Research on Chosen Macroeconomic Indicators of Romania

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Abstract

The purpose of this paper is to investigate the long-run and short-run relationships between economic growth, exports, imports, exchange rate, and interest rate in the case of Romania using the bounds F testing approach developed within autoregressive distributed lag (ARDL) framework by the quarterly time series data for the period 2000q1-2013q4. A time dummy variable was specified to measure the effect of Romania's participation to European Union. Unit root tests were performed to examine variables' level of integration. Relatively new ARDL bounds F testing cointegration method employed has good small sample properties and provides more robust and reliable results. Long-run, short-run and the stronger form of the Granger causalities from the each of the four explanatory variables namely exports, imports, exchange rates and interest rates to gross domestic product were investigated by using Granger non-causality tests. CUSUM and CUSUMSQ stability tests were also implemented. The empirical results of this paper are enlightening with regard to trade policies for the policy makers of Romania.

Keywords: ARDL bounds testing approach, Error correction model, GDP, Granger causality, Romania

Introduction

Disagreements proceed in the empirical literature concerning the causal direction of the effects of trade openness on economic growth. Some researchers claim that causality flows from exports to economic growth and indicates this as the export-led growth (ELG) hypothesis (Awokuse, 2007; Edwards, 1998). Export expansion is viewed as an important determinant of economic growth because of the positive externalities it provides. Moreover, exports can supply foreign exchange allowing for more imports of intermediate goods which in turn increases capital formation and thus encourage output growth. There are also several studies found that it is possible to have growth-led exports (GLE). In the GLE case, export expansion is stimulated by productivity gains caused by increases in domestic levels of skilled-labor and technology (Awokuse, 2007). There may be no causal relationship between exports and economic growth when the time paths of the two series are determined by some other unrelated variables such as investment in the economic system (Guru Gharana, 2012).

Some other empirical studies claim that another alternative is import-led growth (ILG) which suggests economic development is contributed primarily by growth in imports. Imports can be a component for long-run economic growth by providing access to needed intermediate factors and foreign technology to domestic firms (Coe & Helpman, 1995; Lawrence & Weinstein, 1999).

The growth theory superimposes remarkable importance to the effect of exports expansion on economic development. Economic development is promoted by exports which improves the efficiency of the allocation of productive resources and increases the volume of productive resources that cause capital accumulation growth (Hatemi & Irandoust, 2002; Dritsakis, 2004)

Dumitriu, Stefanescu and Nistor (2010) explored the dynamic relation between the exports and the gross domestic product for Romania by employing the Johansen cointegration procedure and the Granger causality test. They found no cointegration between GDP and exports in Romania.

Pop Silaghi (2009) investigated export-led growth and growth-led exports hypotheses by using finite-order vector autoregressive (VAR) models in levels, in first-differences and error correction models for the countries Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovenia, Slovakia. She found that export-led growth hypothesis is valid for the Czech Republic and Lithuania, and growth-led exports hypothesis is valid in Hungary, Romania and Slovenia, according to trivariate systems (GDP, exports and imports).

Dritsakis (2004) in his study analyzed the relationship between exports, investments and economic development in two countries, Bulgaria and Romania. It is found that there is a 'strong Granger causal' relation between economic growth and exports as well as between investments and exports by using a multivariate autoregressive VAR model for the two countries.

Ramos (2001) researched the Granger-causality between exports, imports, and economic growth in Portugal and showed that there is no causality between the variables considered in Portugal.

Ahmed, Butt and Alam (2000) rejected the ELG hypothesis for seven of eight countries they studied using trivariate causality framework. They found support for export-led growth hypothesis only in only one (Bangladesh) of eight countries.

Awokuse (2008) examined the relationship between trade and economic growth in Argentina, Colombia, and Peru for both the role of exports and imports by using cointegrated vector autoregression (VAR) model and Granger causality tests. He found empirical evidence supporting for both export-led and import-led growth hypotheses where the latter is relatively stronger.

Tan et al. (2007) investigated the dynamic relationships between economic growth and macroeconomic variables, namely financial deepening, exports and investment by employing vector error correction model for the cases of Singapore, South Korea, Taiwan and Thailand. Their findings demonstrated that export-led growth hypothesis is valid for all four Asian economies.

Mahadevan and Suardi (2008) showed that Japan's GDP growth is import-led while Hong Kong's GDP growth is both export and import led by using the cointegration test of Johansen and Juselius (1990).

Hye and Boubaker (2011) investigated the export-led growth, import-led growth and foreign debt sustainability hypotheses in the case of Tunisia by using autoregressive distributed lag (ARDL) approach and determined unidirectional causality from exports to economic growth and bidirectional relationship between imports and economic growth. Their findings validate both export-led growth and import-led growth for Tunisia.

Sato and Fukushige (2011) explored causal relationships by constructing a vector autoregression model of economic growth, exports, and imports for North Korea by splitting the sample into two parts and found evidence of import-led growth for the first subperiod, but not for the second subperiod. They showed export-led growth is not valid for North Korea.

Awokuse (2007) used a growth modeling framework and multivariate cointegrated VAR methods to investigate the contribution of both exports and imports to economic growth in Bulgaria, Czech Republic, and Poland. He determined that empirical evidence exists for both ELG and GLE hypotheses for Bulgaria, for both ELG and ILG hypotheses for the Czech Republic, for only the ILG hypothesis in the case of Poland.

Uğur (2008) analyzed the relationship between imports and economic growth in Turkey by decomposing imports into categories. Results of multivariate VAR analysis conducted show bidirectional relationship between GDP and investment goods import and raw materials import, and a unidirectional relationship between GDP and consumption goods import and other goods import.

Mishra, Sharma and Smyth (2010) investigated the export-led growth and import-led growth hypotheses for the countries Fiji, Papua New Guinea, Solomon Islands, Tonga and Vanuatu by using a panel unit root, panel co-integration and panel Granger causality approach. They found there are bi-directional Granger causality between exports and economic growth, imports and economic growth, and exports and imports.

