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DETERMINING KEY DETERMINANTS OF DEMAND FOR INTERNATIONAL RESERVES IN UKRAINE: COINTEGRATION ANALYSIS

Abstract. In this paper we searched for the most important determinants of reserve holdings in Ukraine using quarterly data from 2000 to 2013 years. We evaluated their importance using two econometric techniques: autoregressive distributed lag (ARDL) approach and Vector Error Correction model (VECM) approach. We find that the ratio of imports to GDP, the ratio of broad money to GDP, ratio of net foreign direct investment to GDP, the ratio of short term debt to GDP and GDP determine Ukraine's long-run reserves demand function. Our empirical results show that shocks associated with the financial account is more dangerous for the Ukrainian economy than current account shocks. The low speed of adjustment coefficient of error correction model suggests that National Bank of Ukraine has to carry out more active reserve management policy. Results denied the precautionary motive of reserves accumulation over the long term.

Key words: foreign exchange reserves, capital account vulnerability, current account vulnerability, ARDL, VECM

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ВИЗНАЧЕННЯ ОСНОВНИХ ДЕТЕРМІНАНТ ПОПИТУ НА МІЖНАРОДНІ РЕЗЕРВИ В УКРАЇНІ: КОІНТЕГРАЦІЙНИЙ АНАЛІЗ

Анотація. У даній статті за допомогою двох економетричних технік (побудова векторної моделі коригування помилки та побудова авторегресійної моделі з розподіленим лагом) виявлено наявність довгострокового та короткострокового зв'язку та його напрямок між міжнародними

резервами та факторами, що визначають їх динаміку. Основними факторами, що зменшують резерви у довгостроковому періоді визначено зростання схильності до імпорту, зростання попиту на гроші та розміру короткострокового боргу за залишковим терміном погашення, тоді як збільшують резерви зростання обсягів ВВП та чистого припливу прямих іноземних інвестицій. Доведено, що шоки, пов'язані з фінансовим рахунком платіжного балансу, є більш загрозливими для української економіки, ніж шоки поточного рахунку.

Ключові слова: міжнародні резерви, ARDL, VECM, шоки фінансового рахунку платіжного балансу, шоки поточного рахунку платіжного балансу

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ОПРЕДЕЛЕНИЕ ОСНОВНЫХ ДЕТЕРМИНАНТ СПРОСА НА МЕЖДУНАРОДНЫЕ РЕЗЕРВЫ В УКРАИНЕ: КОИНТЕГРАЦИОННЫЙ АНАЛИЗ

Аннотация. В статье с помощью двух эконометрических техник (построение векторной модели коррекции ошибок и построение авторегрессионной модели с распределенным лагом) выявлено наличие долгосрочной и краткосрочной связи и их направление между международными резервами и факторами, определяющими их динамику. К основным факторам, которые уменьшают резервы в долгосрочном периоде относятся рост склонности к импорту, рост спроса на деньги и размера краткосрочного долга по остаточному сроку погашения, тогда как рост объемов ВВП и чистого притока прямых иностранных инвестиций увеличивают резервы. Доказано, что шоки, связанные с финансовым счетом платежного баланса, являются более опасными для украинской экономики, чем шоки текущего счета платежного баланса.

Ключевые слова: международные резервы, ARDL, VECM, шоки фынансового счета платежного баланса, шоки текущего счета платежного баланса

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Introduction. Over the past decades, the world's international reserves (IR) grew rapidly. The highest growth rates of reserves were observed exactly in emerging market economies. In Ukraine, during the period of independence also a tendency to increase in IR was observed. By the end of 1992 reserves were only around US$0,5 billion. Over the next years, they were accumulated and were reached its peak US$38,352 billion by the end of April 2011. During the period of Ukraine's independence IR are mainly used to finance balance of payments deficits and to maintain the currency stability through the mechanism of foreign exchange intervention. Balance of payments was partially financed by IR in periods of global crisis (in 1998, 2008-2009), and also during 2011-2012 years, when there was deficit of external financing. In 2012 and 2013 the first time since independence IR were decreased mainly due to high volume of payments by the Government and the National Bank of Ukraine (NBU) for a loan of the International Monetary Fund (IMF). Also, a significant reduction over the years 2012-2013 was caused by ensuring Hryvnia exchange rate stability; although in previous years NBU used mainly other monetary policy instruments to influence the exchange rate. The need to finance the deficit of the balance of payments and scheduled repayment of IMF loan led to a reduction in reserve assets already in the 2014-2015 years. A transition to a free exchange rate, political and social instability caused the lack of foreign currency in the domestic foreign exchange market and decreased the IR, which were only US$5,6 billion by the end of February 2015. According to preliminary data as at 1 April 2015, the volume of IR of Ukraine amounted to around US$10 billion. The increase in IR was due to primarily receipt of finances from the IMF under the Extended Fund Facility. So today, in times of significant shortage of foreign currency and instability in the domestic

