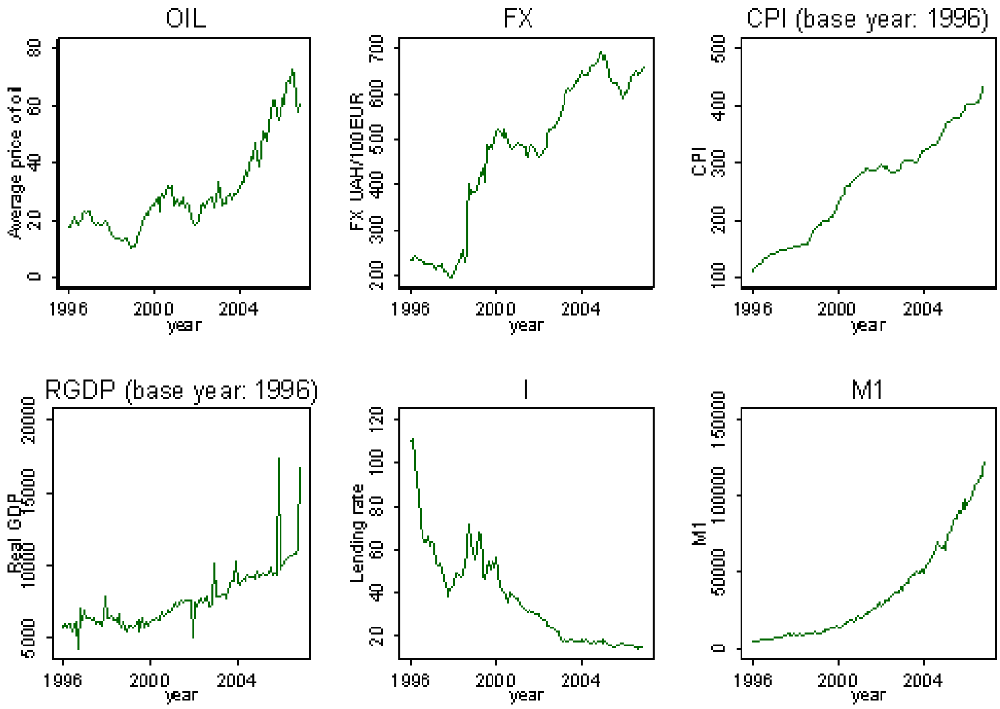


Figure #1. Summary statistics

Visual inspection of Figure #1 suggests that none of the series contains structural breaks. In addition, seasonality is not present either. Hence the data may be readily used for further analysis.

Chapter 5

ESTIMATION RESULTS

Following the algorithm outlined in the methodology section, the first step of the analysis is to check for stationarity properties of the data by means of conventional Phillips-Perron and Augmented Dickey-Fuller unit root tests. Both tests' results are presented in Table #3 and indicate that levels of the series under consideration are I(1), i.e. nonstationary. In addition, one may apply autocorrelation function (ACF) and attest the obtained results using correlogram techniques.

Table #3. Stationarity tests' results

Variable	MacKinnon p-values (H0: unit root exists, α=1%)		
	Phillips-Perron	*Dickey-Fuller*	*Order of integration*
Oil	1.00	1.00	I(1)
Fx	0.78	0.78	I(1)
Cpi	1.00	0.99	I(1)
Rgdp	0.67	0.99	I(1)
I	0.00	0.05	I(1)
M1	1.00	1.00	I(1)
Δoil>0	0.00	0.00	I(0)
Δoil<0	0.00	0.00	I(0)

In case of interest rate series the results of Phillips-Perron and Dickey-Fuller tests are not very convincing, though still in case of the latter we may not reject the null of unit root existence at α (minimum significance level at which we may reject the null hypothesis) being equal to conventional 1%. All the doubts are cast away if one checks for Figure #1. From graphical inspection it is quite obvious that interest rate exhibits unit root.

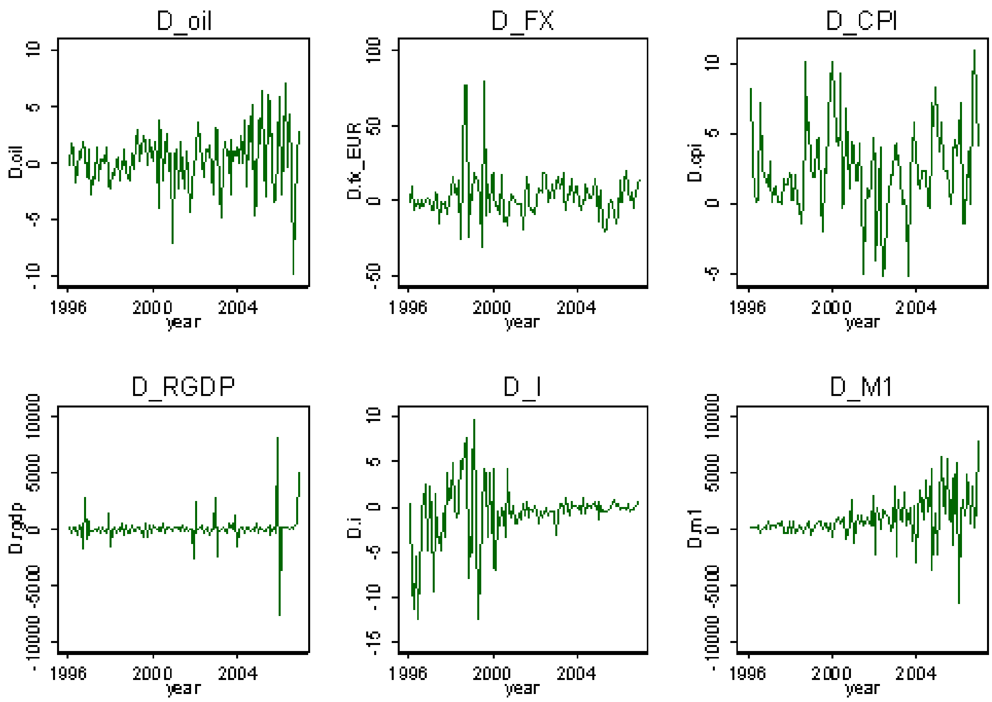


Figure #2. Stationary, I(0), first difference of the variables

The fact that the series we are dealing with are I(1) suggests that one may not directly proceed by estimating SVAR in differences for the reasons already discussed. We check for the existence cointegration (long-run equilibria) between the variables, condition, which must be met for VECM construction. Prior to estimation, we determine potential number of lags to be included in the model. Table #4 reports lag-order selection statistics, of which Akaike's information criterion and LR test are our primary concern. As it often happens, both indicate different lag orders. We consider each possibility, and first follow Akaike's suggestion by including three lags in the VECM. We proceed by estimating VECM with three lags, employing Stata 9.2 software for this purpose.

Table #4. Lag-order selection criteria

Lag	LR	p	AIC	HQIC	SBIC
0			73.88	73.94	74.01
1	2252.10	0	56.85	57.23*	57.78*
2	86.66	0	56.73	57.44	58.47
3	88.00	0	56.61*	57.64	59.15
4	51.53*	0.05	56.77	58.13	60.11

Next, cointegrating rank (rank of matrix Π) is estimated using Johansen methodology. According to the results of trace statistics, we may not reject the null hypothesis that the number of distinct cointegrating vectors is less than or equal to four against the general alternative that it is larger than four. Referring to max statistics next, we find out that at 5% significance level the null hypothesis that the number of distinct cointegrating vectors is equal to three against alternative that it is equal to four can not be rejected. Combining the two tests' results and taking into account that $\lambda_{\max}$ has shaper alternative hypothesis, we conclude that the final number of cointegrated vectors (long-run equilibria) to be included in the VECM with three lags is equal to three, i.e. $rank(\Pi) = 3$. Table #5 presents the results of two Johansen tests discussed above:

Table #5. Johansen tests for cointegration (VECM with three lags)

Max Rank	Eigenvalues	λ_{trace}	α=5%	λ_{max}	α=5%
0	-	171.43	94.15	61.82	39.37
1	0.38	109.61	68.52	43.88	33.46
2	0.29	65.72	47.21	33.12	27.07
3	0.23	32.60	29.68	17.23	20.97
4	0.13	15.37*	15.41	13.95	14.07

After estimation has been carried out, and certain results have been obtained, we implement a series of tests for the purpose of figuring out how adequate our model is. If the model passes all these tests, we conclude that its results may be trusted, further report and discuss them, perform innovation accounting.

