Manufacturing Output in Romania: an ARDL Approach

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Abstract

This paper empirically investigates manufacturing output function for Romania by using the quarterly time series data during the period 2000q1-2013q4. Research variables are manufacturing production index, labor cost index, producer energy price index, interest rate, exchange rate and a time dummy variable measuring the effect of Romania's participation to European Union. Long-run and short-run elasticities of variables were examined using the bounds testing cointegration method proposed by Pesaran et al. (2001). Results of the analysis show that Romania has a long run cointegration. The dynamic error correction model for Romania is found and subsequently long-run and short-run elasticity coefficients are explored by using ARDL model. It is detected that logs of energy price index, labor cost index and interest rates have a substantial long-run effect on the log of manufacturing production index with respective long-run elasticity coefficients of -0.51% (LNEPI), 0.57% (LNLCI) and -0.05% (for LNINR). Log of exchange rates does not have a long-run effect on the log of manufacturing production index. Causality test using the Toda and Yamamoto (1995) Granger non-causality procedure was employed in order to examine Granger causalities between variables and unidirectional Granger causalities as (LNLCI→LNMPI), (LNINR→LNMPI), (LNEXR→LNINR) and (LNEPI→LNMPI) are detected. CUSUM and CUSUMSQ stability tests on hypothesized manufacturing output function were also implemented.

Keywords: ARDL bounds F test, Toda-Yamamoto non-causality, Stability tests, Manufacturing output, Romania

Introduction

Development in industrial production generates the dynamics of growth and economic development. Industrialization is exceptionally substantial for the realization of economic development. In this study, the evidence of long-run cointegration relationship among the logs of manufacturing production index, energy price index, exchange rates and interest rates in Romania is investigated by using autoregressive distributed lag (ARDL) bounds F testing developed by Pesaran and Shin (1995) and Pesaran et al. (2001). Subsequentially the long-run and short-run elasticity coefficients are estimated. Direction of causality between the research variables are also investigated by using recently getting popularized Toda-Yamamoto Granger non-causality testing approach (Toda & Yamamoto, 1995). It is found that the cointegration relationship exists in Romania during the period 2000Q1-2013Q4 for the research variables identified below and after the causality assessment, unidirectional relationships are determined.

There are limited number of empirical researches investigating the determinants of production index in the literature. Bodo et al. (2000) tried to find best model to forecast the index of the industrial production in the Euro area by constructing univariate ARIMA to multivariate cointegrated VAR and conditional models. They found that the conditional error correction model in which the aggregate index of industrial production is explained by the US industrial production index and the business confidence index from the European Commission harmonised survey on manufacturing firms achieves the best forecast performance. Zizza (2002) modeled the monthly volume of the industrial production of the euro area based on the US industrial production index to obtain short-term predictions and proposed the model on the single country forecasts of the production indices for the main euro area countries.

Bodo and Signorini (1987) built several models such as simple univariate, OLS that employs data on electric power input, corrected for the effects of temperature and (indirectly) of the manufacturing output mix and a transfer function model based

on business surveys. They determined that the best single forecasts are those based on the electric power input. Bodo, Cividini and Signorini (1991) used half monthly electricity consumption data to model the industrial production in Italy. They showed that a model using half monthly electricity data generates acceptable estimates of the monthly production index. Clark, P. K. (1987) decomposed quarterly data on industrial production and deflated gross national product in the US into independent nonstationary trend and stationary cycle components using Kalman filtering and smoothinq techniques. He detected that at least half of the quarterly innovation in US economic activity can be attributed to the stationary cyclical component. Barışık and Yayar (2012) used economic variables which are such as outward factors as oil price, exchange rate, export and inward factors as public expenditure, consumption expenditure and import to determine their effects on industrial production by using regression analysis. Authors demonstrated causal relationships between industrial production and economic variables and determined the impulse-responses. They showed that economic variables influence the industrial production.