foreign exchange market it is necessary to determine the major determinant of the demand for IR in Ukraine. Determining key determinants of the demand for reserves and motives for reserve holdings by the NBU can help improve reserve management policy.

Literature review and problem formulation. Analysis of empirical literature shows that most emerging market countries in recent decades mainly as a motive of IR accumulation considered precautionary motive [1, 2, 3]. That is the IR accumulation is considered as reserve holdings for use in the influence of external shocks reducing the probability and consequences of "sudden stop" of capital flows or a sharp increase in capital outflow. Another motive for reserve holdings is considered mercantilist motive, when IR accumulation is considered as a by-product of export-led growth strategies that rely on sterilized intervention to maintain an undervalued currency [4] (for example, the accumulation of reserves in China). Other researchers in explaining the reserves accumulation combine the precautionary demand for reserves with mercantilist motives, where the latter includes deliberate undervaluation both to boost aggregate demand and to build up reserves. Despite the theoretical plausibility, that some emerging market countries are deliberately undervaluing their currencies to gain competitive advantage, the empirical research to date rarely confirmed the mercantilist motive for IR holdings.

We will understand that the demand for IR is the need for reserve assets of central bank, that caused motives and determinants of their accumulation. To model the demand for IR in Ukraine and determine the main motives for holdings at a fixed exchange rate we will carry out econometric analysis. Among econometric tools that are often used to model the demand for IR can be distinguished panel data analysis [5] vector autoregression models [6], ARDL-models [7] and special methods such as quantile regressions [1, 5].

To achieve this goal it is necessary to solve the following tasks:

1. To determine potential determinants of the demand for IR by analyzing empirical literature of IR holdings;
2. To describe data and their measurement;
3. To carry out preliminary analysis of time series and determine econometric modeling method;
4. To estimate reserves demand function.

Research results. Analysis of the empirical literature has allowed determining the main determinants influencing the demand for IR. These determinants that account for the motives of reserve holdings can be grouped into five categories [8, p. 80].

The first group is general country-specific determinants, such as the level of economic development, population. IR stocks should increase with increasing amounts of international transactions, so it is expected that IR are positively correlated with the GDP, population. But there may be a non-linear relationship when most developed countries there were small amounts of reserves.

The second group includes current account (CA) of balance of payments shocks. Imports and export earnings are the most-commonly used variables to capture external shocks to the current account. IR should be increased with significant volatility of export earnings, if they are oriented to protect the economy (mercantilist motive), so it is expected that the reserves would be positively correlated with the instability of export earnings to the country. IR stocks should also increase with increasing external vulnerability because it is assumed that the reserves would be positively correlated with an import or trade openness (precautionary motive).

The third group includes financial account (FA) of balance of payments shocks. Careful attention to FA has been paid after the Asian crisis, which was characterized by a rapid decrease in reserves due to capital flight and loss of access to debt capital that is most clearly reflected in the reserves of emerging market countries. The crises in Mexico (1994), Argentina (1995), Indonesia (1997), Turkey (2001), Argentina (2002) and Uruguay (2003) showed how the banking crisis could affect the balance of payments, as investors begin to withdraw deposits and withdraw foreign currency. At the same time Mexican (1994), Korean (1997) and Thai (1997) crisis also highlighted the risks of

short-term debt (STD) accumulation [1, p. 8]. In this paper, we consider three variables reflecting the demand for reserves with precautionary motive arising from FA shocks: STD by remaining maturity, gross external debt and money supply M2. The ratio of M2 to GDP is a proxy variable that reflects potential losses from exchange rate differences resulting from capital flight by residents. In theory, an increase in M2 should lead to an increase in reserves with precautionary motive. STD is held most threatening for country, so we included this variable in the analysis. But limiting the inclusion of this variable is defined feature of the corporate sector lending sources in Ukraine. During the crisis (2008-2009) most loans are not paid and are refinanced. Therefore, as an alternative, we will use the gross external debt. We also include variable reflecting mercantilist motive for reserve holdings, this is net inflow of foreign direct investment (FDI).