As briefly summarized, results of the empirical studies have inconsistent findings that could be due to discrepancy among the sample periods and the different econometric methodologies applied such as single equation ordinary least squares model, vector autoregression (VAR) model, cointegration methods and Granger causality frameworks. These methods have some limitations. While ordinary least squares is not adequate, the other three methods require research time series variables to be the same order of integration in a research studying cointegration and/or causality relationships (Keong, Yusop & Sen, 2005). Empirical studies using latter three methods have the assumption that all variables in the model are integrated of the same order. The found cointegration or causality results by using these methods may have spurious

relationships and conclusions may be unreliable when included variables are not integrated of the same order (Guru Gharana, 2012). Autoregressive distributed lag (ARDL) bounds F testing method is appropriate regardless of research variables are $I(0)$, $I(1)$ or mixture of both.

In this empirical study, in addition to using variables gross domestic product, imports and exports that are employed in many empirical studies, the variables exchange rates and interest rates are also included in the analysis. Instead of studying bivariate relationships, multivariate relationship by using four explanatory variables where gross domestic product is the dependent variable is used because it is known that multivariate relationships in general may be quite different than bivariate situation (Love & Chandra, 2005; Guru Gharana, 2012). Thus, in case of Romania, export-led growth and import-led growth hypotheses are revisited.

Recently developed and robust autoregressive distributed lag (ARDL) bounds F testing method proposed by Pesaran and Shin (1995 and 1998), and Pesaran et al. (2001) is employed to study the long and the short run relationships among these five time series variables. This method has good small sample properties and ensures more robust and asymptotically reliable results under different situations concerning the cointegration relationships among the variables. (Guru Gharana, 2012).

Method

Framework

Hypothesized functional relationship for this empirical research is given below between five macroeconomic variables plus one time dummy for Romania as

$$GDP_t = e^{\beta_0 + \eta DUM_t} EXP_t^{\beta_1} IMP_t^{\beta_2} EXR_t^{\beta_3} INR_t^{\beta_4} e^{v_t} \quad (1)$$

and by taking natural logarithm on both sides, it is obtained the usual log-linear equation for estimation as

$$LNGDP_t = \beta_0 + \eta DUM_t + \beta_1 LNEXP_t + \beta_2 LNIMP_t + \beta_3 LNEXR_t + \beta_4 LNINR_t + v_t \quad (2)$$

Recently developed more robust autoregressive distributed lag (ARDL) bounds F testing method (summarized under procedure section) is developed and multivariate framework by including LNGDP, LNEXP, LNIMP, LNEXR and LNINR variables is applied in this study. Time series variables are defined in the next section.

Data and Approach

Raw data used in the analysis are obtained from the Eurostat's web page (www.eurostat.com) and defined in Table 1 below. Research variables are the real gross domestic product (GDP), real exports, real imports, exchange rates and interest rates. GDP is gross domestic product at market prices. Exports (EXP) and imports (IMP) variables show exports of goods and services and imports of goods and services. These three variables are measured in millions of national currency (Leu) and they are not seasonally adjusted. Exchange rates (EXR) which are average exchange rates against the Euro and interest rates (INR) showing average day to day money market interest rates are obtained as monthly data and converted to quarterly data (using mean values) by the authors. Unit of the exchange rates is Lei/Euro.

GDP, exports and imports series were deflated by the price indices (2005=100) prepared for gross domestic products at market prices, exports of goods and services and imports of goods and services, respectively and transformed into their natural logarithm form.

Eurostat table codes for the data extracted are namq_gdp_c (for GDP, EXP and IMP), ei_mfrt_m (for EXR) and ei_mfir_m (for INR) for the defined time series and namq_gdp_p for the corresponding price indices.

All of the time series used in the analysis are quarterly data between the first quarter of 2000 and the fourth quarter of 2013 (2000Q1-2013Q4) that covers the date of European Union membership of Romania (01.01.2007). Dummy variable named DUM in the equation (2) is inserted to the model to measure the impact of European Union membership of Romania and coded as 0 and 1 showing nonmembership and membership situation (0 for the term 2000Q1-2006Q4 and 1 for the term 2007Q1-2013Q4).

Results of the analysis in this study are obtained from the Eviews software version 7.1.

Table 1. Short Names of the Research Variables, Their Definitions and Units

Name	Definition	Unit	Term	Name	Definition	Unit	Term
LNGDP	Log of real gross domestic products	Log of million Lei	2000Q1-2013Q4	LNEXR	Log of exchange rates	Log(Lei/Euro)	2000Q1-2013Q4
LNEXP	Log of real exports	Log of million Lei	2000Q1-2013Q4	LNINR	Log of interest rates	Log of rates	2000Q1-2013Q4
LNIMP	Log of real imports	Log of million Lei	2000Q1-2013Q4	DUM	Time dummy variable	0 / 1	2000Q1-2013Q4

Procedure

In this section, autoregressive distributed lag (ARDL) bounds F testing method (Pesaran and Shin, 1995 and 1998; Pesaran et al., 2001) which is adopted to determine the cointegration relationship is briefly summarized.

Methods based on ordinary least squares (OLS) techniques including ARDL and Johansen-Juselius maximum likelihood techniques to study long-run relationships and error correction models to explore Granger causality, suffer from unsuitability for small samples, pre-testing biases, the low power of unit root tests and the need for the rank conditions for valid results. These methods also need variables' to be integrated of the same order whereas in many studies same order integration is not obvious (Guru Gharana, 2012).

After the convenient study that Pesaran et al. (2001) offered, ARDL bounds F testing method has become popular for studying both long-run and short-run relationships and for examining Granger causality. The method modifies the ARDL framework. Endogeneity problem is solved and the long run and the short run parameters of the model are estimated simultaneously by using ARDL bounds F testing method. Small sample properties of this method are superior to multivariate cointegration (Narayan, 2005; Acaravci & Ozturk, 2012). One other flexibility of the ARDL bounds F testing is its usability when variables in the analysis may be $I(0)$, $I(1)$ or combination of both but not more than $I(1)$ (Pesaran et al., 2001). The ARDL bounds testing method allows the variables' having different optimal lags, while it is impossible with conventional cointegration procedures. Unit root tests such as Augmented Dickey-Fuller (ADF) or Phillips-Perron (PP) are performed to determine the order of integration of the series (Dickey & Fuller, 1981; Phillips & Perron, 1988).