Method

Framework

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

$$MPI_t = e^{\beta_0 + \eta DUM} EPI_t^{\beta_1} LCI_t^{\beta_2} EXR_t^{\beta_3} INR_t^{\beta_4} e^{v_t} \qquad (1)$$

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

$$LNMPI_t = \beta_0 + \eta DUM_t + \beta_1 LNEPI_t + \beta_2 LNLCI_t + \beta_3 LNEXR_t + \beta_4 LNINR_t + v_t \qquad (2)$$

Data and Approach

Data used in the analysis is defined in Table 1 and all raw data are obtained from Eurostat's web page[1]. Manufacturing production index (MPI) is the volume index (2010=100) of the production in Romania. Energy price index (EPI) is the output price index (2010=100) in national currency calculated by the producer prices in industry. Labor cost index (2008=100) (LCI) is calculated by compensation of employees plus taxes minus subsidies and rearranged by the authors to get new index which shows 2010=100. Exchange rates and interest rates are well known usual variables, they are obtained as monthly data and converted to quarterly data by the authors.

Also, DUM in the equation (2) is the dummy variable to capture the differences if any in the intercept before and after Romania's being the member of European Union at 01.01.2007. Dummy is coded as 0 and 1 to identify before and after European Union membership of Romania, respectively.

The sample size is 56, beginning from the first quarter of 2000 and ending at the fourth quarter of 2013. All variables except the dummy one are transformed into the natural logarithms in order to estimate elasticity coefficients as shown in the equation (2).

All results in this study are obtained from Eviews version 7.1 software.

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

Name	Definition	Unit	Term	Name	Definition	Unit	Term
LNMPI	Log of manufacturing production index	Log of index (2010=100)	2000Q1-2013Q4	LNEXR	Log of exchange rates	Log(Leu/Euro)	2000Q1-2013Q4
LNEPI	Log of energy	Log of index	2000Q1-	LNINR	Log of interest	Log of rates	2000Q1-

1 www.eurostat.com

| | price index | (2010=100) | 2013Q4 | | rates | | 2013Q4 |
| LNLCI | Log of labor cost index | Log of index (2010=100) | 2000Q1-2013Q4 | DUM | Time dummy variable | none | 2000Q1-2013Q4 |

Procedure

Autoregressive distributed lag (ARDL) F bounds test is performed to identify if there is a long-run relationship among the logs of manufacturing production index, energy price index, labor cost index, exchange rates and interest rates in Romania. ARDL cointegration test is used because this method has some advantages when it is compared to other alternatives such as Engle and Granger (1987), Johansen (1988), and Johansen and Juselius (1990) procedures. First of all it has more power and therefore recommended when sample size is small (Pesaran et al., 2001; Ghatak & Siddiki, 2001; Acaravci & Ozturk, 2012). One other flexibility of the ARDL bounds F testing is its usability when not all variables have the same order of integration. Variables in the analysis may be I(0), I(1) or combination of both. The only necessary condition for the integration order of the variables is order's being at most 1 (Pesaran et al., 2001; Acaravci & Ozturk, 2012). The ARDL bounds testing method allows the variables' to have different optimal lags, while it is impossible with conventional cointegration procedures. Finally, the ARDL bounds cointegration test utilizes only a single reduced form equation, while the conventional cointegration procedures estimate the long-run relationships within a context of system equations (Narayan, 2005; Acaravci & Ozturk, 2012). Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests are performed to determine the order of integration of the series (Dickey & Fuller, 1981; Phillips & Perron, 1988). Also, different variables can be assigned different lag-lengths as they enter the model.

Since we have hypothesized log-linear functional form between the research variables given in the equation (2), in order to perform ARDL bounds F (or Wald) test for examining evidence for long run relationship, an ARDL equation called as unrestricted (or unconstrained, conditional) error correction model (UECM) is constructed as below (Pesaran et al., 2001)

$$\Delta LNMPI_t = \beta_0 + \eta DUM_t + \theta_0 LNMPI_{t-1} + \theta_1 LNEPI_{t-1} + \theta_2 LNLCI_{t-1} + \theta_3 LNEXR_{t-1} + \theta_4 LNINR_{t-1}$$

$$+ \sum_{i=1}^{p} \beta_i \Delta LNMPI_{t-i} + \sum_{i=0}^{q1} \gamma_i \Delta LNEPI_{t-i} + \sum_{i=0}^{q2} \delta_i \Delta LNLCI_{t-i} + \sum_{i=0}^{q3} \xi_i \Delta LNEXR_{t-i}$$

$$+ \sum_{i=0}^{q4} \psi_i \Delta LNINR_{t-i} + v_t$$

(3)