A fourth category is the exchange rate flexibility. Greater exchange rate flexibility should decrease the demand for reserves because the central bank does not need a large stock of reserves to maintain a fixed exchange rate. Therefore, IR must be negatively correlated with the exchange rate volatility. But as noted by M. Obstfeld [2, p. 4] global IR has not decreased in relation to the GDP after the transition to floating rates.

A fifth category is opportunity cost. Opportunity cost of IR is considered lost profit from alternative investments. Often, they are measured as differential between the domestic interest rate and interest rate in the United States. Theoretically, IR must be negatively correlated with opportunity cost.

Aizenman and Marion [9] also show that political uncertainty and political corruption decrease IR stocks. Since the corruption index of Transparency International database available only for annual data, for the political uncertainty modeling we will use dummy variables.

Data. Quarterly data from 2000:1 to 2013:4 are used for the study. 2014 were not used because transition of the NBU to a flexible exchange rate system and the presence of factors of social and political instability, that greatly influenced the IR, complicates modeling.

A dependent variable r is total international reserves as % of GDP at current prices in US dollars except monetary gold. To model the specific characteristics of the country we will use the *GDP*. The population, GDP per capita will not be used because quarterly data are not available. To model CA shocks we use next variables: *imp* is the import of goods and services as % of GDP, *topen* is the sum of imports and exports of goods and services as % of GDP, *exportvol* is the volatility of exports (in quarter t is calculated as the standard deviation for export quarters t, t-1, t-2, t-3, t-4 [10, p. 50]).

To model FA shocks we use next variables: *M2* is the monetization of the economy (M2 / nominal GDP), *fdi* is the net FDI inflows as % of GDP, *std* is the short-term external debt (by remaining maturity) as % of GDP, *extdebt* is the gross external debt as % of GDP. The proxy variable that reflects the exchange rate flexibility *ervol* is the volatility of the nominal effective exchange rate (calculated as the standard deviation of monthly nominal effective exchange rate (for 12 months.)) [5, p. 25]. The proxy variable that reflects the opportunity cost is *opcost*. Accurate assessment of opportunity cost is calculated as the difference between government bond yields (domestic vs. U.S. dollar denominated) [11]. But statistics on Ukrainian government bonds are available only from the end of 2002. Therefore, to calculate opportunity costs, we used the difference between the domestic interbank rate on loans and the rate of US treasury bills from the database of the IMF (International Financial Statistics (IFS)). But, as noted Aizenman [3] the calculated opportunity cost by a standard method for developing countries is statistically insignificant, so often it is excluded from the regression equation. Also we used dummy variables reflecting political instability at the end of 2004, 2010 and 2013 years (*dummy04q3, dummy04q4, dummy 10q4, dummy 13q4* respectively). Also we included dummy variables reflecting the effects of the global financial crisis (*dummy08q4, dummy09ql, dummy09q2, dummy09q3, dummy09q4).*

Data sources were the NBU, State Statistics Committee of Ukraine, IFS. Since NBU calculates short-term debt by remaining maturity only with the IV quarter of 2004 year, for the period from 2000:1 to 2004:3 we used calculations of the Institute for Economic Research and Policy Consulting [12].

Modeling Strategy. To select econometric modeling method of demand for **IR** in Ukraine we conducted a preliminary analysis of time series. Algorithm of preliminary time series analysis involves next steps:

1. Checking the abnormal level of time series;
2. Determining of the time series seasonal component and seasonal smoothing;
3. Taking the logarithm of time series;
4. Carrying out factor analysis of time series (correlation analysis, principal component analysis);
5. Analysis of time series stationary.