In order to perform ARDL bounds F (or Wald) test for examining evidence for long run relationship, a system of unrestricted (or conditional) error correction model (UECM) is estimated (Pesaran et al., 2001). System contains an equation for each variable (as dependent) such as the equation written below for LNGDP when it is thought as dependent:

$$\begin{aligned} \Delta LNGDP_t = & \beta_0 + \eta DUM_t + \theta_0 LNGDP_{t-1} + \theta_1 LNEXP_{t-1} + \theta_2 LNIMP_{t-1} + \theta_3 LNEXR_{t-1} + \theta_4 LNINR_{t-1} \\ & + \sum_{i=1}^p \beta_i \Delta LNGDP_{t-i} + \sum_{i=0}^{q1} \gamma_i \Delta LNEXP_{t-i} + \sum_{i=0}^{q2} \delta_i \Delta LNIMP_{t-i} + \sum_{i=0}^{q3} \xi_i \Delta LNEXR_{t-i} \\ & + \sum_{i=0}^{q4} \psi_i \Delta LNINR_{t-i} + v_t \end{aligned} \quad (3)$$

where v_t is white noise error term independently and identically distributed (iid) with zero mean, homoscedasticity and no autocorrelation and Δ is the first difference operator. θ_i 's are the long run multipliers, the coefficients of the first differences of the lagged variables are short term dynamic coefficients and β_0 is the intercept. This model is estimated by using ordinary least squares (OLS) method. $(p+1)(q1+1)(q2+1)(q3+1)(q4+1)$ number of regressions are estimated to acquire the optimal lag-lengths in the equation and the choice between different lag lengths is made by using information criteria such as Akaike (AIC) or Schwarz (SC). Schwarz information criterion (SC) preferred to AIC because it tends to define more parsimonious specifications (Pesaran & Shin, 1995; Acaravci & Ozturk, 2012).

Alternatively, unrestricted error correction model (UECM) can be derived from underlying VAR(p) model, instead of specifying an ARDL model (Pesaran et al., 2001; Fosu & Magnus, 2006; Keong et al., 2005). Then number of regressions

to specify the unrestricted error correction model becomes $(p+1)(k+1)$ where $(k+1)$ is the number of all variables and p is the desired maximum lag length. Unrestricted error correction model (UECM) derived from underlying VAR(p) can be represented as below (equation 4 is written for each variable again). The difference between equation (3) and (4) is that lag lengths of the first differenced right side variables are the same in equation (4) whereas they may be different in equation (3).

$$\begin{aligned} \Delta LNGDP_t = & \beta_0 + \eta DUM_t + \theta_0 LNGDP_{t-1} + \theta_1 LEXP_{t-1} + \theta_2 LNIMP_{t-1} + \theta_3 LNXER_{t-1} + \theta_4 LNINR_{t-1} \\ & + \sum_{i=1}^p \beta_i \Delta LNGDP_{t-i} + \sum_{i=0}^p \gamma_i \Delta LEXP_{t-i} + \sum_{i=0}^p \delta_i \Delta LNIMP_{t-i} + \sum_{i=0}^p \xi_i \Delta LNXER_{t-i} \\ & + \sum_{i=0}^p \psi_i \Delta LNINR_{t-i} + v_t \end{aligned} \quad (4)$$

ARDL bounds F test statistic is employed to determine whether a long run relationship exists between the variables by imposing equality to zero restriction on all coefficients of lagged level variables. The long run relationship test is equivalent to the cointegration test. Null hypothesis of no cointegration against the alternative hypothesis of existence of cointegration becomes (Keong et al., 2005; Guru Gharana, 2012)

$$\begin{aligned} H_0 : & \theta_0 = \theta_1 = \theta_2 = \theta_3 = \theta_4 = 0 \\ H_1 : & \theta_0 \neq 0; \theta_1 \neq 0; \theta_2 \neq 0; \theta_3 \neq 0; \theta_4 \neq 0; \theta_5 \neq 0 \end{aligned} \quad (5)$$

The asymptotic distribution for the ARDL bounds F test statistic is non-standard under the null hypothesis that there exists no level relationship, irrespective of whether the regressors are $I(0)$ or $I(1)$. Exact critical values for the ARDL bounds F test are not available for several mix of $I(0)$ and $I(1)$ variables but Pesaran et al. (2001) calculated the bounds on the critical values for the asymptotic distribution of the F statistic under different situations by changing the number of explanatory variables (k) in the model and sample size, for different model specifications (like no constant + no trend, restricted constant + no trend etc.) and for each conventional levels of significance 1%, 5% and 10%. In each case, the lower bound is based on the assumption that all of the variables are $I(0)$, and the upper bound is based on the assumption that all of the variables are $I(1)$.

It is concluded that the variables are $I(0)$, when the computed bounds F test statistic falls below the lower bound, so no cointegration is possible by definition. When the bounds F test statistic exceeds the upper bound, it is concluded that there is cointegration. The test is inconclusive when the bounds F test statistic lies between the bounds. Critical table values (bounds) are calculated for small samples (between 30 and 80) by Narayan (2005). Critical bounds are used from Narayan (2005) and from Pesaran et al. (2001) with respect to sample size; the former is for sample size at most 80 and the latter one for more than 80.

The next step is estimating the conditional ARDL (p, q_1, q_2, q_3, q_4) long-run model when cointegration is determined. Pesaran and Shin (1998) demonstrated that the Schwarz criterion is superior over Akaike in the context of ARDL model (Guru Gharana, 2012). The long-run levels model showing the long-run equilibrating relationship and short-run error correction model to measure short-run dynamic effects can be identified by using the ARDL restricted error correction model (RECM) when cointegration is found so that the long-run and the short-run elasticity coefficients are determined.