First, we run Lagrange-multiplier (LM) test for autocorrelation in the residuals. Table #6 contains the results of this test:

Table #6. LM test for autocorrelation (VECM with three lags)

Lag	chi2	df	Prob>chi2
1	50.89	36	0.05
2	62.61	36	0.0039
H0: no autocorrelation at lag order			

Low p-values (Prob>chi2) indicate that we may reject the null at conventional significance levels (α=5%, 10%). Rough inference is that autocorrelation is present and is of the second order. This is indicative of inefficient estimates of coefficients (minimum variance property does not hold any longer) and distorts hypothesis testing procedure through wider confidence intervals. Next, we employ Jarque-Berra test to check if the residuals in the VECM are normally distributed. Normality property is also needed for valid inference when performing hypotheses testing. Table #7 contains the results of this test:

Table #7. Jarque-Bera test for normality (VECM with three lags)

Equation	chi2	df	Prob>chi2
D_oil	18.93	2	0
D_fx	517.43	2	0
D_cpi	3.11	2	0.21
D_rgdp	1261.89	2	0
D_i	56.52	2	0
D_m1	35.79	2	0
ALL	1893.68	12	0
H0: residuals are normally distributed			

Judging by low p-values we may reject the null hypothesis of normality in every equation except for D_cpi at conventional significance levels (α=5%, 10%). These results tell us that hypotheses testing procedure should be implemented with caution and may produce wrong inference. Moreover, according to the theory, if the above two tests (LM, JB) fail, which is exactly our case, it is a vivid indicator of insufficient number of lags included in the model. The focal point of our critique of VECM with three lags relies on the fact that cointegrating terms, which augment every equation, are supposed to be stationary. This is how steady state between the variables is defined in theory. Again, stationarity may be formally checked by means of the tests employed in the beginning of this section (ADF, PP, ACF), but from graphical representation it is already a clear-cut issue that all the cointegrating equations exhibit unit root process, i.e. I(1). Refer to Figure #3 and Table #8.

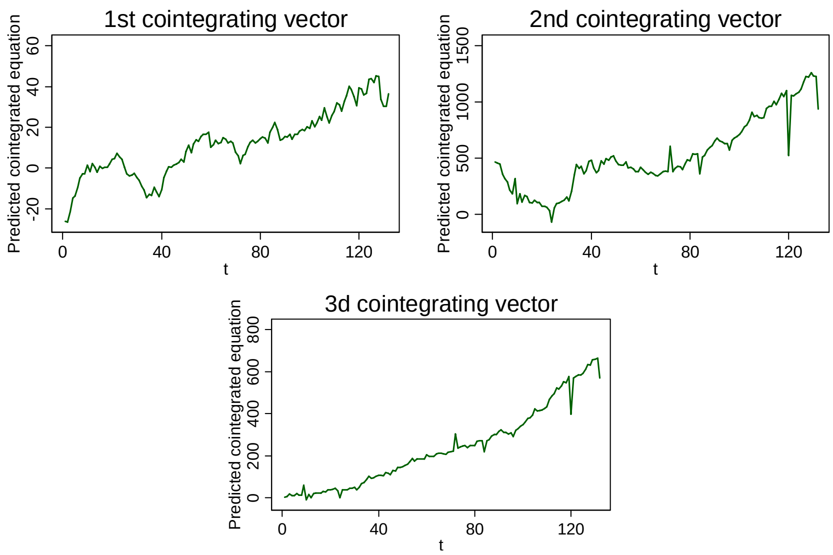


Figure #3. Cointegrating equations (VECM with three lags)

Table #8. Stationarity test results

Variable	**MacKinnon p-values**
	Phillips-Perron
Ce_1	0.34
Ce_2	0.78
Ce_3	0.97
(H0: unit root exists, α=1%)	

Intermediate conclusion is that VECM with three lags is inappropriate for further analysis (IRF), hence its results are not reported hereafter. Model's major flaw is nonstationarity of cointegrating equations, which contradicts the theory and may not be accepted.

We proceed by adding two more lags in the model and perform the same sequence of operations as above in order to first establish models adequacy and then compare the results between the two. This time, according to trace and max statistics, number of cointegrating vectors equals two. Table #9 reports both Johansen tests' results.

Table #9. Johansen tests for cointegration (VECM with four lags)

Max Rank	Eigenvalues	λ_{trace}	α=5%	λ_{max}	α=5%
0	-	138.06	94.15	56.99	39.37
1	0.36	81.06	68.52	29.97	33.46
2	0.21	51.10	47.21	23.28	27.07
3	0.17	27.81*	29.68	18.07	20.97

Next, we check for autocorrelation in the residuals by means of LM test and for residuals' normality via Jarque-Bera test. The results are reported in Tables #10 and #11 respectively. Finally, we save predicted values of the two cointegrating equations, which augment the model, and check if they are stationary. We complete VECM with four lags adequacy analysis by checking if the eigenvalues stability conditions are satisfied.

Table #10. LM test for autocorrelation (VECM with four lags)

Lag	chi2	df	Prob>chi2
1	44.89	36	0.5
2	53.48	36	0.02
H0: no autocorrelation at lag order			

From Table #10 it is clear that at 10% significance level we may not reject the null hypothesis of no autocorrelation in the residuals at the first lag order. But, say, at 1% significance level we also may not reject the null at the second lag order. It is clear that increase in the number of lags reduces the severity of autocorrelation problem, though this conclusion is subject to the benchmark values of significance level one relies on.

Table #11. Jarque-Bera test for normality (VECM with four lags)

Equation	chi2	df	Prob>chi2
D_oil	11.24	2	0.00
D_fx	382.14	2	0.00
D_cpi	3.20	2	0.20
D_rgdp	801.61	2	0.00
D_i	70.34	2	0.00
D_m1	39.62	2	0.00
ALL	1308.17	12	0.00
H0: residuals are normally distributed			

According to Table #11 we observe that increase in the number of lags does not solve the problem of residuals' normality. Nevertheless this is the property of the data and in principle, given limited number of observations (132-4=128), we are not able to do much to improve upon this defect. Finally, from Figure #4 and Table #12, which reports the results of Phillips-Perron unit root test, we conclude that cointegrating terms obtained from the estimated VECM with four lags are stationary, exactly as predicted by the theory. This is crucial, since now we are able to undertake further steps of the analysis, namely innovation accounting. As regards failed Jarque-Bera test, it should be mentioned that this is a common phenomenon, which will not crucially distort final results. The fact that we have managed to reduce the severity of autocorrelation in the residuals and obtained two stationary equilibria is more important.

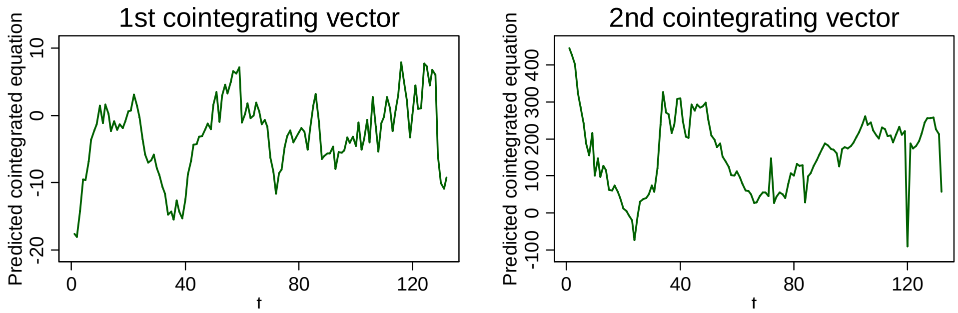


Figure #4. Cointegrating equations (VECM with four lags)

Table #12. Stationarity test results

Variable	**MacKinnon p-values**
	Phillips-Perron
Ce_1	0.00
Ce_2	0.00
(H0: unit root exists, α=1%)	

In addition, we check if the model satisfies eigenvalue stability/cointegration conditions.