Econometric analysis methodology depends on the order of integration of time series:

1. If both variables are stationary (I (0)), we can apply standard econometric analysis methods (in other words we can apply the classical regression analysis);

2. If the variables are integrated of same order (for example, stationary in first differences (I (1))) or of different order, it is necessary to test variables for the cointegration relation to determine the possible long-term relationships between the dependent and independent variables. Cointegration equation is a stationary linear combination of non- stationary or different integrated time series, which is interpreted as the ratio of long-term dynamic equilibrium between variables. There are several methods of cointegration analysis: Engle-Granger approach [13] Johansen approach [14, 15] and ARDL-approach [16];

3. If all variables are integrated of the same order (for example, I (1)), then the presence of cointegration relation is verified by Engle-Granger approach (if we analyze the relationship between two variables) or by Johansen approach (if we analyze more than two variables). If cointegration relation exists then it is necessary to use vector error correction model (VECM);

4. If there is no cointegration relation, it is necessary to uses vector-autoregression unrestricted model (unrestricted VAR) in first differences;

5. If the variables are integrated of different order (for example, I (0) and I (1)), according to the work Engle and Granger to be that the variables are not cointegrated. In this case, it is possible to use unrestricted VAR-model with stationary variables of different orders of integration, but it complicates the interpretation of results. And if in this case to use all time series in first differences, it is possible to loss information about long-term relation between the variables stored in levels;

6. If the variables are integrated of different order (for example, I (0) and I (1)), according to the work [16] they could be cointegrated. In this case, it is necessary to use the ARDL-approach.

Empirical results. Checking the abnormal level of time series was done by Irwin's method. The critical value of the Irwin criterion at 5% significance level for 56 observations is 1,1. If the calculated value is more than critical value then observation is declared abnormal. When modeling time series often abnormal observations, that deviate sharply from the series evolution direction, are discarded or replaced by the calculated observations (for example, calculated by interpolation methods). However, abnormal values may reflect the actual development process. Therefore, these abnormal observations can be modeled using dummy variables corresponding to fixed points in time. In our series abnormal values were accounted for structural changes in the economy of Ukraine, so they are not discarded or replaced by the calculated observations and modeled using dummy variables.

In the next step time series were tested for seasonality using graphical analysis of data and correlogram analysis. Time series with seasonality were seasonally adjusted using Census X-2 method in Eviews 8.

For analytical purposes, all variables (except variable opcost) were taken in natural logarithms, since the absolute values of variables and their variations are large, that can prevent the analysis of the influence of other factors such as dummy variables. Also time series was taken the logarithm not only for their smoothing, but also to take account of the multiple impact of variables. It is noted that the logarithmic transformation may form a stationary time series [17], which is a prerequisite for further modeling.

Analysis of the correlation matrix shows that there is a strong link between the only IR and money supply (l_m2), GDP (lgdp) and export volatility (lexportvol). The average correlation is observed between IR and trade openness (ltopen), FDI (lfdi) and gross external debt (ledebt). A weak correlation is observed between IR and opcost and lstd. This connection in the demand for reserves with interest rates differential can be accounted for the fact that interest rate does not play a significant role in the regulation of the currency market in emerging market country. A weak correlation with short-term external debt can be accounted for the feature of lending sources of the corporate sector. It was also found multicollinearity between the variables l topen and l imp, l_m2 and l gdp, l edebt, l std and l edebt, l exportvol and l_m2, l gdp. To avoid multicollinearity should be included in the model only one variable from multicollinearity combinations. The results of the factor analysis using principal components analysis not confirm the results of correlation analysis to exclude variables l ervol and l std from econometric analysis, so in this stage decided to exclude only variable opcost. However, it should be noted that the high value of the pair correlation coefficient of variables may be due to close connection between analyzed variables, the presence of a third variable, which greatly affects the first two or presence of rising trend that can cause high correlation between data [18]. Thus, the results of classical correlation analysis may be wrong, that the statistics can be accounted for the non-stationary of initial time series.