The long-run relationship model is

$$\begin{aligned} LNGDP_t = & \alpha_0 + \lambda DUM_t + \sum_{i=1}^p \alpha_{gdp,i} LNGDP_{t-i} + \sum_{i=0}^{q_1} \alpha_{exp,i} LEXP_{t-i} + \sum_{i=0}^{q_2} \alpha_{imp,i} LNIMP_{t-i} \\ & + \sum_{i=0}^{q_3} \alpha_{exp,i} LNXER_{t-i} + \sum_{i=0}^{q_4} \alpha_{inr,i} LNINR_{t-i} + v_t \end{aligned} \quad (6)$$

where all variables are previously defined, α_0 is the constant term and v_t is the white noise error term. The short-run relationship model (RECM) is

$$\Delta LNGDP_t = \beta_0 + \eta DUM_t + \omega \hat{ECT}_{t-1} + \sum_{i=1}^p \beta_i \Delta LNGDP_{t-i} + \sum_{i=0}^{q1} \gamma_i \Delta LNEXP_{t-i} + \sum_{i=0}^{q2} \delta_i \Delta LNIMP_{t-i} + \sum_{i=0}^{q3} \xi_i \Delta LNEXR_{t-i} + \sum_{i=0}^{q4} \psi_i \Delta LNINR_{t-i} + e_t \quad (7)$$

where ω is the coefficient of the error (or equilibrium) correction term ECT. It shows variables' speed to converge to equilibrium and it is expected that ω has a significant negative value. Equation (7) can also be used for testing short-run and long-run Granger causality.

The variable ECTt-1 (error or equilibrium correction term) in the equation (7) is one lagged values of the estimated ordinary least squares (OLS) residuals (vt) of the long-run model given in equation (6). Long-run coefficients can also be calculated by using estimated θ coefficients of the unrestricted error correction model (UECM, equation 3 or 4). The long-run estimated relationship for any Xi is obtained by $-(\theta_1 / \theta_0)$. For example in equation (3 and 4), the long-run export and import elasticities are $-\theta_1/\theta_0$ and $-\theta_2/\theta_0$, respectively. The short-run effects are captured by the coefficients of the first-differenced variables in (3 and 4) (Keong et al., 2005). Both functional form misspecification and assumptions about the residuals in the restricted error correction model (equation 7) such as no serial correlation, normality and homoscedasticity should be checked by performing diagnostic tests.

A joint hypothesis testing for the coefficients of lagged differences of variables can be used for short-run Granger causality test for each regressor in the equation (7). The significance of the coefficient of the error correction term (ECTt-1) can be used for testing long-run Granger causality. A combined hypothesis test for the coefficients of lagged differences of variables and coefficient of the error correction term (ECTt-1) can be used for strong form of Granger causality test (Acaravci & Ozturk, 2012; Guru Gharana, 2012). Stability of the model can be tested through recursive regression residuals using the Brown et al. (1975) method, also known as the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) tests. The coefficients of the model are stable when the plots of calculated statistics lie between the critical bounds of 5% significance (Guru Gharana, 2012).

Toda and Yamamoto (1995) proposed another causality (named non-causality) testing approach. Toda-Yamamoto Granger non-causality test corresponds to the vector autoregressive (VAR) model (Toda & Yamamoto, 1995):

$$\begin{aligned} LNGDP_t = & \alpha_0 + \left(\sum_{i=1}^k \alpha_{1i} LNGDP_{t-i} + \sum_{i=k+1}^{d \max} \alpha_{2i} LNGDP_{t-i} \right) + \left(\sum_{i=1}^k \beta_{1i} LNEXP_{t-i} + \sum_{i=k+1}^{d \max} \beta_{2i} LNEXP_{t-i} \right) \\ & + \left(\sum_{i=1}^k \gamma_{1i} LNIMP_{t-i} + \sum_{i=k+1}^{d \max} \gamma_{2i} LNIMP_{t-i} \right) + \left(\sum_{i=1}^k \delta_{1i} LNEXR_{t-i} + \sum_{i=k+1}^{d \max} \delta_{2i} LNEXR_{t-i} \right) \\ & + \left(\sum_{i=1}^k \varphi_{1i} LNINR_{t-i} + \sum_{i=k+1}^{d \max} \varphi_{2i} LNINR_{t-i} \right) + \varepsilon_t \end{aligned} \quad (8)$$

Equation (8) is written for each of the five variables as a system first to determine optimum VAR lag-length k by using information criteria such as Akaike or Schwarz. The greatest order of integration, which is obtained from the unit root tests, of all five variables is defined as dmax and then above (equation 8) VAR system is estimated. Null hypothesis of no Granger causality against the alternative hypothesis of existence of Granger causality is defined for each equation (left side variable) in the VAR system. Hence the Granger causality for instance from LNEXP to LNGDP (LNEXP→LNGDP) implies $\beta_{1i} \neq 0$ ($\forall i$) in the first equation written for LNGDP (equation 8).

Toda-Yamamoto Granger non-causality test can be performed irrespective of whether the variables are I(0), I(1) or I(2), cointegrated or not cointegrated, but inverse roots of autoregressive (AR) characteristic polynomial should be inside of the unit circle to estimate robust causality result.

Results

While in the stationary time series shocks are temporary and series revert to their long run mean values in a short term, nonstationary series have a long memory and shocks affect them in a permanent way. Spurious regressions occur when time series are analyzed as stationary although one or more are nonstationary. In this study, Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests are performed. ADF and PP unit root (that means nonstationarity) test results for the logs of the real gross domestic product (LNGDP), real exports (LNEXP), real imports (LNIMP), exchange rates (LNEXR) and interest rates (LNINR) during the period 2000Q1-2013Q4 in Romania are given in Table 2.

Results of the PP unit root test denote that all of the time series are stationary at most in their first differences. The LNGDP series appears to be trend stationary (and stationary with a drift) while log of exchange rates (LNEXR) and log of imports (LNIMP) series seem to be stationary with a drift and log of interest rates (LNINR) seem to be stationary without a drift and trend in both levels and first difference. Results of the both ADF and PP unit root tests clearly indicate that log of exports (LNEXP) series is nonstationary when the variable is defined at levels with or without constant and trend.

It is concluded that the maximum order of integration of the series is I(1). All series in the analysis should be integrated of the same order for using the conventional cointegration analysis such as Engle and Granger or Johansen methods. This provides a good rationale for using the bounds test approach. Usability of the ARDL bounds F testing (cointegration analysis) method with a mixture of I(0) and I(1) data is the one of the superiorities of this method.