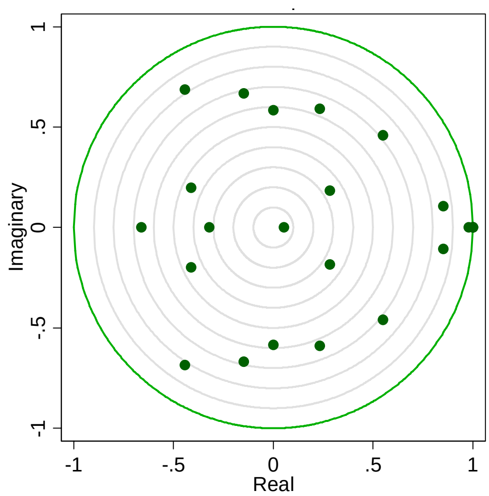


Figure #5. Eigenvalues stability circle

As may be inferred from the figure above, some of the eigenvalues are inside the unit circle, some are equal to one. This composition is exactly the one necessary for cointegration between the variables to exist. As a benchmark, remember that in case of two-variable model with one lag, $\Delta Y_t = \alpha + (Z_1 - I)Y_{t-1} + \varepsilon_t$, stability conditions imposed on eigenvalues of matrix Z_1 are such that one eigenvalue is equal to one, another is always smaller than one in absolute terms. The result reported in Figure #5 is exactly generalization of this condition to the six-variable model with four lags. Estimation results of VECM with four lags and two cointegrating vectors are reported in Table #13.

Table #13. VECM estimation results

Element		**Equation (# of observations 128)**					
		D_oil	D_fx	D_cpi	D_rgdp	D_i	D_m1
L_Ce	Ce1	-0.14*	-0.82*	0.14**	19.75	0.01	59.87+
		(0.014)	(0.024)	(0.010)	(0.394)	(0.912)	(0.098)
	Ce2	0	0.03	0.02**	3.51*	0	4.1+
		(0.801)	(0.197)	(0.000)	(0.023)	(0.391)	(0.090)
Oil	LD	0.19+	0.93	-0.19+	-67.43+	-0.01	-2.77
		(0.061)	(0.155)	(0.054)	(0.10)	(0.943)	(0.966)
	L2D	-0.06	-0.11	-0.27**	-99.17*	-0.04	-128.59*
		(0.514)	(0.866)	(0.005)	(0.013)	(0.761)	(0.040)
	L3D	0.09	-0.05	-0.06	-109.68**	-0.06	-57.88
		(0.383)	(0.944)	(0.57)	(0.009)	(0.652)	(0.377)
Fx	LD	-0.01	0	0	-6.19	0.02	7.54
		(0.626)	(0.969)	(0.972)	(0.367)	(0.435)	(0.482)
	L2D	-0.04*	-0.12	-0.02	-9.85	-0.05*	8.02
		(0.019)	(0.238)	(0.163)	(0.143)	(0.022)	(0.445)
	L3D	0.01	-0.07	0	-8.5	0.02	-9.41
		(0.733)	(0.51)	(0.774)	(0.205)	(0.382)	(0.369)
Cpi	LD	-0.02	-0.44	0.39**	-38	-0.06	-187.35**
		(0.812)	(0.498)	(0.000)	(0.358)	(0.642)	(0.00)
	L2D	0.07	-0.53	-0.23*	54.79	-0.05	119.39+
		(0.535)	(0.437)	(0.030)	(0.209)	(0.733)	(0.079)
	L3D	0.03	0.18	0.02	-73.21+	0.09	90.77
		(0.77)	(0.769)	(0.848)	(0.069)	(0.48)	(0.149)
P-values in parentheses (** significant at 1%; * significant at 5%; + significant at 10%)							

Table #13 (cont)

Element		Equation (# of observations 128)					
		D_oil	D_fx	D_cpi	D_rgdp	D_i	D_m1
Rgdp	LD	0	0	0**	-0.74**	0	-0.49**
		(0.504)	(0.259)	(0.002)	(0.000)	(0.21)	(0.004)
	L2D	0	0	0**	-0.39**	0	-0.52**
		(0.45)	(0.491)	(0.000)	(0.002)	(0.474)	(0.008)
	L3D	0	0	0*	-0.29**	0	-0.43*
		(0.743)	(0.717)	(0.037)	(0.009)	(0.73)	(0.013)
I	LD	0.08	0.71	0.05	13.42	0.29**	39.33
		(0.289)	(0.147)	(0.525)	(0.668)	(0.002)	(0.421)
	L2D	0.01	0.75	0.14+	-0.02	0.04	14.93
		(0.919)	(0.13)	(0.058)	(1)	(0.644)	(0.762)
	L3D	-0.07	-0.24	0.02	46.05	-0.06	44.18
		(0.35)	(0.611)	(0.754)	(0.128)	(0.531)	(0.349)
M1	LD	0*	0	0	0.1	0	0.04
		(0.010)	(0.276)	(0.335)	(0.107)	(0.363)	(0.697)
	L2D	0	0	0*	-0.15*	0	0.02
		(0.486)	(0.573)	(0.018)	(0.017)	(0.421)	(0.814)
	L3D	0	0	0	0.1+	0	0.57**
		(0.298)	(0.756)	(0.51)	(0.097)	(0.87)	(0.00)
P-values in parentheses (** significant at 1%; * significant at 5%; + significant at 10%)							

The obtained estimates are not quite informative since all the variables are measured in different units as well as the system is presented in a reduced form. Our next step will be to perform innovation accounting. We mainly focus on IRF in order to quantify the impact of a one standard deviation shock in the error term of oil price variable (~2.2) on the main macroeconomic variables included in the model. In what follows IRFs are reported in graphic and table formats.

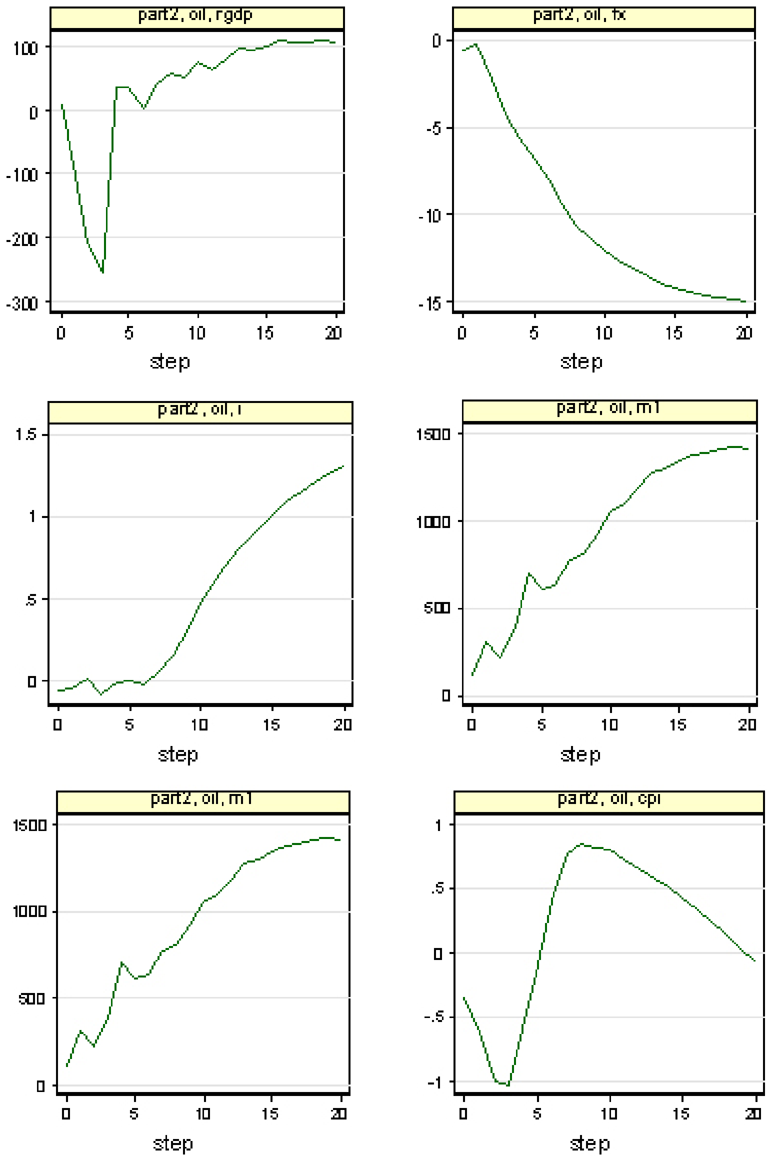


Figure #6. IRF: impulse (oil)

