The Estimation of the Cointegration Relationship between the Economic Growth, Investments and Exports. The Romanian Case

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Abstract. *This paper attempts to analyze the relationship between exports, investments and economic growth in Romania. For the search of this relationship I use a multivariate autoregressive VAR model. The results of cointegration analysis showed that there is one cointegrated vector among exports, investments and economic growth. Granger causality tests based on error correction models (ECM) have indicated that investment and export influences the steady-state level of GDP.*

Key words: exports; economic growth; investments; error correction model; Granger causality.

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Starting with 2000, Romania has registered a medium growth rate of almost 5%, which determined the slow decrease of income differences by comparison to the medium level that exists in the European Union (from almost 25% in 2001 to 32% in 2006 from GDP/inhabitant EU-15). Two of the real convergence sources were exports and investments. Thus, between 2000 and 2005, the exports have increased with almost 170% (in real terms), and the investments rate has increased from 18, 5% to 23% from GDP. The rise of the real GDP was of almost 45% in the same period. Romania has registered a rise of the economic opening degree as well as a reorientation of the commercial exchanges towards the European Union, aspects which explain the dynamic of the exports.

The economic theory suggests that the expansion of the exports generates an improvement of the efficiency in allocating the productive resources and a rise of the production volume by accumulating capital (Romer, 1989, Edwards, 1992). According to Edwards (1997), the export rise determines the increase of the degree of economic openness, thus those economies will be able to absorb faster (by imitation) the technologies of the more advanced countries. Thus, a rise of the total factor productivity will result, which will positively influence on the long-run the economic growth.

According to the neoclassical theory of international commerce, the commercial integration process will induce in the case of the Central and Eastern Europe countries (characterized by a low capital stock and a cheap labour force) a decrease in the relative prices for the intensive goods and an increase in the export weight of the capital intensive goods. This approach is replenished by the new theories of the economic growth, according to which the commercial exchanges influence the economy through the scale economies and through a more efficient use of resources. Commerce allows the more rapid access of technologies, which is an important factor for the sustainable economic growth. Ben-David and Loewy (1998) have proven the positive impact of modifying the export structure of a country over its real convergence.

A series of empirical studies have tested both the correlation between the export dynamics and the process of economic growth, and the methods of transmitting the effects between the two variables. In order to detect the causal relation between them, Pereira and Xu (2000) used the causality concept in the Granger thinking. According to it, exports sustain economic growth, the estimation of the increase variable being improved by including the export as lagged variable. Likewise, the economic growth is a cause for the export variable if the latter's estimation contains a decrease of the forecast error by including theeconomic growth, as lagged variable.

Subasat (2002) has shown that exports are a source for economic convergence, the countries with a medium development level and an export expansion increase faster than those less orientated towards export. For the economies that are at a reduced/high level of development, there is no significant connection between the export increase and economic growth. Also, Sarkar (2002) has shown that only for the countries with a medium level of development there is a significant correlation between the degree of economic openness and the economic growth. Dritsakis (2004) analyzed the relationship between economic growth, investments and exports in Romania and Bulgaria's case. The results suggest both the existence of a cointegration relationship between the three variables, as well as the positive impact of the exports and investments over the real GDP.

As far as the investments are concerned, the neoclassical theory suggests the importance of the capital stock increase for the countries that are at a reduced level of economic development. The influence over the economic growth will be only on a medium term, which is until the steady-state level of income is reached. The investments' sources refer both to the increase of the saving rate and to the direct foreign investments flow. If the latter suppose a technological transfer, the real convergence process will be a sustainable one. For the new EU member countries, FDI have supported the economic growth process, two of the transmission channels being represented by investments and exports. This is due to the fact that the FDI beneficiary countries have registered both an increase of the degree of economic openness and an increase of the capital stock.

By analysing the impact of modifying exports and direct foreign investments over the real GDP in Romania (1991-2005), it has been observed the conclusive influence of the FDI over the economic growth process:

$$RGDP = -3.0465 + 0.118 \times Rexp + 0.883 \times RFDI;$$

(-0.460) (1.261) (7.255) – t statistic; $R^2 = 0.955$

The three variables have been calculated based on the increase rates, and the annual data has been taken from The National Statistics Institute. The FDI elasticity is almost 0.88, thus at a rise of 10%, GDP (in current prices) has increased with 8.8%. By comparison to exports, the elasticity was only 11.8% (being statistically insignificant), which reflects its low contribution to the calculation of the GDP.

The purpose of this study is to estimate the long term relation of the evolution between the real GDP, the gross capital formation (as investment proxy), and the degree of economic openness.