Table 2. Results of the Unit Root Tests

Variable	Test Statistic	Log Levels				First Difference			
		ADF	Lag	PP	Lag	ADF	Lag	PP	Lag
LNGDP	τ	1.8371	(5)	2.2818	(11)	-2.0510**	(4)	-15.9840***	(11)
	τ_{μ}	-1.8702	(5)	-5.0624***	(16)	-2.8147*	(4)	-20.3196***	(11)
	$\tau_{\mu+T}$	-1.3141	(5)	-6.4817***	(25)	-3.1703	(4)	-20.4638***	(11)
LNEXP	τ	2.4256	(4)	4.2520	(16)	-2.3951**	(3)	-8.3444***	(10)
	τ_{μ}	-0.9942	(4)	-2.0898	(16)	-3.5287**	(3)	-12.2584***	(21)
	$\tau_{\mu+T}$	-2.4400	(4)	-3.9643	(9)	-3.4796*	(3)	-15.0300***	(18)
LNIMP	τ	1.0053	(4)	2.2071	(19)	-2.3852**	(4)	-8.4032***	(20)
	τ_{μ}	-1.4209	(4)	-2.6572*	(19)	-2.8266*	(4)	-9.7659***	(27)
	$\tau_{\mu+T}$	-1.7048	(4)	-2.5437	(14)	-3.0959	(4)	-14.3959***	(19)
LNEXR	τ	1	(1)	1.3172	(5)	-4.4269***	(0)	-4.3650***	(3)
	τ_{μ}	-3.7459***	(1)	-3.8443***	(3)	-4.8451***	(0)	-4.8439***	(3)
	$\tau_{\mu+T}$	-3.3283*	(1)	-2.8906	(3)	-5.3471***	(0)	-5.3809***	(3)
LNINR	τ	-2.0012**	(0)	-2.0152**	(1)	-7.1682***	(0)	-7.1899***	(3)
	τ_{μ}	-1.0767	(0)	-1.0694	(1)	-7.4284***	(0)	-7.4286***	(2)
	$\tau_{\mu+T}$	-2.6033	(0)	-2.8393	(2)	-7.3499***	(0)	-7.3510***	(2)

Notes: $\tau_{\mu+T}$ represents the most general model with a drift and trend; τ_{μ} is the model with a drift and without trend; τ is the most restricted model without a drift and trend. (2) Numbers in brackets are lag lengths used in the ADF test (as determined by AIC) to remove serial correlation in the residuals. When using the PP test, numbers in brackets represent Newey–West bandwidth (as determined by Bartlett–Kernel). (3) Superscripts ***, ** and * denote rejection of the null hypothesis at the 1%, 5% and 10% levels respectively. (4) Unit root test results are obtained from E-VIEWS 7.1.

The optimal lag lengths for the first-differenced variables are determined using Schwarz information criterion (SC) allowing maximum lag length of 6 and then equation (3) denoting the unrestricted error correction model (UECM) is derived from underlying ARDL model. Instead of estimating 75=16807 equations, a hierarchical approach is used to evaluate the optimum lag lengths for the first differenced variables in the UECM following the method proposed by Kamas and Joyce (1993) (Yüce Akıncı & Akıncı, 2014).

Table 3. Results of the AIC and SC for the Unrestricted Error Correction Model (UECM)

Lag Length	Δ LNGDP		Δ LNEXP		Δ LNIMP		Δ LNEXR		Δ LNINR	
	AIC	SC	AIC	SC	AIC	SC	AIC	SC	AIC	SC
0	NA	NA	-	-	-	-	-	-	-	-
1	2.2548	1.9602	5.1043	4.6072	5.3033	4.7679	5.2919	4.7183	5.3481	4.7363
2	2.2557	1.9212	5.0647	4.5294	5.2679	4.6943	5.2660	4.6541	5.3966	4.7465
3	4.3629	3.9877	5.1653	4.5917	5.2279	4.6160	5.3526	4.7025	5.3618	4.6734
4	4.9684	4.5517	5.1519	4.5401	5.2106	4.5605	5.4002	4.7119	5.4357	4.7091
5	5.0291	4.5702	5.1120	4.4619	5.1768	4.4885	5.3856	4.6590	5.3970	4.6322
6	4.9772	4.4752	5.0885	4.4001	5.1485	4.4219	5.3794	4.6146	5.3997	4.5967
	4.9772	4.4752	5.0562	4.3226	5.1505	4.3783	5.3924	4.5816	5.4546	4.6052

Lag length p for the Δ LNGDP variable in equation (3) is determined firstly by using minimum SC value. After the lag length p is determined, Δ LNGDPt-p is fixed and the same process is run for the first differenced explanatory variables Δ LNEXP, Δ LNIMP, Δ LNEXR and Δ LNINR respectively. The results of the Schwarz information criterion (and Akaike's information criterion, AIC) are shown in Table 3. Estimated coefficients of the UECM (equation 3) are shown in Table 4, where optimum lag lengths are chosen as p=5, q1=0, q2=0, q3=0 and q4=1.

Table 4. Unrestricted Error Correction Model (UECM)

Regressor	Coefficient	t statistics	p value
Intercept	3.2616	3.6463	0.0009
DUM	-0.0340	-2.5794	0.0145
LNGDPt-1	-0.5785	-5.2395	0.0000
LNEXPt-1	0.1007	1.7612	0.0875
LNIMPt-1	0.2168	4.0459	0.0003
LNEXRt-1	-0.0736	-1.9729	0.0569
LNINRt-1	0.0282	2.8090	0.0083

$\Delta \text{LNGDPt-1}$	-0.0718	-0.5852	0.5624
$\Delta \text{LNGDPt-2}$	-0.2909	-3.5611	0.0011
$\Delta \text{LNGDPt-3}$	-0.4667	-5.5922	0.0000
$\Delta \text{LNGDPt-4}$	0.3718	3.5338	0.0012
$\Delta \text{LNGDPt-5}$	-0.1175	-0.9889	0.3299
ΔLNEXPt	0.0887	1.6304	0.1125
ΔLNIMPt	0.1160	2.9276	0.0061
ΔLNEXRt	-0.1157	-1.5334	0.1347
ΔLNINRt	0.0178	1.9077	0.0652
$\Delta \text{LNINRt-1}$	-0.0158	-1.7469	0.0900

Using lag orders of $p=5$, $q_1=0$, $q_2=0$, $q_3=0$ and $q_4=1$ for the first differenced variables and the results of the estimated unrestricted (unconstrained) error correction model (UECM), Wald (F) test is performed for the hypothesis given in the equation (5) for the sample period of 2000q1-2013q4. The results of the bounds F test are summarized in the Table 5.