To test the hypothesis of stationary (on a linear trend) or non-stationary of time series there are a number of different tests. However, all tests have drawbacks or limitations. For the accuracy of the results in the analysis of time series for stationary should be used not one but several tests and confirm the conclusion by graphic procedures. A graphic procedure of time series analysis includes not only analysis of time series graphs, but analysis of autocorrelation function graphs (correlograms). To determine the order of integration of time series we will use the unit root tests. Today most popular tests are Augmented Dickey-Fuller (ADF) test, Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test and Phillips-Perron (PP) test. To increase the reliability of the results, we will use all three tests simultaneously. Testing with ADF-test was conducted using the Dolado, Jenkinson and Sosvilla-Rivero procedure [19]. The calculations were carried out in EViews 8. The analysis of stationary was ambiguous, time series l topen, l exportvol, l fdi, l edebt were non-stationary in levels according to ADF- and PP-tests, while stationary according to KPSS-test, and conversely a time series l_m2. Results for variable l imp according to all unit root tests were strange, all tests identified time series as stationary, but this conclusion is not supported by correlogram analysis.

Such results can be accounted for structural breaks in the time series, because structural changes was in this time period in Ukrainian economy. Especially structural breaks in time-series dynamics are observed in period of global crisis (in 2008-2009 years). As noted Perron [20] the presence of a structural breaks dramatically reduces power known unit root tests, and vice versa, testing the structural break in models with a unit root is extremely difficult. Since we had ambiguous results of unit root tests, it is necessary to check time series stationary with structural break in the dynamics. We use Andrews-Zivot test [21] and Perron test [22] which you can add in Eviews 8. To improve the reliability of the results all the time series in levels were checked for the presence of a unit root with structural break. As a result of all procedures series l fdi and l ervol are defined as integrated of order 0, and all other variables are defined as integrated of order 1.

Since most series are integrated of order 1, including the dependent variable, it is possible to detect among them stationary cointegrating relationship(s) that is, to try to detect the presence of long-term relationships between the dependent variable l_r and their determinants. Cointegration analysis will be carried out by Johansen approach. The algorithm of Johansen approach involves next steps [23, p. 321-326]:

1. Setting the appropriate lag length of the model. The most common procedure in choosing the optimal lag length is to estimate a VAR model including all our variables in levels (non-differenced data). The optimal lag length is chosen based on the analysis of information criteria of LR-test in Eviews 8;

2. Choosing the appropriate model regarding the deterministic components in the multivariate system (based on the Pantula principle). We will test only three models (2, 3, 4): intercept (no trend) in cointegrating equation (CE) and no intercept or trend in VAR, intercept in CE and VAR, no trends in CE and VAR, ilntercept in CE and VAR, linear trend in CE, no trend in VAR. The Pantula principle can be summarized as follows. We estimate all three alternative models and move from the most restrictive model (no deterministic components) to the least restrictive model, comparing the maximal Eigenvalue test statistic to its critical value. The model will be selected only when the null hypothesis is not rejected for the first time;

3. Determining the number of cointegrating vectors based on trace statistics and the maximum eigenvalue statistics;

4. Testing for weak exogeneity and coefficients significance of normalized cointegrating vector by introducing restrictions in the cointegrating vector components.

If it is determined the presence of long-term relationships between variables, the next step is to develop a vector error correction model (VECM). When VECM modeling the variables not included in the cointegration analysis (order of integration 0) can be used as exogenous, but it is somewhat complicates the results interpretation.

After VECM modeling the residual diagnostic tests are carried out. Diagnostic tests include tests the null hypothesis of no serial correlation, normality test, heteroskedasticity test.

As a result of econometric modeling was developed different models depending on the variables included. It should be noted that during the models development we preferred the variable l imp instead of l topen, because in most models it was to be more significant. It is also confirmed by Granger causality tests. Similarly we preferred the variable lstd instead l edebt. Most developed models depending on the specifications are presented in Table 1 (Model 1, Model 2, Model 3). Diagnostic tests do not show characteristics of incorrect specification of VECM functional form in all models. Let's consider the results of the estimated models.