where vt is white noise error term and Δ is the first difference operator. 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). 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. Residuals for the unrestricted error correction model (UECM) should be serially independent and the model itself should be dynamically stable. ARDL bounds F test statistic is calculated by imposing equality to zero restriction on all estimated coefficients of lagged level variables. Null hypothesis of no cointegration against the alternative hypothesis of existence of long-run cointegration becomes

$$H_0 : \theta_0 = \theta_1 = \theta_2 = \theta_3 = \theta_4 = 0$$

$$H_1 : \theta_0 \neq 0; \ \theta_1 \neq 0; \ \theta_2 \neq 0; \ \theta_3 \neq 0; \ \theta_4 \neq 0; \ \theta_5 \neq 0$$

(4)

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, unrestricted

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 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

$$LNMPI_t = \alpha_0 + \lambda DUM_t + \alpha_1 LNEPI_{t-1} + \alpha_2 LNLCI_{t-1} + \alpha_3 LNEXR_{t-1} + \alpha_4 LNINR_{t-1} + v_t \tag{5}$$

and the short-run relationship model (RECM, Restricted Error Correction Model) is

$$\Delta LNMPI_t = \beta_0 + \eta DUM_t + \omega E\hat{C}T_{t-1} + \sum_{i=1}^{p} \beta_i \Delta LNMPI_{t-i} + \sum_{i=0}^{q1} \gamma_i \Delta LNEPI_{t-i} + \sum_{i=0}^{q2} \delta_i \Delta LNLCI_{t-i}$$

$$+ \sum_{i=0}^{q3} \xi_i \Delta LNEXR_{t-i} + \sum_{i=0}^{q4} \psi_i \Delta LNINR_{t-i} + e_t \tag{6}$$

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 its to have a significant negative value.

The variable ECTt-1 (error or equilibrium correction term) in the equation (6) is one lagged values of the estimated ordinary least squares (OLS) residuals (vt) of the long-run model given in equation (5). Long-run coefficients can also be calculated by using estimated θI coefficients of the unrestricted error correction model (UECM, equation 3). The long-run estimated relationship for any Xi is obtained by $-(\theta I / \theta 0)$. Both functional form misspecification and assumptions about the residuals in the restricted error correction model (equation 6) such as no serial correlation, normality and homoscedasticity should be checked by performing diagnostic tests.

Toda-Yamamoto Granger non-causality test corresponds to the vector autoregressive (VAR) model (Toda & Yamamoto, 1995):

$$LNMPI_t = \alpha_0 + \left(\sum_{i=1}^{k} \alpha_{1i} LNMPI_{t-i} + \sum_{i=k+1}^{d\,max} \alpha_{2i} LNMPI_{t-i} \right) + \left(\sum_{i=1}^{k} \beta_{1i} LNEPI_{t-i} + \sum_{i=k+1}^{d\,max} \beta_{2i} LNEPI_{t-i} \right)$$

$$+ \left(\sum_{i=1}^{k} \gamma_{1i} LNLCI_{t-i} + \sum_{i=k+1}^{d\,max} \gamma_{2i} LNLCI_{t-i} \right) + \left(\sum_{i=1}^{k} \delta_{1i} LNEXR_{t-i} + \sum_{i=k+1}^{d\,max} \delta_{2i} LNEXR_{t-i} \right)$$

$$+ \left(\sum_{i=1}^{k} \varphi_{1i} LNINR_{t-i} + \sum_{i=k+1}^{d\,max} \varphi_{2i} LNINR_{t-i} \right) + \varepsilon_t \tag{7}$$

Equation (7) 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 7) 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 LNEPI to LNMPI (LNEPI→LNMPI) implies $\beta 1i \neq 0$ ($\forall$ i) in the first equation written for LNMPI (equation 7).

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

In this section, the results of various stages of analysis are presented and discussed. These include the unit root results for stationarity test, cointegration relationship, short-run and long-run estimations, and the causality analysis.

Augmented Dickey-Fuller and Phillips-Perron unit root test results for the logs of the manufacturing production index, energy price index, labor cost index, exchange rates and interest rates are given in Table 2. Test results show that all the time series variables are stationary at most in their first differences but some may be stationary in their levels. 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 but superiority of the ARDL bounds cointegration analysis is its usability with a mixture of I(0) and I(1) data. It is concluded from the results of the unit root tests that the maximum order of integration is found as 1.