Table 5. Results of the Bounds F Cointegration Test

F statistic	Sample sizes of critical table values	$\alpha = 0.01$		$\alpha = 0.05$		$\alpha = 0.10$	
		I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
6.9890	n = 55	4.244	5.726	3.068	4.334	2.578	3.710
(n = 56, k = 4)	n = 60	4.176	5.676	3.062	4.314	2.568	3.712

Notes: Critical values I(0) and I(1) are obtained from Narayan (2005), "Critical values for the bounds test: caseIII: unrestricted intercept and no trend", p.1988; $k=4$. F statistic is significant at the 5% significance level.

The result of the bounds test confirms the presence of a long run relationship when the log of gross domestic product (LNGDP) is dependent variable of the model for the period 2000Q1-2013Q4 in Romania. Calculated F statistic is 6.9890. Upper bound critical values are $I(1)=5.726$ ($n=55$) and $I(1)=5.676$ ($n=60$) for $k+1=5$ variables ($k=4$) and 1% significance level. Null hypothesis of no cointegration is rejected at the 1% significance level because F test statistic is greater than the critical upper bounds value I(1). It is concluded from the ARDL bounds F testing methodology that there is strong evidence of long-run equilibrating relationship between LNGDP as the dependent variable and LNEXP, LNIMP, LNEXR and LNINR as the regressors for the period of 2000q1-2013q4 in Romania.

It is confirmed that there exists a long run relationship between the logs of gross domestic product (LNGDP), exports (LNEXP), imports (LNIMP), exchange rates (LNEXR) and interest rates (LNINR) but it is important the unrestricted error correction model (UECM)'s being met the necessary assumptions which are checked by the diagnostic tests. Results are reported in the Table 6.

Table 6. Diagnostic Tests for the Unrestricted (unconstrained) Error Correction Model (UECM)

Null Hypothesis	Test Statistic	df	p value	Null Hypothesis	Test Statistic	df	p value
No Serial Correlation	$\chi^2_1 = 0.5981$	1	0.4393	Homoscedasticity	$\chi^2_{16} = 6.2449$	16	0.9852
No Serial Correlation	$\chi^2_4 = 5.3920$	4	0.2494				

Normality	$\chi^2_2 = 1.0196$	2	0.6006	No ARCH effect	$\chi^2_1 = 0.5018$	1	0.4787
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Lagrange multiplier test of residual serial correlation is performed to check if residuals have serial correlation for the lag lengths 1 and 4; Jarque-Bera normality test based on the skewness and kurtosis measures of the residuals is used to control if the distribution of the residuals is normal; Breusch-Godfrey heteroscedasticity test based on the regression of squared residuals on the original regressors of the model is performed to test the null hypothesis of homoscedasticity and the null hypothesis of no ARCH effects in the residuals is tested by regressing the squared residuals on the one period lagged squared residuals and a constant term. Obtained hypothesis testing results do not reject the null hypotheses. It is concluded that the unrestricted error correction model (UECM) satisfies the given assumptions.

After determining the long-run cointegration relationship, the short-run and the long-run elasticity coefficients are estimated by using the ARDL procedure. For both of the long-run and the short-run ARDL models (equations 6 and 7), equations are estimated and Schwarz information criterion is used to determine the optimum lag lengths following again the method proposed by Kamas and Joyce (1993) (Yüce Akıncı & Akıncı, 2014). Estimated long-run levels model is shown in the Table 7. Lagged values of the estimated residuals of the long-run levels model are used as error (equilibrium) correction term (ECT) in the short-run model.

Table 7. Estimated Long-run Coefficients

Regressor	Coefficient	Standard Error	t statistic	p value
Intercept	2.4430	0.7003	3.4883	0.0012
DUM	-0.0238	0.0116	-2.0446	0.0475
LNEXP	0.0924	0.0451	2.0476	0.0472
LNIMP	0.1388	0.0341	4.0749	0.0002
LNEXR	-0.0526	0.0320	-1.6436	0.1081
LNINR	0.0146	0.0072	2.0215	0.0500
LNGDPt-1	0.4462	0.0817	5.4611	0.0000
LNGDPt-2	-0.0978	0.0278	-3.5149	0.0011
LNGDPt-3	-0.1394	0.0280	-4.9877	0.0000
LNGDPt-4	0.8848	0.0310	28.5477	0.0000
LNGDPt-5	-0.5197	0.0815	-6.3799	0.0000

Note: Dependent Variable is LNGDP, the chosen model is ARDL(5, 0, 0, 0, 0)

In the long run, elasticity coefficient of log of the imports (LNIMP) is 0.14% and it is significant at the 1% level. Elasticity coefficients of the logs of exports (LNEXP) and interest rates (LNINR) are estimated as 0.09% and 0.01% respectively and they are significant at the 5% level. Estimated long-run elasticity of the log of the exchange rates (LNEXR) is -0.05% and the p-value obtained is 10.8%. The long-run estimates show that exports, imports and interest rates are positively correlated but exchange rates are negatively correlated to economic growth. The negative relationship between the exchange rate and GDP shows that the depreciation of the exchange rate will slow down economic growth in Romania. Dummy variable (DUM) with the estimated coefficient of -0.02 is found statistically significant at the 5% level. It is concluded that after the European Union membership, the log of gross domestic product (LNGDP) of Romania is 0.02 points on average less than before the membership. Also, it is found but not reported here that when DUM is not in the model, coefficients of the model are not stable. The lagged values of the dependent variable (LNGDP) from 1 to 5 are found significant at the 1% level as shown in Table 7.

Table 8. Values of the AIC and SC for the Restricted Error Correction Model (RECM)

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ΔLNEXRt	-0.1092	0.0635	-1.7188	0.0942
ΔLNINRt	0.0201	0.0080	2.5046	0.0169
$\bar{R}^2 = 0.9956 \quad \hat{\sigma} = 0.0145 \quad AIC = -5.4062 \quad SC = -4.9043$				

Notes: $\bar{R}^2$ is the adjusted squared multiple correlation coefficient, $\hat{\sigma}$ is standard error of the regression, AIC and SC are Akaike's and Schwarz's information criteria. Dependent variable of the model is ΔLNGDP .