Model 1. The model includes four endogenous variables: l_r, l imp, l gdp, l std. Cointegration analysis confirmed the presence of long-term relationships and 2 cointegrating vectors was found. The weak exogeneity test enables us to find whether a variable enters in the adjustment process to correct the disequilibrium or not. If the cointegrating vector does not have any influence on a particular variable, i.e. the speed of adjustment coefficient is not statistically different from zero, then that variable is said to be weakly exogenous with respect to long-run parameters. In the present context, STD (l std) is weakly exogenous at 5 percent level of significance, that is only l imp and l gdp enter in the adjustment process to correct the disequilibrium. The test for the coefficients significance determined as significant determinants l_r and l imp, and other determinants are not significant. Thus, we decided to exclude statistically insignificant variables from cointegrating equation (l std, l_gdp).

Table 1.

Results of cointegration analysis (Johansen approach) _____

Model 1 _____

Long term part of the VECM (without restrictions) _____

1.. -i.'" = 0. 89 l$_{std}$, j 9,Sfi]$_{jmp}$, _$_t$, ' - 0, 71 ■ + Q. 0Z@trend +$4\,5,6\,2$ Long term part of the VECM (with restrictions) _____

1.,_ j, —— 7, 2 5 ■]$_{jmp}$, _$_1$, — 0.01©trend + 31.Z5 _____

VECM

$$d(I_r) = —0, 07^{KKK} \text{ CoontEql - O, 43 • d> 1,, _t, ■ - 0,3 5}^{KKK} d(\,_2\,) +- O, 42^{KKK} c$$

Equation statistics _____

R-squared=0,87, Adjusted R-squared=0,77, S.E. of regression=0,04, Sum squared resid=0,06, Log likelihood=101,91, F-statistic=8,24, Prob(F-statistic)=0,00, Mean dependent var=0,02,

S.D. dependent var=0,09, Akaike info criterion=-2,99, Schwarz criterion=-2,10 _____

Diagnostic tests _____

Autocorrelation LM test =12,45 (0,71), 14,39 (0,57), 16,82 (0,40);

Jarque-Bera= 9,86 (0,27);

White test =339,66 (0,77)

Model 2

Long term part of the VECM

$$— 3,73 \blacksquare \text{Ijmp,-!}, — 0,01 \blacksquare © trend + - 17,48 \underline{\text{VECM}}$$

rï Дт>ï']ᴵ = --0 10- ᴶ -) ¹ CointEql - *ZQ,3~Z*   d (1 r(-1j)- *ZO,*   - -) (

Equation statistics

R-squared=0,82, Adjusted R-squared=0,77, S.E. of regression=0,04, Sum squared resid=0,08, Log likelihood=93,51, F-statistic=15,02, Prob(F-statistic)=0,00, Mean dependent var=0,02,

S.D. dependent var=0,09, Akaike info criterion=-2,99, Schwarz criterion=-2,61

Diagnostic tests

Autocorrelation LM test =5,26 (0,26), 1,01 (0,90), 4,49 (0,34);

Jarque-Bera = 8,06 (0,11);

White test =69,02 (0,20)

Model 3

Long term part of the VECM

VECM

d(l, j = -0, or~ ■ CointEql - ₀, 5 3 ■ d(1,. _t.) - 0, 5 5^"" ■ d(1,. _2,) + 48 ■

Equation statistics

R-squared=0,77, Adjusted R-squared=0,72, S.E. of regression=0,10, Sum squared resid=0,05, Log likelihood=87,07, F-statistic=13,90, Prob(F-statistic)=0,00, Mean dependent var=0,02,

S.D. dependent var=0,09, Akaike info criterion=-2,93, Schwarz criterion=-2,51

Diagnostic tests

Autocorrelation LM test =5,55 (0,23), 5,14 (0,27), 3,30 (0,50);

Jarque-Bera= 2,30 (0,68);

White test =55,29 (0,43)

*Note: *, **, *** mean 10%, 5%, 1% level of significance respectively; CointEq means long-term equation; d means using the first difference of the exiting series.*

Source: own calculations

A positive sign of l gdp coefficient confirms theoretical hypothesis that IR stocks increases with increasing amount of international transactions, but in this case the variable is insignificant. Over the long-term period the current account vulnerability variable (l imp) impacts on IR most significantly. This can be accounted for a significant share of critical imports (primarily gas, oil and petroleum products) in structure of Ukrainian import. At the same time, a statistically significant positive impact of exports volatility (lexportvol) has not been found. In most developed models (which confirmed the presence of cointegration relationship) this variable (l exportvol) was defined as weakly exogenous in the long run, in other words, it does not enters in the adjustment process to correct the IR disequilibrium. That suggests that in this time period export earnings volatility had little impact on IR, while the increase in imports significantly decreased reserves. The significant opposite sign of the import does not follow theory. In other words, reserves accumulation is negatively related to the level of imports, that is, the NBU does not consider precautionary motive of reserve holdings.