Table #14. IRF: impulse (oil)

Step	Rgdp (mil. UAH)	Fx (UAH/100EUR)	Cpi (%)	I (%)	M1 (mil. UAH)	Oil (USD)
0	9.49	-0.56	-0.35	-0.05	115.63	2.40
1	-86.04	-0.27	-0.62	-0.05	309.65	2.59
2	-206.76	-2.25	-1.01	0.01	224.30	2.17
3	-254.06	-4.20	-1.03	-0.09	387.74	1.89

Table #14 (cont)

Step	Rgdp (mil. UAH)	Fx (UAH/100EUR)	Cpi (%)	I (%)	M1 (mil. UAH)	Oil (USD)
4	35.61	-5.59	-0.59	-0.01	702.54	1.69
5	35.47	-6.82	-0.09	-0.01	612.91	1.64
6	1.45	-7.94	0.41	-0.03	635.24	1.48
7	42.30	-9.34	0.77	0.06	773.39	1.34
8	56.86	-10.63	0.85	0.15	806.19	1.35
9	52.49	-11.44	0.83	0.30	920.68	1.34
10	74.11	-12.05	0.80	0.47	1054.28	1.32
11	63.86	-12.6	0.73	0.61	1096.74	1.31
12	78.05	-13.1	0.65	0.72	1100.75	1.24

As may be inferred from the above output one standard deviation shock (~2.2 USD) in the error term of oil price variable in period zero results in more than proportionate contemporaneous increase in oil price level from its mean value by 2.4 USD. After one month increase is even more severe and constitutes 2.6 USD. In the subsequent periods we observe decaying tendency with increase in oil price level approaching 1 USD in the long run (roughly, when the number of periods is larger than twenty). Accumulated effect over the 12 months period is obtained by summing up the coefficients of the impulse response functions indicated in Table #14 and constitutes 21.76 USD. Turning to real GDP series, we observe positive contemporaneous response in the magnitude of 9.5 mil. UAH to a one standard deviation oil price shock. Given that during the considered decade average change in real GDP between the two consecutive months constituted 84.5 mil. UAH, the observed increase is minute and in fact it only reflects forthcoming negative impact of increasing oil price on real economic activity. Already after one month when the cumulative increase in oil price variable reaches 5 USD, real GDP decreases by -86 mil. UAH from its mean value. In two months the decrease is even more severe and constitutes -207 mil. UAH given the cumulative oil price increase reaches the level of 7.15 USD. The peak of real GDP fall, -254 mil. UAH, is reached after three months when cumulative oil price increase tops the level of 9 USD. All this suggests that the effect of oil price shock on real economic activity in Ukraine is lagged in nature, with lag length being equal to one month. Three months after shock, cumulative fall in real GDP constitutes -537.4 mil. UAH. In the subsequent periods, stabilization phase prevails and is characterized by gradual increase of real GDP. Economy fully retrieves the fall in output caused by negative oil price shock approximately in a year and a half since its initiation.

Next we analyze, how Ukrainian government, in particular its monetary unit, responds to a fall in real economic activity caused by increasing price of oil. In particular, such variables as monetary aggregate M1, interest rate and nominal foreign exchange rate are analyzed. These are the instruments (control variables as it was mentioned in the Introduction) available to Ukrainian government to manage evolving economic processes. The analysis reveals that one standard deviation shock in the price of oil results in contemporaneous increase in M1 by 116 mil. UAH. The effect is still increasing thereafter, though its speed is less pronounced after the fifth month. Stabilization phase is observed fifteen months after the shock with convergence limit being equal to 1100 mil. UAH. This is roughly the mean change of M1 (907 mil. UAH) between the two successive months observed in the data. Interest rate reaction is quite predictable, since increase in M1 leads to interest rate decline. This is exactly what we observe on the graph. Over half a year period cumulative interest rate decreases by -0.23%. The remaining time span is characterized by gradual increase, which prevails until the upper limit of 1.5% is reached.

The explanation behind the observed patterns of M1 and interest rate behavior is that government pumps additional liquidity in the economy to stimulate aggregate demand, which is supposed to make decline in real GDP less severe. I.e. the government's primary concern is to retain output level, which prevailed prior to oil shock occurrence, and to recover economic activity at cost of higher inflation in the long run. The explanation may be easily visualized within AS-AD framework. Refer to Figure #7 for details.

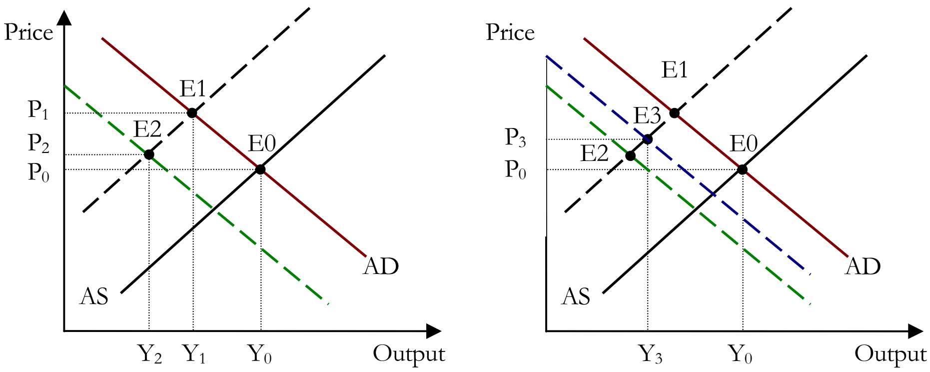


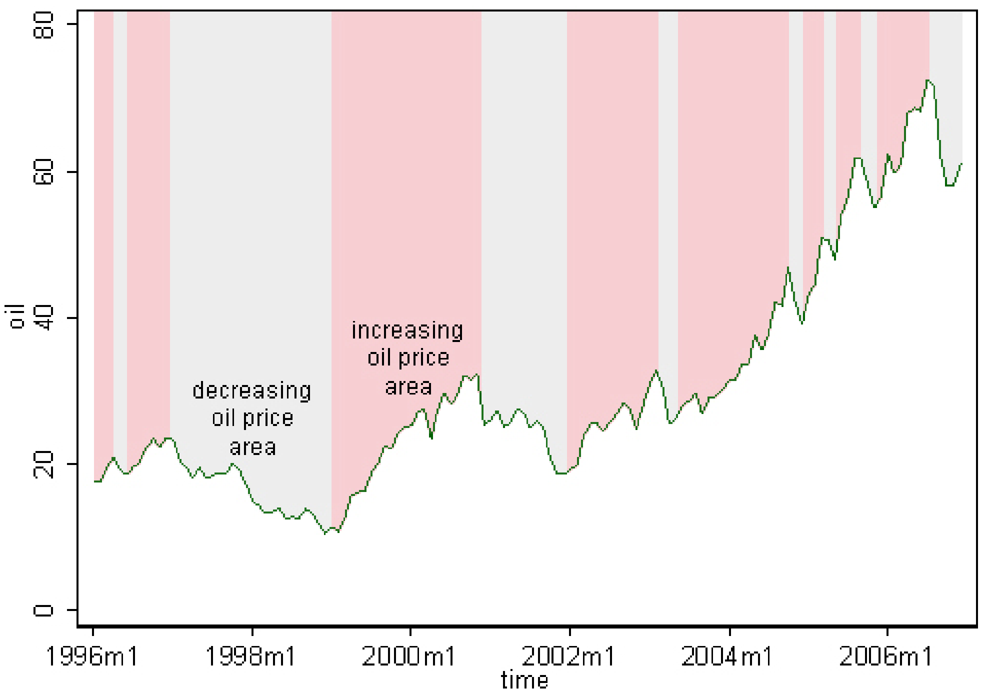
Figure #7. Effect of oil price shock: AS-AD framework