Table 2. Unit Root Test Results

Variable	Test Statistic	Log Levels				First Difference			
		ADF	Lag	PP	Lag	ADF	Lag	PP	Lag
LNMPI	τ	1.3936	(4)	3.4234	(15)	-2.3960**	(3)	-11.1903***	(12)
	τ_μ	0.1130	(4)	-0.6775	(26)	-3.2804**	(4)	-18.6985***	(49)
	$\tau_{\mu+T}$	-3.2862*	(4)	-4.1533***	(4)	-3.4310*	(4)	-32.8554***	(53)
LNEPI	τ	1.1122	(1)	3.3928	(5)	-2.1605**	(0)	-2.1099**	(7)
	τ_μ	-4.1844***	(1)	-9.9320***	(1)	-2.4922	(0)	-2.1656	(4)
	$\tau_{\mu+T}$	-3.1663	(1)	-4.7479***	(0)	-3.9112**	(0)	-3.8793**	(2)
LNLCI	τ	0.7401	(4)	4.2055	(3)	-2.8659***	(3)	-6.2997***	(3)
	τ_μ	-1.2460	(4)	-9.7099***	(54)	-2.2730	(3)	-9.1705***	(4)
	$\tau_{\mu+T}$	-0.9854	(4)	-3.0293	(16)	-2.1454	(3)	-12.2755***	(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)
LNEXR	τ	1.2047	(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)

Notes: (1) $\tau_{\mu+T}$ 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 bandwith (as determined by Bartlett–Kernel). (3) Superscripts ***, ** and * denote rejection of the null hypothesis at the 1%, 5% and 10% levels respectively. (4) Tests for unit roots have been carried out in E-VIEWS 7.1.

Values of the Akaike and Schwarz information criteria obtained from the construction of the unrestricted error correction model (UECM) are reported in the Table 3 choosing the maximum lag lengths as five. The method proposed by Kamas and Joyce (1993) is followed in determining the optimum lag lengths for the unrestricted error correction model by using Schwarz information criterion (SC) (Yüce Akıncı & Akıncı, 2014). First, the optimum lag length for the differenced log of the manufacturing production index (ΔLNMPI) is determined when the other differenced series are not in the model. Then the same procedure is applied for the first regressor (first difference of the log of the energy price index, ΔLNEPI) to determine best lag length but using the fixed lag length found for the differenced log of the manufacturing production index (ΔLNMPI). After determining optimum lag lengths for ΔLNMPI and ΔLNEPI, lag length for the ΔLNLCI is specified by fixing the lag lengths for the ΔLNMPI and ΔLNEPI series. The procedure goes on the same way until the optimum lag lengths for all differenced series are identified. The chosen optimum lag lengths in the unrestricted error correction model are 4 (ΔLNMPI), 0 (ΔLNEPI), 4 (ΔLNLCI), 1 (ΔLNEXR) and 0 for ΔLNINR.

$$\Delta LNMPI_t = \beta_0 + \eta DUM_t + \theta_0 LNMPI_{t-1} + \theta_1 LNEPI_{t-1} + \theta_2 LNLCI_{t-1} + \theta_3 LNEXR_{t-1}$$

$$+\theta_4 LNINR_{t-1} + \sum_{i=1}^{4} \beta_i \Delta LNMPI_{t-i} + \sum_{i=0}^{0} \gamma_i \Delta LNEPI_{t-i} + \sum_{i=0}^{4} \delta_i \Delta LNLCI_{t-i}$$

$$+\sum_{i=0}^{1} \xi_i \Delta LNEXR_{t-i} + \sum_{i=0}^{0} \psi_i \Delta LNINR_{t-i} + e_t \qquad (8)$$