The VECM of reserves shows that the short-term equilibrium depends on its own lagged values, marginal propensity to import and STD. At that, in the short run an increase in import to GDP results an increase in reserve holdings, suggesting the precautionary holding of IR. While an increase in short-term debt decreases IR in the short run. The coefficient of the speed of adjustment points out that only 7 percent of the deviation from disequilibrium is eliminated within the first quarter. This is a low speed of adjustment. According to the Clark's proposition [24] a country with a low speed of adjustment towards equilibrium would require a high level of reserves to finance its balance of payment. This also indicates that the NBU should improve reserve management policy to increase the

speed of disequilibrium adjustment.

Model 2. The second model considered only as endogenous l_r and l imp. The behavior of the variables is similar to the variables behavior from the previous model. But this model was introduced as exogenous exchange rate volatility, which has a significant impact on IR. But a sign of the variable does not follow the theoretical hypothesis, in which an increase in the exchange rate volatility decreased IR stock. In our case, by contrast, an increase in the exchange rate volatility increases IR. This can be accounted for the fact that we considered the period, when used de facto fixed exchange rate. That is, in this case the precautionary motive would be a possible reason for the positive impact on IR. In this case, a sudden peak of the exchange rate volatility during the crisis (the peak in the second quarter of 2009 year) was associated with an increase in reserves (with a peak in the third quarter of 2009 year), which was associated with receiving tranche of the IMF program "stand-by". In other periods the exchange rate was characterized by low volatility.

Model 3. This model describes the impact of money on foreign exchange reserves. From the equation we see that between the demand for reserves and the demand for money, there is a strong negative long-term relationship. That was not according to the theoretical expectations and denied the reserve holdings with self-insurance motive against capital flight by residents in the domestic banking sector. The negative sign of lagged variables of money in the short run may also be associated not only with the FA shock, but with a reduction in money supply due to the sterilized intervention by the NBU in the short run to avoid the inflationary impact of reserve accumulation. The speed of adjustment of the deviation from the long-run equilibrium in this case is very low and is only -0,01, that is, only 1 percent of the deviation from disequilibrium is eliminated within the first quarter. This is very low. Thus it can be concluded that the elimination of the CA shocks in the Ukrainian economy is faster than elimination of FA shocks. That is, our economy is very vulnerable to "sudden stop" of capital inflows and its outflows, that increases the population panic and causes negative effects in the domestic banking sector.

ARDL-approach. Since two of the main determinants of potential demand for reserves were integrated of order 0 to consider long-term relationships between them and IR we decided to use ARDL-approach. According to work [16] variables of different orders of integration can also be cointegrated.

ARDL-algorithm approach involves next steps:

1. Determining the optimal lag model using Akaike information criterion and Schwarz information criterion;

2. Carrying out residual diagnostics tests: no serial correlation, normality, hetero skedasticity ;

3. Checking the stability of the model using CUSUM-test;

4. Checking cointegrating relationship between the variables in levels using the Wald test;

5. If cointegration relationship is found, it is necessary to estimate long-term coefficients of the equation;

6. Development of error correction model to analyze short-term coefficients.

We considered different models depending on the inclusion of variables. Long-term relationships with variable ervol hasn't been found. Best of the developed model is presented in Table 2 (Model 4).

Table 2.