Economy starts in equilibrium at point E0 (Y_0, P_0). When oil price shock strikes, economy moves to point E1 (Y_1, P_1): Y_1-Y_0=Δ_{Y1}<0, P_1-P_0=Δ_{P1}>0, i.e. AS curve shifts upward and to the left along AD curve. This shift is exactly the realization of cost effect, which is a part of oil transmission mechanism. The magnitude of a shift depends on price elasticity of AD curve: the more elastic the curve is, the lower is the change in aggregate price level caused by reduced output. Next, demand effect discussed in the literature review section comes at play and AD curve shifts downward and to the left, bringing economy to point E2 (Y_2, P_2): Y_2-Y_0=Δ_{Y2}<0, P_2-P_0=Δ_{P2}>0 or P_2-P_0=Δ_{P2}<0. The fact that Δ_{P2} can be either positive or negative is not surprising and depends on the magnitude of a shift. This may be easily seen from the above graphs. Not going deep into details according to Peersman and Robays (2009) the following factors are responsible for the magnitude of a downward AD shift: inelastic oil demand from consumers' side, precautionary savings motive and effect of uncertainty (postponement of irreversible energy associated investments and purchases). Next, government takes an action and stimulates aggregate demand through an increase in M1 and decrease in the interest rate. AD curve shifts upward and to the right. Economy moves to point E3 (Y_3, P_3): Y_3-Y_0=Δ_{Y3}<0, P_3-P_0=Δ_{P3}>0, ending up with less severe drop in output level (Δ_{Y3}>Δ_{Y2}) but higher inflation (Δ_{P3}>Δ_{P2}).

From the above discussion it is clear that downward demand effect may bring economy to point E2 (Y_2, P_2): Y_2-Y_0=Δ_{Y2}<0, P_2-P_0=Δ_{P2}<0, i.e. both output level and inflation will decrease. This is exactly what we observe with our data. From Figure #6 it may be seen that one standard deviation shock in oil price variable results in a cumulative decrease of inflation being equal to -3.7% during the first six months that follow (point E2: Δ_{Y2}<0, Δ_{P2}<0 is reached). Starting the sixth month persistent increase in inflation, which lasts for the remaining half a year, is observed (point E3: Δ_{Y3}>Δ_{Y2}, Δ_{P3}>Δ_{P2} is reached). More formal way to check for the validity of AS-AD analysis discussed above is to explicitly assume that point E2: Δ_{Y2}<0, Δ_{P2}<0 is reached in six months and point E3: Δ_{Y3}>Δ_{Y2}, Δ_{P3}>Δ_{P2} is reached in twelve months after oil price shock hits the economy, i.e. it takes the economy about a year to fully complete the path presented in Figure #7: E0 -> E1 -> E2 -> E3. Simple calculations using the data from Table # 14 reveal that Δ_{Y2}= -466<0, Δ_{P2}= -3.7<0, Δ_{Y3}= -100>Δ_{Y2}, Δ_{P3}= 1.33>Δ_{P2}. Therefore all the necessary conditions for downward demand effect to exist are satisfied and the above discussion is valid.

In addition, we briefly comment on nominal foreign exchange rate response to a one standard deviation shock in oil price. As one may infer from IRF analysis, UAH appreciates against foreign currency, EUR. Though the degree of appreciation is not large during the first three months following the shock, it is increasing in the subsequent periods. Given managed floating exchange rate regime pursued by NBU, UAH appreciation may reflect regulator's interventions in the interbank foreign exchange market, in particular increased supply of foreign currency. This is done for the purpose to curb possible inflation and maintain stable value of the currency.

Finally, we turn to investigate if the asymmetry effect between oil price changes and real GDP response is present in the data. As it was described in the methodology section, approach proposed by Mork (1989) is employed for this purpose. Figure #7 presents the graphical realization of oil price movements for the considered decade with particular emphasis given to oil price increases (pink hue) and decreases (grey hue). Figure #8, in turn, presents decomposition of oil price variable into two separate ones, which are used for further analysis.



Source: Author's calculations

Figure #8. Oil price dynamics

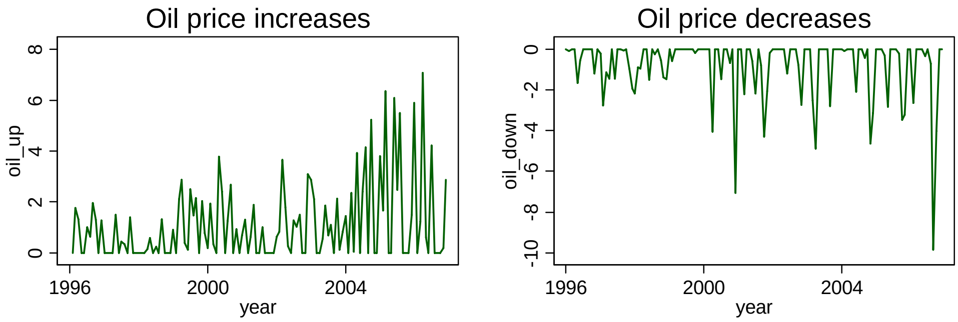


Figure #9. Decomposed oil price series

From the above two graphs it is already obvious that the series are covariance stationary. Nevertheless, the formal inspection is performed and its results are reported in Table #3.

The fact of oil price increases (Δoil>0) and decreases (Δoil<0) stationarity suggests that we can not simply replace oil price variable (oil) with one of the two (Δoil> or Δoil<0) and re-estimate VECM for further asymmetry effect investigation. To overcome this obstacle, we construct SVAR in differences and exogenously augment it with predicted values of the two error correction terms obtained from the previous VECM estimation (see Table #13). Similarly, SVAR in differences contains three lags[12] (this is also the result suggested by Akaike's information criterion, which we do not report here). In principle, the approach used has its advantages in that it allows the possibility to control for outliers by means of incorporating into the model a set of dummy variables, the option, which was not available for VECM due to software limitations. An outlier is defined as a particular observation, such that the magnitude of the difference between its current and lagged values exceeds the magnitude of the mean change by two standard deviations. Notwithstanding, some disadvantages are also present. For example while performing IRF we will only have a chance to estimate how one standard deviation shock in the error term of Δoil>0 (Δoil<0) variable affects the behavior of Δrgdp. This limitation restricts us from estimating dynamics of oil price increases and real GDP directly. Since our goal is to check for the existence of asymmetry only, we accept this shortcoming. Finally, we focus on short time span (~ 4-5 months after oil price shock) and say that asymmetry is present if the absolute value of cumulative change in Δrgdp in case of Δoil>0 is statistically different from the case of Δoil<0.

To clear the issue, the following type of a model is estimated:

$$A^{CHOLETSKY} Y_t = \sum_{i}^{n=3} \Gamma_i Y_{t-i} + ce\_1 + ce\_2 + dummy + \varepsilon_t \,, \qquad (3)$$

$$Y_t = \left(\Delta oil > 0 \;\; [\Delta oil < 0] \quad \Delta fx \quad \Delta cpi \quad \Delta rgdp \quad \Delta i \quad \Delta m1\right)^T$$

For simplicity we define the matrix of contemporaneous effects as $A^{CHOLETSKY}$. As it was already discussed this matrix is needed for innovation accounting, namely IRF.