Table 3. AIC and SC Information Criteria for the UECM Model

Lag Length	$\Delta LNMPI_{t-i}$ AIC	SC	$\Delta LNEPI_{t-i}$ AIC	SC	$\Delta LNLCI_{t-i}$ AIC	SC	$\Delta LNEXR_{t-i}$ AIC	SC	$\Delta LNINR_{t-i}$ AIC	SC
0	-	-	-3.5608	-3.1063	-3.7182	-3.2258	-3.9419	-3.2601	-4.0263	-3.2687
1	-3.0077	-2.7130	-3.5300	-3.0376	-3.6818	-3.1515	-4.0524	-3.3327	-3.9953	-3.1999
2	-2.9461	-2.6115	-3.5512	-3.0209	-3.6513	-3.0831	-4.0588	-3.3012	-4.0375	-3.2042
3	-3.3495	-2.9743	-3.6179	-3.0498	-3.6157	-3.0096	-4.0720	-3.2765	-4.0517	-3.1805
4	-3.5841	-3.1674	-3.6023	-2.9962	-3.9466	-3.3027	-4.0462	-3.2129	-4.0125	-3.1034
5	-3.5527	-3.0939	-3.5886	-2.9385	-3.9079	-3.2196	-3.9931	-3.1136	-4.0098	-3.0538

ARDL bounds F test results are reported in Table 4 below. The result of the bounds test confirms the presence of a long run relationship when the log of manufacturing production index is dependent variable of the model for the period 2000Q1-2013Q4 in Romania. Calculated F statistic is 5.3082. Upper bound critical values are I(1)=4.334 (n=55) and I(1)=4.314

(n=60) for five variables (k=4) and 5% significance level. Null hypothesis of no cointegration is rejected at the 5% significance level because F test statistic is greater than the critical upper bounds value I(1).

Table 4. Results of F Bounds Test

F Statistic	Sample Size for Critical Table Values	$\alpha = 0.01$		$\alpha = 0.05$		$\alpha = 0.10$	
		I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
5.3082	n=55	4.244	5.726	3.068	4.334	2.578	3.710
(n=56)	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.

After confirming the existence of a long-run relationship among the logs of manufacturing production index, energy price index, labor cost index, exchange rates and interest rates, the diagnostic tests were examined from the unrestricted error correction (bounds test) model (UECM). These include Lagrange multiplier test of residual serial correlation, Ramsey's RESET test using the square of the fitted values for correct functional form (no mis-specification), Jarque-Bera normality test based on the skewness and kurtosis measures of the residuals and Breusch-Godfrey heteroscedasticity test based on the regression of squared residuals on the original regressors of the model. Diagnostic test results which are given below in Table 5 show that all assumptions about the specified model are met. None of the null hypotheses of no serial correlation, no mis-specification, normal distribution of the residuals and homoscedasticity can be rejected.

Table 5. Diagnostic tests from the Unrestricted (unconstrained) Error Correction Model (Bounds Test Model)

Null Hypothesis	Test Statistic	df	p-value	Null Hypothesis	Test Statistic	df	p-value
No Serial Correlation	$\chi_1^2 = 1.1453$	1	0.2845	Normality	$\chi_2^2 = 1.8868$	2	0.3893
No mis-specification	$\chi_1^2 = 1.9894$	1	0.1584	Homoscedasticity	$\chi_{19}^2 = 18.2936$	19	0.5029

Stability of the estimated parameters is tested by applying the cumulative sum of recursive residuals (CUSUM) and of squared residuals (CUSUMSQ) proposed by Brown et al. (1975). CUSUM and CUSUMSQ test results show that the parameters of the UECM model are relatively stable over time. The plots are given in Figure 1 below. The red lines represent critical bounds at 5% significance level.

Figure 1. Cumulative Sum of Recursive Residuals and of Squares of Recursive Residuals for the UECM Model
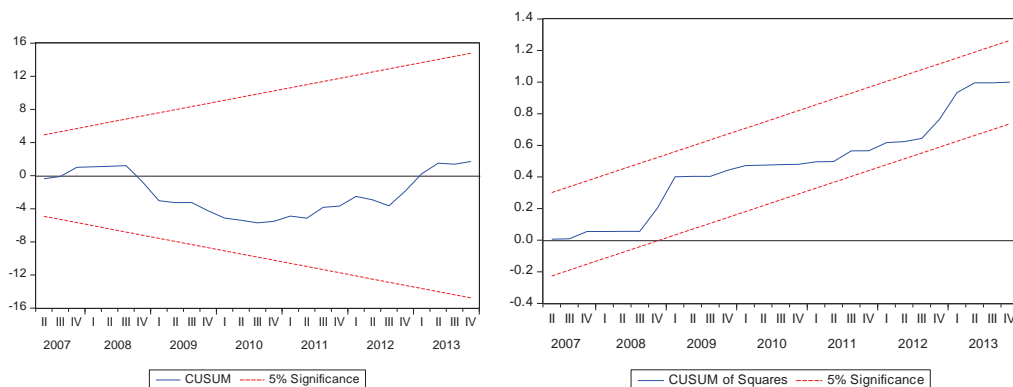
After determining the long-run cointegration relationship, the short-run and the long-run elasticity coefficients are estimated by using the ARDL procedure. Estimated long-run levels model is assigned as below and shown in the Table 6. Lagged values of the estimated residuals of the long-run levels model are used as error (equilibrium) correction term in the short-run model. Results of the short-run model are given in the Table 7.