For this objective I have used the quarterly available data of Eurostat for the period 1999:1 and 2006:4, the variables being expressed in constant prices (euro million, 1995). As temporal series are concerned, I have used statistical data expressed in logarithm. To eliminate the influence of seasonal factors, I preferred to un-season these variables (based on the Tramo/seats function from Eviews). As introduction, I have made a short presentation of the used econometric method, after which I have investigated the stationary variables using the Dickey-Fuller test. Next, I have used the Johansen procedure of variable cointegration which allowed me to apply the corresponding VAR model. In the end, I have tested the Granger causality between these variables.

Model presentation

In order to establish the causality relationship between the three variables I used the VAR model in the form: U (VAR) = (Y, INV, EXP). Its advantage is that it allows the interpretation of any variable as a possible endogen one and that it explains the variation through previous personal values and those of the model. This model is applied to the stationary series of data that are not cointegrated. Not respecting these conditions was solved by introducing a term of error correction (EC) (Engle, Granger, 1987), to the initial VAR model, thus resulting a new model known as error correction vector – VECM. The cointegration is the property of two or more temporal series of having the same long term stochastic trend. The non-stationary is characterized by the presence of at list one unit root in the initial presence of the autoregressive vector.

A VAR type non stationary model with three variables and a deterministic term can be written as follows:

$$U_t = A_0 + A(Log)U_t + e_t,$$

where:

$A(LOG) = [a_{ij}(Log)]$ is a 3x3 matrix of the polynom $a_{ij}(Log) = \Sigma a_{ij1} Log^1$, and a_{ij} is the polynom's degree;

$A_0 = (a_{10} a_{20} a_{30})$ is a constant, and e_t is a 3x1 vector of the random error.

The VAR model can be written as a VECM, assuming the existence of at least one cointegration vector

$$\Delta U_t = A_0 + A(Log)\Delta U_{t-1} + \delta EC_{t-1} + \mu_t, \quad (1)$$

where:

μ_t is a 3x1 vector of „noise errors", E(μ) = 0 and (μ_t μ_{t-1}) = Ω, for t = s and zero, in the other cases.

After identifying the parameters for the cointegration vector, the economic increase equation can be written as follows:

$$\ln Y_t = \beta_1 \times \ln INV_t + \beta_2 \times \ln EXP_t. \quad (2)$$

The error correction term can be obtained from the previous equation:

$$EC_t = \ln Y_t - \beta_1 \times \ln INV_t - \beta_2 \times \ln EXP_t. \quad (3)$$

Including the economic increase equation in model (1) we obtain:

$$\Delta \log Y_t = a_0 + \Sigma a_{1j} \Delta \log Y_{t-j} + \Sigma a_{2j} \Delta LogINV_{t-j} + \\ + \Sigma a_{3j} \Delta LogEXP_{t-j} + \delta EC_{t-1} + e_t, \quad (4)$$

where EC_{t-1} represents the equilibrium departure in the t period, and the δ coefficient refers to the adjustment speed of the dependent variable towards its long term equilibrium.

The methodology of testing the causality in Granger thinking assumes initially testing the stationary using the unit root test. If there is at least one unit root, than the model is not stationary and the cointegration test are applied (Johansen). Otherwise, VAR can be used for the stationary model. If the presence of cointegration is discovered, VECM representation will be obtained, to which the causality test is applied. If there is no cointegration relation between the variables, a representation by differentiating the initial VAR model (VARD) will be done, after which the Granger test will be used.

a) *The determination of the unit roots*

In order to test the analyzed stationary variables, I have applied the Dickey-Fuller (ADF) test, based on the following regression:

$$\Delta X_t = \delta_0 + \delta_1 t + \delta_2 X_{t-1} + \sum_{i=1}^{k} \alpha_i \Delta X_{t-i} + u_t.$$

The ΔX_{t-i} variable, expressed in logarithm, refers to the first difference with *k* lags; the u_t variable adjusts the autocorrelation error. The δ_0, δ_1, δ_2 and α_i coefficients are initially estimated. The hypothesis of an existing unit root for X_t variable are:

$$H_0: \delta_2 = 0; H_\varepsilon: \delta_2 < 0.$$

If H_0 is accepted, than the model is non-stationary. If the null hypothesis applied to the values of the differentiated model of 1st order is rejected, then that variable is a unit root and its integration order is 1. If the null hypothesis is accepted, and the one applied to the differentiated model of the 2nd order is rejected, then the integration order of the variable is 2 and so on. The hypotheses are tested by using the statistic test t for the δ_2 coefficient.