Significance of the error (equilibrium) correction term (ECTt-1) clearly shows long-term Granger causality. The sign of the error correction term (ECT) is correct and it measures the speed at which prior deviations from the equilibrium are corrected in the current period. Estimated ECT coefficient is -0.99 (ECTt-1 = -0.9890) and significant at the 1% level, thus indicating that almost 99% of the dis-equilibrium due to the previous term's shocks is adjusted back to the long-run equilibrium in the current term. The speed of adjustment is very high.

All explanatory variables which are logs of exports, imports, exchange rates and interest rates (LNEXP, LNIMP, LNEXR and LNINR) have significant short-run impact on the log of gross domestic product (LNGDP) during the term 2000q1-2013q4 in Romania. Estimated short-run elasticities are 0.10% for the log of exports (LNEXP), 0.11% for the log of imports (LNIMP), -0.11% for the log of the exchange rates (LNEXR) and 0.02% for the log of interest rates (LNINR) and they are significant at the 10%, 1%, 10% and 5% levels respectively. All five lagged changes except the second lag of ΔLNGDP are statistically significant at the 1% level whereas sixth lag of ΔLNGDP is insignificant (but kept in the model to ensure residuals have no serial correlation and the coefficients of the model are stable). Dummy variable (DUM) in the short-run model is found insignificant ($p=0.52$).

The diagnostic tests are performed for the restricted error correction (short-run) model (RECM) and results are reported in Table 10. The Lagrange multiplier tests are used to test the null hypotheses of no serial correlation in the residuals for lag-one and lag-four periods. p values obtained for the Lagrange multiplier tests are 0.1812 and 0.0403 respectively. There exists no first order serial correlation in the residuals at the conventional significance levels but the p-value of the fourth order serial correlation test is not high (4.03%). This may be evaluated as the weakness of the estimated model (but this model is the best one among the obtained models). Null hypothesis of normality is not rejected by the Jarque-Bera normality test (p-value is 0.6354). The Breusch-Godfrey heteroscedasticity test confirmed that there is no heteroscedasticity in the residuals (p-value is 0.1790). The null hypothesis of no ARCH effects in the residuals is tested by regressing the squared residuals on the one period lagged squared residuals and a constant term. Null of no ARCH effects is not rejected (p-value is 0.2258). Finally, null hypothesis of no mis-specification is not rejected at the 5% level by the calculated Ramsey's RESET test statistic (p-value is 0.0675).

Table 10. Diagnostic Tests for the Restricted Error Correction Model (RECM)

Null Hypothesis	Test Statistic	df	p-value	Null Hypothesis	Test Statistic	df	p-value
No Serial Correlation	$\chi^2_1 = 1.7880$	1	0.1812	Homoscedasticity	$\chi^2_{12} = 16.2743$	12	0.1790
No Serial Correlation	$\chi^2_4 = 10.0082$	4	0.0403	No ARCH Effect	$\chi^2_1 = 1.4669$	1	0.2258
Normality	$\chi^2_2 = 0.9070$	2	0.6354	No mis-specification	$\chi^2_1 = 3.3424$	1	0.0675

Stability of the parameters is tested by applying the cumulative sum of recursive residuals (CUSUM) and of squared recursive residuals (CUSUMSQ). Results are shown in Figure 1. The coefficients of the model are found stable because the plots of CUSUM and CUSUMSQ statistics fell inside the critical bounds of 5% significance level.

Figure 1. Cumulative Sum of Recursive Residuals and of Squares of Recursive Residuals for the RECM Model.

ARDL bounds F testing method is used to determine if there exists a long-run relationship (cointegration) among the logs of gross domestic product (LNGDP), exports (LNEXP), imports (LNIMP), exchange rate (LNEXR) and interest rates (LNINR). ARDL cointegration method does not indicate the direction of causality. The long-run, short-run and the strong form of the Granger causality test are performed to test the causality hypotheses from each of the explanatory variables to the log of the gross domestic product (LNGDP) by using restricted error correction model (RECM) given in equation (7).

Short-run (weak) Granger causalities for the chosen model where LNGDP is the dependent (or normalized) variable are

tested by using the null hypotheses of $H_0 : \gamma_i = 0$ (no $\Delta \text{LNEXP} \rightarrow \Delta \text{LNGDP}$), $H_0 : \delta_i = 0$ (no $\Delta \text{LNIMP} \rightarrow \Delta \text{LNGDP}$),

$H_0 : \xi_i = 0$ (no $\Delta \text{LNEXR} \rightarrow \Delta \text{LNGDP}$) and $H_0 : \psi_i = 0$ (no $\Delta \text{LNINR} \rightarrow \Delta \text{LNGDP}$) which show short-run non-causalities from the logs of exports (LNEXP), imports (LNIMP), exchange rates (LNEXC) and interest rates (LNINR) to the log of gross domestic product (LNGDP). Wald test is used to perform hypothesis testing on the coefficient restrictions.

Long-run Granger causality from the explanatory variables to LNGDP is tested by using Wald test (or t test) on coefficient of the error correction term (ECT) in equation (7). The null hypothesis which shows there is no long-run Granger causality

from the explanatory variables to LNGDP is $H_0 : \omega = 0$ (no $\text{ECT} \rightarrow \Delta \text{LNGDP}$).

Strong form of the Granger causality is tested by using Wald test on joint coefficient restrictions of the restricted error

correction model (RECM) in equation (7). The null hypotheses are $H_0 : \omega = \gamma_i = 0$ (no $\Delta \text{LNEXP} + \text{ECT} \rightarrow \Delta \text{LNGDP}$),

$H_0 : \omega = \delta_i = 0$ (no $\Delta \text{LNIMP} + \text{ECT} \rightarrow \Delta \text{LNGDP}$), $H_0 : \omega = \xi_i = 0$ (no $\Delta \text{LNEXR} + \text{ECT} \rightarrow \Delta \text{LNGDP}$) and

$H_0 : \omega = \psi_i = 0$ (no $\Delta \text{LNINR} + \text{ECT} \rightarrow \Delta \text{LNGDP}$).