$$LNMPI_t = 4.6319 + 0.0328 DUM_t - 0.5112 LNEPI_t + 0.5703 LNLCI_t - 0.1385 LNEXR_t$$

$$-0.0451 LNINR_t + \hat{v}_t$$

(9)

Table 6. Estimated Long-run Coefficients

Regressor	Coefficient	Standard Error	t Statistic	p-value
LNEPI	-0.5112	0.1707	-2.9939	0.0043
LNLCI	0.5703	0.1505	3.7896	0.0004
LNEXR	-0.1385	0.1047	-1.3231	0.1918
LNINR	-0.0451	0.0218	-2.0735	0.0433
C	4.6319	0.3077	15.0536	0.0000
DUM	0.0328	0.0512	0.6407	0.5247

In the long run, elasticity coefficients of energy price index, interest rates and exchange rates are all negative and their values are -0.51, -0.05 and -0.14 respectively. Long term elasticities for energy price index and interest rates are statistically significant at the 1% and 5% level. However, the coefficient of exchange rates in the long run is not statistically significant within the conventional 1-10% levels of significance. The long run elasticity coefficient of labor cost index is positive (0.57) and significant at the 1% level.

Although the coefficient of exchange rates in the long run is not statistically significant, in the short run, both the elasticity and lag-one period elasticity of exchange rates are significant at the 5% level. The contribution from exchange rates in the short run is about -0.37% (ΔLNEXRt = -0.3659) and short run lag-one period elasticity is positive 0.37% (ΔLNEXRt-1 = 0.3672).

On the other hand, estimated short run elasticities for energy price index and interest rates are -0.54% (ΔLNEPIt = -0.5399) and 0.02% (ΔLNINRt = 0.0238) but they are not statistically significant while both of energy price index and interest rates are significant in the long run.

Table 7. Restricted Error Correction Representation (Short-run EC Model)

Regressor	Coefficient	Standard Error	p-value
$E\hat{C}T_{t-1}$	-0.2944	0.1051	0.0082
$\Delta LNMPI_{t-1}$	0.0887	0.1542	0.5690
$\Delta LNMPI_{t-2}$	0.2310	0.1497	0.1318
$\Delta LNMPI_{t-3}$	0.0084	0.1345	0.9504
$\Delta LNMPI_{t-4}$	0.4958	0.1394	0.0011
$\Delta LNEPI_{t}$	-0.5399	0.3642	0.1471
$\Delta LNLCI_{t}$	-0.0827	0.2755	0.7657
$\Delta LNLCI_{t-1}$	-0.2725	0.1821	0.1434
$\Delta LNLCI_{t-2}$	-0.5384	0.1823	0.0056
$\Delta LNLCI_{t-3}$	-0.0943	0.1534	0.5429
$\Delta LNLCI_{t-4}$	0.5633	0.2257	0.0174
$\Delta LNEXR_{t}$	-0.3659	0.1666	0.0348
$\Delta LNEXR_{t-1}$	0.3672	0.1589	0.0269
$\Delta LNINR_{t}$	0.0238	0.0184	0.2039
Intercept	0.0385	0.0182	0.0415
DUM_{t}	-0.0199	0.0146	0.1820
$\overline{R}^{2} = 0.7035$	$\hat{\sigma} = 0.0325$	$AIC = -3.7671$	$SC = -3.1610$

Notes: (1) Model specification is ARDL(5, 0, 5, 2, 0) with dependent variable $\Delta LNMPI_{t}$ and $E\hat{C}T_{t-1}$ is the equilibrium correction term. (2) $\overline{R}^{2}$ is the adjusted squared multiple correlation coefficient and $\hat{\sigma}$ is the standard error of the regression. (3) AIC and SC are Akaike's and Schwarz's Bayesian Information Criteria.