Appendix B contains estimation results of the reduced form VAR in differences with oil price variable being replaced by oil price increases (Δoil>0). The same model, but for oil price decreases (Δoil<0) is reported in Appendix C. The results of impulse-response analysis may be found below and are provided in Figure #10 and Table #15.

[12] To clarify the issue, number of lags to be included into the conventional VAR is equal to four, hence, similar to VECM, VAR in differences absorbs one lag

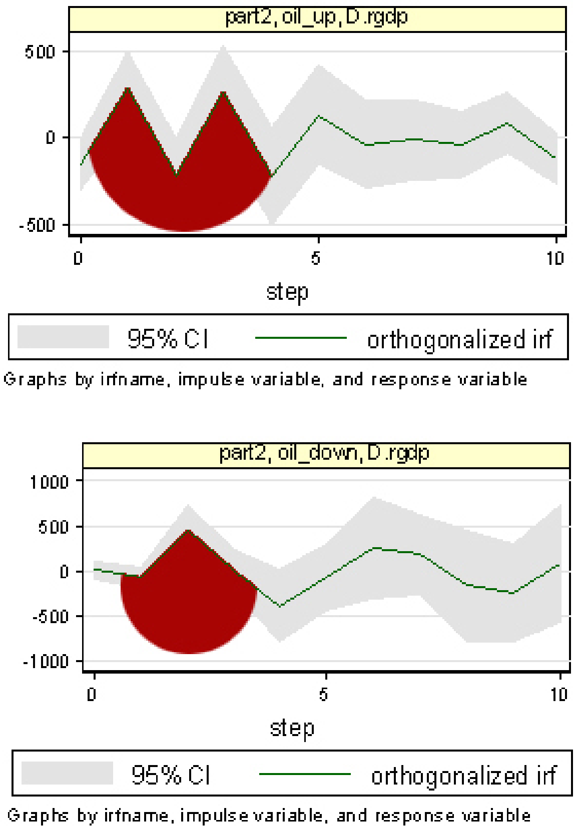


Figure #10. IRF: impulse(Δoil>0, Δoil<0), response (Δrgdp)

Table #15. IRF: response (Δrgdp)

Step	Impulse	
	Δoil>0	Δoil<0
0	-145.61	-35.81
1	287.16	-79.10
2	-213.50	376.51
3	268.20	-46.83
4	-220.01	-195.22
Σ	-23.76	19.55

From the above two graphs we may infer that response of the change in real GDP (Δrgdp) between two consecutive periods to one standard deviation shock in the error term of oil price increases (Δoil>0) is approximately the same as the one to the shock in oil price decreases ($\Delta oil<0$). Five months after shock occurrence cumulative change in $\Delta rgdp$ constitutes -23.76 in case of $\Delta oil>0$ and 19.55 in case of $\Delta oil<0$. The difference between the absolute values of the two constitutes 4.21, which is not statistically different from zero. We conclude that effect of oil price increases and decreases on real GDP is symmetric. Hence one may expect lower oil price to stimulate Ukrainian economy in the short run. Given that Ukraine is a transition country with technologically outdated industrial sector, which is marginally effective even in relatively 'favorable economic times' as characterized by cheap raw materials and energy, the obtained result is not surprising.

C h a p t e r 6

CONCLUSION

Completion of the above analysis gives us the possibility to answer a number of questions, which may be highly relevant for policy makers. In particular, we have found out that during the considered decade (01/1996-12/2006) abrupt increase in the price of oil has no negative contemporaneous effect on real GDP. In fact GDP is still growing, but this growth is moderate if compared to average monthly growth observed in the data. Negative effect comes at play starting one month after the shock initiation with the peak of real GDP decline (-254 mil. UAH.) being reached in three months that follow, when cumulative oil price increase tops the level of 9 USD. Over four months period cumulative decrease in real GDP constitutes about -537 mil. UAH. Our results are not easily comparable with conclusion reached by Myronovych (2002), since the latter treats all the series in growth rates. But we both agree upon the effect of oil price increase on real GDP being lagged in nature. Myronovych reports lag length being equal to one quarter, as opposed to our result, which is one month. The fact that we observe decline in real economic activity caused by increase in oil price suggests that during the considered period mostly oil supply shocks prevailed.

Given the observed dynamics of variables, we conclude that transmission of oil price increase to real economy occurs mainly through cost and downward demand effects. Both are part of indirect effect discussed in the literature review section. We employ AS-AD framework for explanation of the processes taking place in the economy and manage to numerically prove the validity of both effects using the data obtained from IRF analysis. In particular, demand effect is characterized by the following short-run (~ 4-5 months after oil price shock initiation) symptoms: lower inflation level, higher drop in real GDP if compared to the long run (~ 12 months) mainly due to independent reduction in aggregate demand, which takes place after the cost effect is accomplished, more rapid increase in monetary aggregate M1, caused by decreasing interest rate. In turn, long run is described by higher and persistently increasing inflation level, gradual recovery of real GDP, which makes the cumulative GDP decline less pronounced compared to the short run, less rapid increase in M1 and increase in the interest rate. In general, economy suffers more in the short run, i.e. the long run is less disastrous for the economy. This conclusion is fully supported by the results of IRF analysis. Given decrease in the interest rate and rapid increase in monetary aggregate M1 in the short run, we conclude that government pumps extra liquidity in the economy to stimulate aggregate demand. This is the explanation why in the long run economy ends up with higher inflation and less severe drop in real GDP. Hence, Ukrainian government is the one of Keynesian type and it chooses to maintain output level at cost of higher inflation.

It is worth of emphasizing that we fail to empirically observe direct effect, which theoretically should have forerun both cost and downward demand effects, and resulted in increased inflation and decreased output in the short run. Neither have we observed cyclical second round inflationary effect.

Finally, we find that asymmetry effect as pioneered by Mork (1989) is not present in the data. Real GDP reacts symmetrically to oil price fluctuations in the short run.

BIBLIOGRAPHY

Aliyu, S.U.R. 2009. Oil price shocks and the macroeconomy of Nigeria: a non-linear approach. *Munich Personal RePEc Archive.*

Andrews, D. 1993. Optimal tests when a nuisance parameter is present only under the alternative. *Econometrica* 61: 821-856.

Bacon, R., M., Kojima. 2008. Vulnerability to oil price increases. A decomposition analysis of 161 countries. *World Bank Extractive Industries and Development Series #1*.

Bai, J., Perron, P. 1998. Estimating and testing linear models with multiple structural changes. *Econometrica* 66: 47-48.

Bernanke, B.S. 1983. Irreversibility, uncertainty, and cyclical investment. Querterly Journal of Economics 98: 85-106.

Chen, S.-S., H.-C., Chen. 2007. Oil prices and real exchange rates. *Energy Economics Journal* 29: 390-404.

Chen, S-S. 2009. Oil price pass-through into inflation. *Energy Economics Journal* 31: 126-133.

Clarida, R., J., Gali. 1994. Soruces of real exchange-rate fluctuations: how important are nominal shocks? *Carnegie-Rochester Conference Series on Public Policy* 41: 1-56.

Cologni, A., M., Manera. 2008. Oil prices, inflation and interest rates in a structural cointegrated VAR model for the G-7 countries. *Energy Economics Journal* 30: 856-888.

Elder, J. 2004. Another perspective on the effects of inflation volatility. *Journal of Money, Credit, and Banking* 36: 911-928.

Elder, J., A., Serletis. 2009. Oil price uncertainty in Canada. *Energy Economics Journal* 31: 852-856.

Hamilton, J.D. 1999. A parametric approach to flexible nonlinear inference. *University of California at San Diego, Economics Working Paper Series, Department of Economics, UC San Diego.*

Hamilton, J.D. 2003. What is an oil shock? *Journal of Econometrics* 113: 363-398.

Hamilton, J.D. 1999. A parametric approach to flexible nonlinear inference. *Department of Economics, University of California, San Diego.*

Hamilton, J.D. 1996. This is what happened to the oil price-macroeconomy relationship. *Journal of Monetary Economics* 38: 215-220.