Results of the Granger non-causality tests are reported in Table 11.

Table 11. Results of the Short-run, Long-run and the Stronger Form of the Granger Causality Tests

Short-run Granger Causality			Strong form of the Granger Causality		
Null Hypothesis	Wald F Test Statistic	p- value	Null Hypothesis	Wald F Test Statistic	p- value
$H_0 : \gamma_i = 0$	$F_{1,36} = 3.8742$	0.0568	$H_0 : \omega = \gamma_i = 0$	$F_{2,36} = 11.7502$	0.0001

No $\Delta \text{LNEXP} \rightarrow \Delta \text{LNGDP}$	No $\Delta \text{LNEXP} + \text{ECT} \rightarrow \Delta \text{LNGDP}$
$H_0 : \delta_i = 0$	$H_0 : \omega = \delta_i = 0$
$F_{1,36} = 8.9635$ 0.0050	$F_{2,36} = 12.3069$ 0.0001
No $\Delta \text{LNIMP} \rightarrow \Delta \text{LNGDP}$	No $\Delta \text{LNIMP} + \text{ECT} \rightarrow \Delta \text{LNGDP}$
$H_0 : \xi_i = 0$	$H_0 : \omega = \xi_i = 0$
$F_{1,36} = 2.9542$ 0.0942	$F_{2,36} = 11.8095$ 0.0001
No $\Delta \text{LNEXR} \rightarrow \Delta \text{LNGDP}$	No $\Delta \text{LNEXR} + \text{ECT} \rightarrow \Delta \text{LNGDP}$
$H_0 : \psi_i = 0$	$H_0 : \omega = \psi_i = 0$
$F_{1,36} = 6.2731$ 0.0169	$F_{2,36} = 12.2748$ 0.0001
No $\Delta \text{LNINR} \rightarrow \Delta \text{LNGDP}$	No $\Delta \text{LNINR} + \text{ECT} \rightarrow \Delta \text{LNGDP}$

Long-run Granger Causality		
Null Hypothesis	Wald F Test Statistic	p- value
$H_0 : \omega = 0$	$F_{1,36} = 18.0309$	0.0001
No ECT $\rightarrow \Delta \text{LNGDP}$		

When the model is normalized on the log of the gross domestic product (so LNGDP is the dependent variable of the model), there exists a strong long-run Granger causality from the logs of exports (LNEXP), imports (LNIMP), exchange rates (LNEXR) and interest rates (LNINR) to the log of gross domestic product (LNGDP) in Romania for the period of 2000q1-2013q4.

The F-tests on the joint deletion of the corresponding coefficients show strong evidences of short-run Granger causalities from the log of exports to the log of GDP, from the log of imports to log of GDP, from the log of exchange rates to log of GDP and from the log of interest rates to the log of GDP at the 10%, 1%, 10% and 5% significance levels respectively. Also, results of the strong Granger causality tests indicate that there are strong causalities from each of the log of the explanatory variables namely exports, imports, exchange rates and interest rates to the log of GDP.

Discussion

In this study, an empirical model is investigated between five time series variables which are logs of gross domestic product (LNGDP), exports (LNEXP), imports (LNIMP), exchange rates (LNEXR) and interest rates (LNINR) during the term from the first quarter of 2000 to the fourth quarter of 2013 (2000q1-2013q4) in Romania.

Autoregressive distributed lag (ARDL) model is specified to identify the relationship between the log of gross domestic product (LNGDP) and the other four explanatory variables. ARDL bounds F test procedure is used to determine the cointegration relationship for Romania and a cointegration relationship is detected when log of gross domestic product (LNGDP) is identified as dependent to the other four explanatory macroeconomic variables in the model. After confirming that there exists cointegration relationship, the long run and the short run elasticity coefficients of the log of gross domestic product (LNGDP) are explored.

Results of this analysis indicate that there exists a long run cointegration relationship between the logs of gross domestic product (LNGDP), exports (LNEXP), imports (LNIMP), exchange rates (LNEXR) and interest rates (LNINR) in Romania where the log of gross domestic product (LNGDP) is defined as dependent variable in an ARDL framework. Because of

cointegration relationship, it is reasonable to estimate a dynamic error correction model for Romania and subsequently estimate the long and the short run elasticity coefficients. Long-run and short-run elasticity coefficients are explored by using ARDL model and the causalities from the explanatory variables to LNGDP are determined.

Results show that logs of exports (LNEXP), imports (LNIMP), exchange rates (LNEXR) and interest rates (LNINR) have a substantial long-run effect on the log of gross domestic product (LNGDP) with respective long-run elasticity coefficients of 0.09% (LNEXP), 0.14% (LNIMP), -0.05% (LNEXR, p-value is 10.8%) and 0.01% (LNINR). Under specified model, log of exchange rates (LNEXR) has a long-run effect on the log of gross domestic product (LNGDP) at the 10.81% significance level. The long-run estimates show that exports, imports and interest rates are positively correlated but exchange rate is negatively correlated to economic growth. The negative relationship between the exchange rate and GDP shows that the depreciation of the exchange rate will slow down economic growth in Romania. Dummy variable (DUM) with the estimated coefficient of -0.02 is found statistically significant at the 5% level and it is concluded that after the European Union membership, the log of gross domestic product (LNGDP) of Romania is 0.02 points on average less than before the membership.

Dynamic short-run effects are estimated and results show that each of the four explanatory variables affect the log of gross domestic product (LNGDP) in the short term too. Estimated short-run elasticity coefficients are 0.10% for exports (LNEXP), 0.11% for imports (LNIMP), -0.11% for exchange rates (LNEXR) and 0.02% for interest rates (LNINR) in Romania.

Finally, long-run, short-run and the stronger form of the Granger causalities from each of the four explanatory variables to the log of gross domestic product (LNGDP) are examined by Granger non-causality testing method. Unidirectional short-run Granger causalities are determined from exports to gross domestic product (LNEXP→LNGDP), from imports to GDP (LNIMP→LNGDP), from exchange rates to GDP (LNEXR→LNGDP) and from interest rates to GDP (LNINR→LNGDP). There also exists the stronger form of the Granger causalities from each of the explanatory variables to GDP.

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