Lag-two period and lag-four period elasticities for labor cost index in the short run are -0.54 ($\Delta LNLCI_{t}$ = -0.5384) and 0.56% ($\Delta LNLCI_{t}$ = 0.5633). Both these coefficients are significant at the 1% and 5% levels respectively.

Short run growth policies measured by the lag-four period manufacturing production index is significant at the 1% level and contribute about 0.57% ($\Delta LNMPI_{t-4}$ = 0.5633) to the current manufacturing production index.

The error (equilibrium) correction term (ECT) measures the speed at which prior deviations from the equilibrium are corrected in the current period. The estimated ECT coefficient is -0.29 (ECTt-1 = -0.2944) and significant at the 1% level, thus indicating that almost 30% of the dis-equilibrium due to the previous year's shocks is adjusted back to the long-run equilibrium in the current year.

The diagnostic tests given in the Table 8 are examined from the restricted error correction (short-run) model (RECM). The Lagrange multiplier tests are performed to test the null hypotheses of no serial correlation in the residuals for lag-one and lag-four periods. Both hypotheses cannot be rejected (p-values are 0.1376 and 0.2481 respectively). Null hypothesis of no mis-specification is not rejected by the calculated Ramsey's RESET test statistic (p-value is 0.7802). Null hypothesis of normality is not rejected according to the Jarque-Bera normality test (p-value is 0.5468). Performing the Breusch-Godfrey heteroscedasticity test comfirms that there is no heteroscedasticity in the residuals (p-value is 0.3801). Finally, 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 0.8453). All diagnostic test results confirm that all necessary conditions for the restricted error correction model are met.

Table 8. Diagnostic tests from the Restricted (constrained) Error Correction Model (Short-run ECM)

Null Hypothesis	Test Statistic	df	p-value	Null Hypothesis	Test Statistic	df	p-value
No Serial Correlation	$\chi^2_1 = 2.2047$	1	0.1376	Normality	$\chi^2_2 = 1.2072$	2	0.5468
No Serial Correlation	$\chi^2_4 = 5.4062$	4	0.2481	Homoscedasticity	$\chi^2_{15} = 16.0301$	15	0.3801
No mis-specification	$\chi^2_1 = 0.0779$	1	0.7802	No ARCH Effect	$\chi^2_1 = 0.0381$	1	0.8453

Stability of the estimated parameters is tested by applying the cumulative sum of recursive residuals (CUSUM) and of squared recursive residuals (CUSUMSQ).

Figure 2. Cumulative Sum of Recursive Residuals and of Squares of Recursive Residuals for the RECM Model
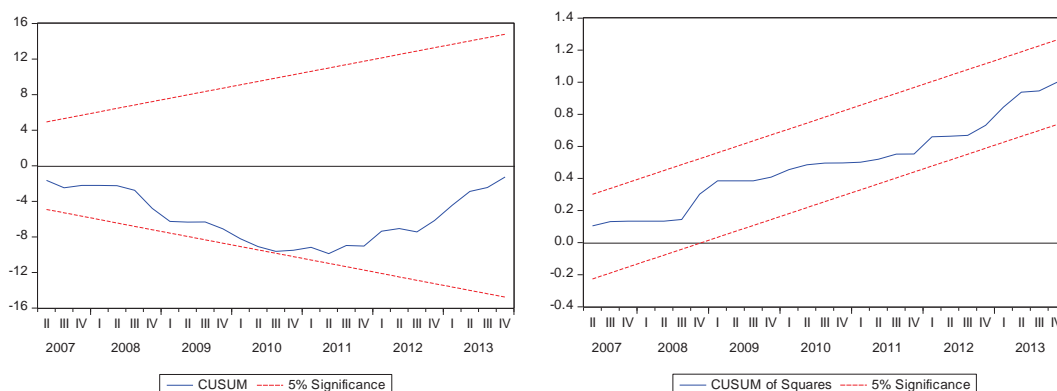
The results of Toda-Yamamoto Granger non-causality test are reported in the Table 9. Unidirectional causations from labor cost index to manufacturing production index (LNLCI→LNMPI), from interest rates to manufacturing production index (LNINR→LNMPI), from exchange rates to interest rates (LNEXR→LNINR) and from energy price index to manufacturing production index (LNEPI→LNMPI) are determined at the 1% (χ2 = 21.38), 1% (χ2 = 15.18), 5% (χ2 = 13.74) and 10% (χ2 = 9.73) levels of significance respectively.