Hamilton, J.D. 1983. Oil and the macroeconomy since World War II. *Journal of Political Economy* 91: 228–248.

Harris, R.I.D. 1995. Using cointegration analysis in econometric modeling. *Hertfordshire, Prentice Hall, United Kingdom.*

Hendry, D.F. 1995. Dynamic Econometrics. *Oxford University Press, Oxford (United Kingdom).*

Hirsh, M. 2009. The end of oil. *The NY Times.*

Huang, Bwo-Hung, M.J., Hwang, Hsiao-Ping, Peng. 2005. The asymmetry of the impact of oil price shocks on economic activities: An application of the multivariate threshold model. *Energy Economics Journal* 27: 455-476.

Korhonen, I., A., Mehrotra. 2009. Real exchange rate, output and oil: Case of four large energy producers. *BOFIT.*

Krolzig, H.-M. 1997. Markov-Switching Vector Autoregressions. Modelling, Statistical Inference and Application to Business Cycle Analysis. *Springer Verlag, Berlin.*

Lardic, S., M., Valerie. 2008. Oil prices and economic activity: An asymmetric cointegration approach. *Energy Economics Journal* 30: 847-855.

Larsson, R., J., Lyhagen, M., Lothgren. 2001. Likelihood-based cointegration tests in heterogeneous panels. *Econometrics Journal* 41: 109–142.

Lee, K., S., Ni, R.A., Ratti. 1995. Oil shocks and the macroeconomy: the role of price volatility. *Energy Journal* 16: 39–56.

Majd, S., R., Pindyck. 1987. Time to build, option value, and investment decisions. *Journal of Financial Economics* 18: 7-27.

Mork, K.A. 1989. Oil shocks and the macroeconomy when prices go up and down: an extension of Hamilton's results. *Journal of Political Economy* 97: 740–744.

Mork, K.A., Oslen, O. and Mysen, H. 1994. Macroeconomic responses to oil price increases and decreases in seven OECD countries. *Energy Economics Journal* 15: 19-35.

Myronovych, A. 2002. The impact of oil price shocks on Ukrainian economy. *MA Thesis, KSE.*

Pedroni, P. 2004. Panel cointegration: asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis. *Econometric Theory* 20: 597–625.

Rautava, J. 2004. The role of oil prices and the real exchange rate in Russia's economy – a cointegration approach. *Journal of Comparative Economics* 32: 315-327.

Sadorsky, P., 1999. Oil price shocks and stock market activity. *Energy Economics Journal* 21: 449-469.

Schorderet, Y. 2004. Asymmetric cointegration. *Working paper, Department of Econometrics, University of Geneva.*

Tatom, J. 1988. Are the macroeconomic effects of oil price changes symmetric? *Carnegie −Rochester Conference Series on Public Policy* 28: 325–368.

Teräsvirta, T. 2004. Smooth Transition Regression Modeling. *In Lütkepohl, Applied Time Series Econometrics, Cambridge: Cambridge University Press.*

Tsay, R.S. 1998. Testing and modeling multivariate threshold models. *Journal of the American Statistical Association* 93: 1188-1202.

Weise, C.L. 1999. The asymmetric effects of monetary policy: a nonlinear vector autoregression approach. *Journal of Money, Credit, and Banking* 31: 85-108.

Zhang, D. 2008. Oil shock and economic growth in Japan: A nonlinear approach. *Energy Economics Journal* 30: 2374-2390.