Before verifying the stationary, we must establish the number of lags of the model, on the basis of the minimum values for the Akaike (AIC) and Schwartz (SC) criteria, which are calculated as follows:

AIC = [2k/T] + ln (the square remainder sum/T),

SC = [klnT/T] + ln (the square remainder sum /T).

where k – number of the estimated parameters, and T – observations number.

I have observed that the minimum values of the two criteria are different, so I have reached Canova's (2006) conclusion, according to which for a number higher than 20 quarter observations, the Schwartz criteria is a consistent one, and the AIC is not consistent.

The stationary research assumes the existence of an unit root. Its number gives also the integration order for each variable. Table 1 presents the results of applying the ADF test for Romania.

The model's stationary variables

Table 1

LogY						
Initial structure			*The first difference*			Integration order (I)
ADF Test – 4 difference lags			ADF Test – 3 difference lags			
-3,326023	1% critical value	-4,3382	-3,476322	1% critical value	-3,6959	I = 2 (1%) I = 1 (5%) I = 0 (10%)
	5%	-3,5867		5%	-2,9750	
	10%	-3,2279		10%	-2,6265	
LogEXP						
Initial structure			*The first difference*			Integration Order (I)
ADF Test – 4 difference lags			ADF Test– 0 difference lags			
-3,15241	1% critical value	-4,3382	-4,967172	1% critical value	-3,6651	I = 1 (1%; 5%; 10%)
	5%	-3,5867		5%	-2,9627	
	10%	-3,2279		10%	-2,6200	
LogINV						
Initial structure			*The first difference*			Integration order (I)
ADF Test– 4 difference lags			ADF Test – 0 difference lags			
3,938837	1% critical value	-3,6959	-5,899291	1% critical value	-3,6661	I = 1 (1%; 5%; 10%)
	5%	-2,9750		5%	-2,9627	
	10%	-2,6265		10%	-2,6200	

The results show that the investments and exports variables expressed in logarithm become stationary (for 1%, 5% and 10% critical value) by transformation with the first difference. In the case of the economic growth variable, the null hypothesis of the existence of a unit root is rejected at 5% and 10%, but it is accepted at 1%; so, it is non-stationary at 1% for the first difference but stationary for the other two significance levels. The integration order (I) of the three variables has been determined according to the number of the unit roots.

b) *The cointegration study*

If the data series are non-stationary in the initial form, they can be cointegrated, that is there is at least one linear combination between them that is stationary. The cointegration condition (that is the existence of a long term linear relation) is respected, because the variables have the same integration order. The applied methodology is the one proposed by Johansen (1990), according to which the null hypothesis of the cointegration non-existence shall be tested.

VAR U p-dimensional vector is constructed and k lags:

$$U_t = A_1U_{t-1} + ... + A_kU_{t-k} + e_t,$$

where the U vector includes the three non-stationary variables of the 1st integration order (for 5% critical value) and it has p dimension.

This model can be re-written in an error correction form as follows:

$$\Delta U_t = \Gamma_1\Delta U_{t-1} + ... + \Gamma_{k-1}\Delta U_{t-k-1} + \Pi U_{t-k} + e_t.,$$

where Γ and Π matrix are given by the relations:

$$\Gamma_i = - [I - \sum_{i=1}^{k-1}\pi_i\ ] \text{ și } \Pi = - [I - \sum_{i=1}^{k}\pi_i\ ].$$

Under the cointegration hypothesis, the p dimension matrix contains information regarding the long term relation between the U vector variables. This hypothesis is influenced by the *r* grade of Π matrix. Three situations are taken into account:

a) *r* can be completed, in other words the r grade of the Π matrix is p. In this case, all the variables from the U vector are stationary. Generally, this situation will not appear as long as one or more variables have the integration order 1;

b) *r* is zero, in other words Π is the null matrix. In this case, there is no long term relation between the variables and the VAR must be estimated in differences;

c) *r* < p and it represents the number of the cointegration vectors between the variables of the U vector. This implies the fact that the *pxr* α and β a matrix so that Π =αβ', where β is the matrix of the cointegrated vectors and α is the adjustment coefficient matrix. Evan if the U elements can not be stationary, the cointegration vectors are linear stationary combinations of these elements, that is *t* β'*X* is stationary.

With the help of Eviews I have tested the hypothesis referring to the grade of Π matrix, using *trace test* option. The null hypotheses are the one of the inexistence of a cointegration relation between the variables. It is validated if $\lambda_{statistic} < \lambda_{critic}$ (for 1% and 5% significance levels), the λ values being generated by the Eviews program. The Johansen procedure offers information only regarding the number of cointegration relations inside a model, not regarding the variables that are cointegrated.