Discussion

In this paper, an empirical model investigated among five time series variables which are logs of manufacturing production index, energy price index, labor cost index, exchange rates and interest rates. Data belong to Romania and enclose the term from the first quarter of 2000 to fourth quarter of 2013.

Autoregressive distributed lag (ARDL) model is specified to identify the relationship between the log of manufacturing production index and the other four explanatory variables. ARDL bounds F test procedure is used to determine the cointegrating relationship for Romania and a cointegrating relationship is detected when log of manufacturing production index is dependent to other explanatory variables in the model. After confirming that there exist cointegration, the long run and the short run elasticity coefficients of the log of manufacturing production index are explored.

Results of this analysis indicate that there exists a long run cointegration relationship between the logs of manufacturing production index, energy price index, exchange rates and interest rates in Romania where the log of manufacturing output is defined as dependent variable in an ARDL framework. It is reasonable to estimate dynamic error correction model for Romania and subsequently estimate the long and the short run relationships. Long-run and short-run elasticity coefficients are explored by using ARDL model and the direction of causality is detected. Results show that logs of energy price index, labor cost index and interest rates have a substantial long-run effect on the log of manufacturing production index with respective long-run elasticity coefficients of -0.51% (LNEPI), 0.57% (LNLCI) and -0.05% (LNINR). Under specified model, log of exchange rates does not have a long-run effect on the log of manufacturing production index. It is found that there are dynamic short-run effects. As well as lag-four of the log of the manufacturing production index contributes 0.50%, the short-run log of exchange rates is -0.37% and lag-one of the log of exchange rates is 0.37%. Lag-two and lag-four of the log of the labor cost index have a short-run effect on the log of manufacturing production index. The respective short-run elasticity coefficients are estimated as -0.54% and 0.56%.

Finally, direction of causality is examined by Toda-Yamamoto Granger non-causality testing process which is suitable even when the series are integrated of different orders. Unidirectional Granger causalities are determined from labor cost index to manufacturing production index (LNLCI→LNMPI), from interest rates to manufacturing production index (LNINR→LNMPI), from exchange rates to interest rates (LNEXR→LNINR) and from energy price index to manufacturing production index (LNEPI→LNMPI).

Table 9. Results of Toda-Yamamoto Granger non-causality Test

Dependent Variable: LNMPI				Dependent Variable: LNEPI			
Excluded	Chi-sq. Test Statistic	df	p-value	Excluded	Chi-sq. Test Statistic	df	p-value
LNEPI	9.7334	5	0.0832	LNMPI	6.4955	5	0.2609
LNLCI	21.3823	5	0.0007	LNLCI	2.5399	5	0.7705
LNEXR	8.4378	5	0.1337	LNEXR	3.2200	5	0.6661
LNINR	15.1795	5	0.0096	LNINR	1.0138	5	0.9614
Dependent Variable: LNLCI				Dependent Variable: LNEXR			
Excluded	Chi-sq. Test Statistic	df	p-value	Excluded	Chi-sq. Test Statistic	df	p-value
LNMPI	1.7558	5	0.8818	LNMPI	6.5615	5	0.2553
LNEPI	6.5796	5	0.2538	LNEPI	4.1658	5	0.5258
LNEXR	6.6196	5	0.2505	LNLCI	4.5223	5	0.4769
LNINR	2.4492	5	0.7841	LNINR	2.7699	5	0.7354
Dependent Variable: LNINR							
Excluded	Chi-sq. Test Statistic	df	p-value				
LNMPI	3.7689	5	0.5831				
LNEPI	4.5667	5	0.4710				
LNLCI	3.3070	5	0.6528				

LNEXR	13.7444	5	0.0173

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