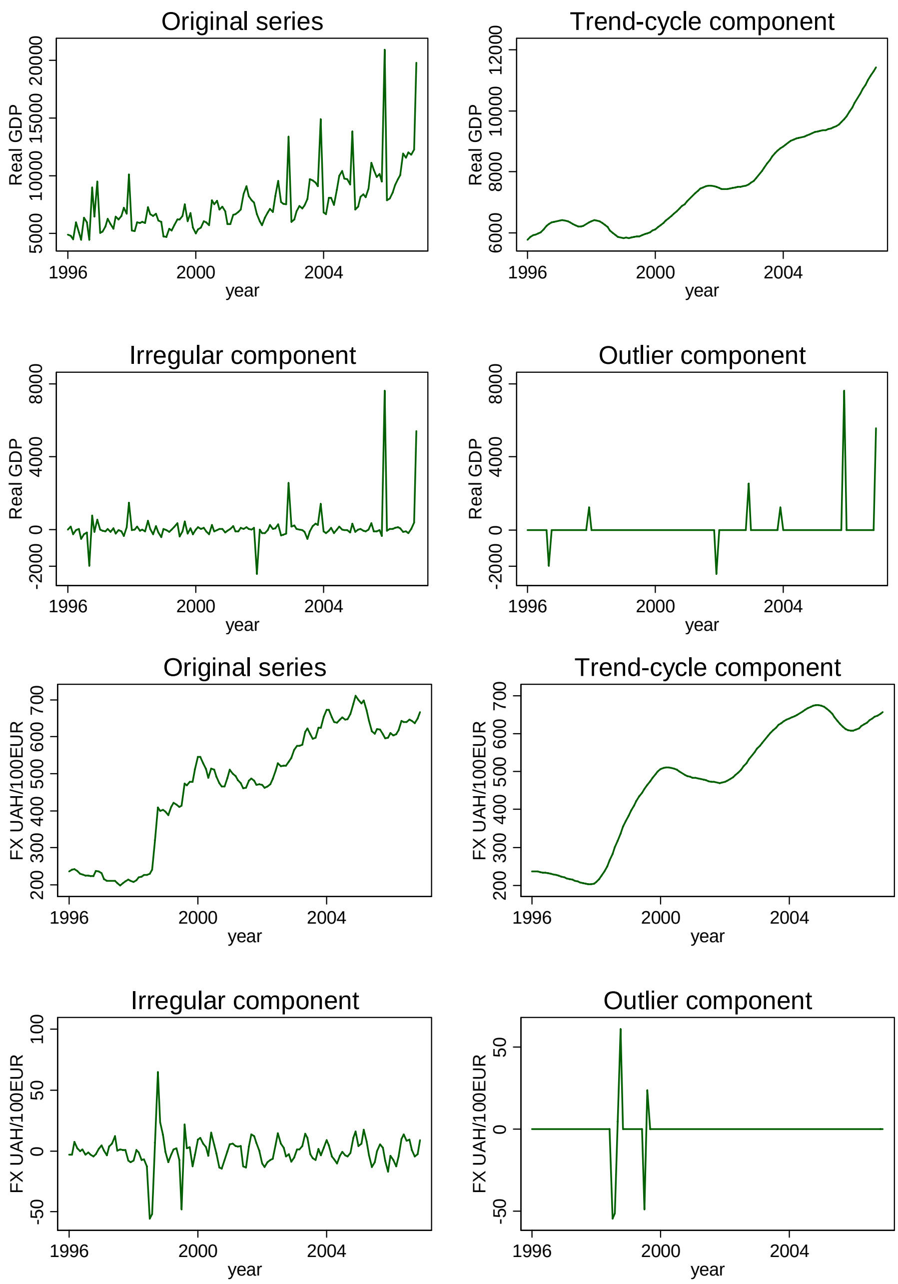


Figure #11. Time series decomposition: Rgdp, Fx

APPENDIX B: REDUCED FORM VAR. CASE OF ΔOIL>0

Table #16. Reduced form VAR. Case of Δoil>0

Element		Equation (# of observations 75)					
		Δoil>0	D_fx	D_cpi	D_rgdp	D_i	D_m1
Δoil>0	LD	-0.01	0.65	-0.19	107.8	-0.42	208.7
		(0.905)	(0.514)	(0.346)	(0.161)	(0.118)	(0.176)
	L2D	0.4**	0.22	-0.72**	15.22	-0.02	-5.78
		(0.00)	(0.83)	(0.001)	(0.848)	(0.934)	(0.971)
	L3D	0.4**	-1.84+	-0.14	75.43	-0.2	185.5
		(0.00)	(0.062)	(0.488)	(0.324)	(0.46)	(0.226)
Fx	LD	-0.01	-0.02	0	9.75	0	14.93
		(0.6)	(0.867)	(0.994)	(0.194)	(0.973)	(0.322)
	L2D	-0.02+	0.08	-0.03	2.85	-0.06*	18.98
		(0.07)	(0.431)	(0.217)	(0.718)	(0.033)	(0.231)
	L3D	0	-0.14	-0.03	-1.07	0.02	-14.32
		(0.772)	(0.178)	(0.142)	(0.894)	(0.539)	(0.376)
Cpi	LD	0	-0.15	0.69**	75.24*	-0.13	-98.68
		(0.978)	(0.73)	(0.00)	(0.03)	(0.292)	(0.155)
	L2D	-0.07	-0.07	-0.33**	-0.97	-0.08	78.85
		(0.265)	(0.897)	(0.003)	(0.982)	(0.599)	(0.352)
	L3D	0.16**	0	0.08	55.87	0	151*
		(0.002)	(0.997)	(0.414)	(0.132)	(0.987)	(0.043)
Rgdp	LD	0*	0	0	-1.06**	0	-0.59**
		(0.033)	(0.583)	(0.471)	(0.00)	(0.404)	(0.00)
	L2D	0	0	0**	-0.37**	0	-0.49*
		(0.713)	(0.540)	(0.001)	(0.00)	(0.766)	(0.028)
	L3D	0**	0	0*	-0.34**	0	-0.56**
		(0.01)	(0.531)	(0.042)	(0.00)	(0.692)	(0.00)
I	LD	0.09+	0.33	-0.12	13.81	0.261*	-12.67
		(0.059)	(0.474)	(0.203)	(0.7)	(0.035)	(0.86)
	L2D	-0.05	0.47	0.15*	2.87	0.03	42.17
		(0.267)	(0.211)	(0.05)	(0.921)	(0.808)	(0.47)
	L3D	-0.03	0.47	0.1	-0.7	-0.11	41.66
		(0.476)	(0.257)	(0.217)	(0.983)	(0.338)	(0.515)
P-values in parentheses (** significant at 1%; * significant at 5%; + significant at 10%)							

Table #16 (cont)

Element		Equation (# of observations 75)					
		Δoil>0	D_fx	D_cpi	D_rgdp	D_i	D_m1
M1	LD	0	0	0	0.09	0	-0.21+
		(0.139)	(0.498)	(0.99)	(0.135)	(0.606)	(0.096)
	L2D	0	0	-0.001*	0.04	0	0.04
		(0.4)	(0.952)	(0.04)	(0.539)	(0.946)	(0.777)
	L3D	0	0	0+	0.23**	0	0.74**
		(0.14)	(0.522)	(0.095)	(0.00)	(0.489)	(0.00)
Ce	Ce1	0.02	-0.1	0.17**	-54.21*	-0.03	-42.18
		(0.56)	(0.723)	(0.004)	(0.014)	(0.69)	(0.343)
	Ce2	0	0.04+	0.02**	-5.21**	0.01	-0.84
		(0.167)	(0.078)	(0.00)	(0.00)	(0.389)	(0.815)
dum	fx	-0.31	72.29**	1.9	48.4	3.6+	13.57
		(0.719)	(0.00)	(0.246)	(0.938)	(0.094)	(0.991)
	i	-0.31	-2.22	-1.75+	109.8	-3.01*	-780.8
		(0.569)	(0.661)	(0.092)	(0.78)	(0.027)	(0.323)
	rgdp	1.35*	4.63	2.58*	2759**	1.15	1761.4*
		(0.019)	(0.385)	(0.018)	(0.00)	(0.424)	(0.034)
P-values in parentheses (** significant at 1%; * significant at 5%; + significant at 10%)							

APPENDIX C: REDUCED FORM VAR. CASE OF ΔOIL<0

Table #17. Reduced form VAR. Case of Δoil<0

Element		Equation (# of observations 53)					
		Δoil<0	D_fx	D_cpi	D_rgdp	D_i	D_m1
Δoil<0	LD	0.46*	0.09	-0.58*	-59.71	0.03	-82.09
		(0.029)	(0.928)	(0.019)	(0.223)	(0.873)	(0.591)
	L2D	-0.16	-2.36	0.11	249.07**	-0.06	-241.34
		(0.604)	(0.108)	(0.766)	(0.00)	(0.821)	(0.275)
	L3D	0.19	1.38	-0.01	-50.47	0.2	-78.91
		(0.356)	(0.152)	(0.977)	(0.28)	(0.279)	(0.588)
Fx	LD	-0.03	-0.02	0	2.16	0.02	22.81
		(0.224)	(0.877)	(0.879)	(0.667)	(0.307)	(0.145)
	L2D	0.02	0.05	-0.03	5.81	-0.06**	-1.08
		(0.388)	(0.663)	(0.26)	(0.284)	(0.00)	(0.949)
	L3D	0.02	0.11	0	-6.23	0	-2.18
		(0.42)	(0.268)	(0.869)	(0.188)	(0.895)	(0.882)
Cpi	LD	0.19	-0.81	0.2	-7.14	0.04	-284**
		(0.214)	(0.26)	(0.251)	(0.837)	(0.8)	(0.00)
	L2D	-0.4**	-0.23	-0.03	17.62	0.16	133.35
		(0.00)	(0.746)	(0.86)	(0.610)	(0.228)	(0.215)
	L3D	0.05	-0.23	0.05	23.25	-0.05	70.44
		(0.702)	(0.693)	(0.706)	(0.412)	(0.624)	(0.425)
Rgdp	LD	0	0	0	-0.35**	0	-0.06
		(0.5)	(0.780)	(0.742)	(0.00)	(0.617)	(0.883)
	L2D	0	0	0	-0.34**	0	-0.1
		(0.991)	(0.496)	(0.979)	(0.00)	(0.600)	(0.813)
	L3D	0	0	0	-0.14	0	-0.22
		(0.750)	(0.659)	(0.683)	(0.165)	(0.114)	(0.471)
I	LD	-0.06	0.4	0.02	-7.75	0.16*	67.15
		(0.512)	(0.334)	(0.837)	(0.699)	(0.042)	(0.282)
	L2D	0.13	-0.24	0.17	-35.04	0.2+	-5.22
		(0.28)	(0.668)	(0.215)	(0.191)	(0.062)	(0.95)
	L3D	-0.17	-0.62	0.13	17.39	-0.03	49.97
		(0.1)	(0.196)	(0.278)	(0.451)	(0.724)	(0.487)
P-values in parentheses (** significant at 1%; * significant at 5%; + significant at 10%)							

Table #17 (cont)

Element		Equation (# of observations 53)					
		Δoil<0	D_fx	D_cpi	D_rgdp	D_i	D_m1
M1	LD	0	0+	0	0.03	0	0.12
		(0.79)	(0.081)	(0.294)	(0.483)	(0.825)	(0.329)
	L2D	0*	0*	0	0.05	0	0.1
		(0.029)	(0.037)	(0.57)	(0.244)	(0.912)	(0.461)
	L3D	0	0	0	0.08+	0	0.3+
		(0.631)	(0.961)	(0.541)	(0.100)	(0.328)	(0.051)
Ce	Ce1	0.05	0.02	-0.05	7.91	-0.08	69.74
		(0.544)	(0.96)	(0.616)	(0.669)	(0.267)	(0.227)
	Ce2	0	0.04+	0.01*	-1.98+	0	5.88+
		(0.505)	(0.096)	(0.03)	(0.063)	(0.96)	(0.076)
dum	fx	1.49	89.09**	4.65	871.7	14.1**	-985.58
		(0.561)	(0.00)	(0.12)	(0.14)	(0.00)	(0.592)
	i	1.1	-15.49**	-1.38	-188.37	-10**	-370.54
		(0.371)	(0.00)	(0.335)	(0.505)	(0.00)	(0.674)
P-values in parentheses (** significant at 1%; * significant at 5%; + significant at 10%)							