Between the three variables there is one cointegration relation, at the significance levels 1% and 5% (I have taken into account the cointegration based on a deterministic linear trend – table 2).

The number of cointegration relations inside the model

Table 2

Values of Π matrix	$\lambda_{statistic}$	λ_{critic} (5%)	λ_{critic} (1%)	Results comment
0.695555	45.01871	29.68	35.65	Trace test indicates one
0.198880	9.340743	15.41	20.04	cointegration relation at 1% and
0.085715	2.688399	3.76	6.65	5% levels (45.01871 > 29.68 and 45.01871 > 35.65).

The cointegration relation obtained by normalizing the coefficients shows a positive correlation on a long term between the economic growth, on one hand, and investments, exports, on the other hand.

$$LogY = 0.49LogINV + 0.18LogEXP + 3.60.$$

According to the above mentioned relation, the real GDP on the long term in relation to the investments modification is 0.49%, which means that at a 10% increase, the economic growth rate will be 4.9%. The elasticity according to the export variable is 0.18, thus its increase of 10% will have as an effect a growth rate 1.8% higher than in the previous period.

The relative low contribution of the exports comes against the vision according to which they were the growth engine in Romania starting with 2000. But, by calculating the GDP as sum of the added gross values, by the internal economic agents, a possible explanation is obtained. The added value contained in exports is a reduced one, limiting mainly to the workers' salaries from those activity sectors. The structure of the exports from the analyzed period is characterized by increased lohn weight (almost 40% from the exports). According to the content of the cointegration notion, the above relation can be interpreted by simultaneous evolution of increase, investments and exports towards the long term equilibrium of the real GDP. But this result does not reveal anything regarding causality because common evolution does not assume a causal relation between them. The next step assumes the estimation of the ECM vector for causality testing.

c) *VAR model with the error correction mechanism* (VECM)

The error correction model is used to investigate the causal relations between the three analyzed variables. The values obtained by applying this model will be introduced in equation (4), as follows:

$$\Delta LogY_t = -0.33\Delta LogY_{t-1} - 0.05\Delta LogINV_{t-1} + $$
$$+ 0.07\Delta LogEXP_{t-1} – 0.13 (LogY_{t-1} – 0.49LogINV_{t-1} -$$
$$- 0.18LogEXP_{t-1} – 3.60).$$

Granger causality assumes the existence of a transmission mechanism for the influences over the dependent variable LogY, by the adjustment coefficient ä. Because it is significally different from zero and negative, than VECM contributes to maintaining the long term equilibrium of the real GDP variable (13% from the deviation of the GDP modification is explained by the error correction vector). This value of 13% is seen as the convergence speed of the real GDP to its stationary level inside the model that includes investments and exports. In Solow model, the convergence speed assumed an inverted relation between the real GDP growth and its previous level.

In order to discover the necessary period to reach half of the gap between the present level and the stationary level of the GDP, I used the following relation:

$$\text{Time} = \ln (2)/\text{adjustment speed} = \frac{\ln(2)}{0.13} = 5.33 \text{ quarter.}$$

It results that in almost 10.6 quarters (that is in the II quarter of 2009); the real GDP will reach its stationary level, in the absence of the increase of the total factor productivity.

In order to test the causality in the Granger thinking between these variables, I have retained 4 lags because the influence over the dependent variable assumes a certain temporal difference (in the conditions of quarterly data). The null hypothesis (H_0) is one of the inexistence of a Granger causality (table 3).

Granger causality between the model's variable (Romania's case)

Table 3

H_0:	Observa-tions	F-Statistics	Probability
LogINV is not a cause for LOGY	27	3.48233	0.02833
LogY is not a cause for LogINV		0.76032	0.56453
LogEXP is not a cause for LogY	27	4.78151	0.00834
LogY is not a cause for LogEXP		0.75265	0.56920
LogEXP is not a cause for LogINV	27	0.19195	0.93947
LogINV is not a cause for LogEXP		0.66594	0.62382

The hypothesis according to which investments do not influence the growth is rejected, so it is considered that the real GDP prediction is increased by using the investments variable. Thus is validated the role of the capital accumulation in the real convergence process of the Romanian economy. Another valid hypothesis is the causality between exports and growth in the Granger thinking. Most of the exports had as source foreign direct investments which support also the process of recuperating the development gaps. As a conclusion, the accuracy of the estimation for the future growth rate will be higher if the investments and exports variables are exogen inside the model. According to Granger methodology we can not verify the influence of the GDP growth over the investments that is the existence of the accelerator.