Results of cointegration analysis (ARDL approach)

_____ **Model 4** _____
Long term part of the ARDL _____
$l_r = 0,83$ - $l_{gd|1}$ - $0,59'''''$ $1,03 \sim L_{:|d} + Q,iq$---$L_{f[|1}$ _____
ARDL _____

$$d\,'l\,,=\ 0{,}54-\bullet\,d(\ ]_{,,}\ _{\_1,}'-0{,}28-d\ (\ ]\ ,\ 0\ .\ 59^{***}\,d(l_{,..\_3=,})-0\ 35''\,d\ (]_{gd?}$$

<u>**Equation statistics**</u> _____

R-squared=0,81, Adjusted R-squared=0,74, S.E. of regression=0,05, Sum squared resid=0,08, Log likelihood=92,23, F-statistic=l 1,50, Prob(F-statistic)=0,00, Mean dependent var=0,02, S.D. dependent var=0,09, Akaike info criterion=-2,97, Schwarz criterion=-2,76 _____

<u>**Diagnostic tests**</u> _____

Autocorrelation LM test =5,44 (0,25), 4,48 (0,25), 3,64 (0,52);

Jarque-Bera = 6,30 (0,72);

<u>White test =64,75 (0,48)</u> _____

Note: *, **, *** mean 10%, 5%, 1% level of significance respectively; ecm means long-term equation; d means using the first difference of the exiting series.

Source: own calculations

Model 4. In this model endogenous variables were l_r, l std, l_gdp, l imp, l f d i. From Model 1, this model differs inclusion of variable l fdi. Based on the criteria Akaike and Schwartz optimal model was selected with three lags. Diagnostic tests confirm the correct model specification and CUSUM-test confirms the model stability. In the result of the Wald test (checking the coefficients of the variables in levels) null hypothesis that there is no cointegrating relationship can be rejected at the 5% level of significance, as calculated F- statistic is 4,43, which is higher than the upper limit of the critical value 3,94 based on [16]. This means that there is a long-term relationship between reserves and its determinants.

The error correction model and long-term part of ARDL model are presented in Table 2. The error correction model has only statistically significant elements. The coefficients of the variables l imp, l std, l gdp in the long term equation have the same signs as in Model 1, but in this model we identified a statistically significant impact of FDI, that means the positive impact of capital inflows on reserves (mercantilist motive). Unlike other estimated models in the short run we found a statistically significant impact of lagged values of GDP, but with a negative sign. The speed of adjustment of the deviation from the long-run equilibrium in this case is -0,08, in other words, only 8% of disequilibrium is eliminated during the first quarter, that is also very low.

Conclusions. Results of our analysis can be resumed follows:

1. Using two econometric techniques (VECM-approach and ARDL-approach) we found a long-run and short-run relationships between IR and their determinants;

2. The key determinants that decrease IR in the long run are the increase of marginal propensity to import as current account shock, the increase in demand for money and the increase in the short-term debt as financial account shocks;

3. The growth of GDP and net FDI inflows positively impacts on IR (with a coefficient signs according to the theoretical background). Thus we can assume the presence of a precautionary and mercantilist motives of reserve holdings;

4. But, at the same time opposite sign of the variables to theoretical model (imports, money supply, short-term debt) suggests that the NBU does not consider the reserve holdings as a buffer to self-insurance against external and internal shocks;

5. The speed of adjustment of the deviation from the long-run equilibrium in all models is very low (less than 10%), so Ukraine needs a high level of reserves to finance the balance of payments. This also indicates that the NBU should improve reserve management policy to increase the speed of adjustment;

6. External shocks associated with the financial account is more dangerous for the Ukrainian economy (current account shocks are eliminated almost 10 times faster than financial account shocks);

7. At the same time the impact of demand for money is significant, negative, and the speed of adjustment of IR in this case is very low (only 1% of disequilibrium is eliminated during the first quarter). This fact is very dangerous for our economy, because it is also a dollarized. As noted in Obstfeld's work «reserve accumulation is a key tool for managing domestic financial instability as well

as exchange rates in a world of increasing financial globalization» [2, p. 2]. That is the main reason for reserve holdings by the central bank as a lender of last resort should have a protection of the domestic banking sector. Especially for an emerging market in which domestic bond markets are thin, and significant capital outflows in times of crisis cause devaluation expectations and discredit of the banking system, that causes deposit outflows, the only management tool of exchange rate during such periods are the interventions in the foreign exchange market.

In next studies we will calculate levels of adequacy and optimality of international reserves in Ukraine taking into account the main determinants that impact on them.

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