I have used the Sims causality (1980) whose significance is the following: if the future values of y variable allow the explanation of the current values of the x variable, then x is considered to be the cause of y. Thus, if the future investments values (differenced by specific lag, in the conditions of some quarterly series of data) influence the growth in the present than the real GDP is the cause of the gross capital formation (the essence of the accelerator).

$$LogY = -0.06\times LogINV(-1) + 0.83\times LogY(-1) + 0.15\times LogINV(3) + 0.89.$$

According to the previous estimation, the real GDP modification in the t quarter will positively influence the investments in t+3.

d) Reviewing the model. Inclusion of economic openness degree (EOD)

To capture the influence of imports over the long term economic growth, I have replaced exports with degree of economic openness, calculated as the ratio between the exports, imports sum and GDP. The available data are quarterly for the period 1999:1–2006:4, and their source is Eurostat.

This variable is non-stationary at its initial level, having the 1^{st} order of integration for 5%, 10% significance and 2^{nd} order for 1% significance. In the initial model I have replaced the exports with the new variable. After identifying the parameters for the cointegration vector, the economic growth equation becomes:

$$\ln Y_t = \beta_1\times \ln INV_t + \beta_2\times \ln EOD_t.$$

The correlation term for the error can be obtained from the previous equation:

$$EC_t = \ln Y_t - \beta_1\times \ln INV_t - \beta_2\times \ln EOD_t.$$

Including the economic growth equation in the form of model (4) is obtained:

$$\Delta\log Y_t = a_0 + \Sigma a_{1j}\Delta\log Y_{t-j} + \Sigma a_{2j}\Delta LogINV_{t-j} + \\ + \Sigma a_{3j}\Delta LogEOD_{t-j} + \delta EC_{t-1} + e_t, \quad (5)$$

Between the three variables there is one cointegration relation at the significance level of 1% and of 5% (I have taken into consideration the cointegration based on a linear deterministic trend – table 4).

The number of cointegration relations inside the EOD model

Table 4

Matrix Π values	$\lambda_{statistic}$	λ_{critic} (5%)	λ_{critic} (1%)	Results comment
0.694180	47.12126	29.68	35.65	The trace test indicates one
0.250175	11.57846	15.41	20.04	cointegration relation at the levels of 1% and 5%
0.093382	2.941007	3.76	6.65	(47.12126 > 29.68 and 47.12126 > 35.65).

The cointegration relation obtained by normalising the coefficients shows a positive correlation on the long term between the economic growth, on one side, and the investments, EOD, on the other side.

$$LogY = 0.41LogINV + 0.28LogEOD + 5.74.$$

According to the above relation, the real GDP elasticity on the long term by comparison to the investments modification is 0.41%, which means that at a 10% growth, the economic growth rate will be 4.1%. Elasticity according to the openness degree is 0.28, so its increase with 10% will cause a growth rate of 2.8%. The obtained results suggest a higher elasticity of the GDP than EOD by comparison to that of the exports. It results that increasing the commercial deficit (evolution induced by the EOD growth) will have positive effects over the real GDP evolution. The previous conclusion, although sursprising at first, can be explained by the effect brought by the imports over the Romanian economy.

The realisation of the error correction model shows the following causality relation between the three variables:

$$\Delta LogY_t = -0.21\Delta LogY_{t-1} - 0.04\Delta LogINV_{t-1} + \\ + 0.03\Delta LogEOD_{t-1} - 0.11(LogY_{t-1} - 0.41LogINV_{t-1} - \\ - 0.28LogEOD_{t-1} - 5.74).$$

The above equation shows that the enclosure of the EOD variable leads to the decrease of 0.02 percentage points of the adjustment speed of real GDP towards its stationary level (from 13% in the exports model to 11% in the EOD model). To discover the period necessary to reach half of the gap between the GDP current and its steady-state level, I have used the following relation:

$$Time = \frac{\ln(2)}{0.11} = 6.30 \text{ quarters.}$$

It results that in almost 12.6 quarters (that is in the first quarter of 2010) the real GDP will reach its stationary level, which anticipates a decrease of the economic growth rate, in the absence of the increase of total factor productivity. The real GDP long term equilibrium is reached faster when using exports variables than in including EOD; the explanation refers to greater lag of transmission for the imports effects over the economic growth.

In conclusion, the error correction vector is a valid model for analyzing the long term relation between the real GDP, investments, exports, economic opening degree. The increases of these variables are able to generate positive effects over economic growth, a superior influence having the investments.

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