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VAR analysis on Foreign Direct Investment in Romania

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Abstract. *A research analysis of the impact of FDI on GDP, exports and imports in Romania, on the basis of econometric models, provides us with an opportunity to examine how they have established in the transition period a number of interdependencies, more or less intense, among the variables mentioned above. In a way, the analysis which we performed gives us an opportunity to see not only the rigid positions of explained and explanatory variables, but also a change in the causality among these, which can be identified, both by different sizes of elasticity coefficients and by applying Vector Autoregresive model (VAR).*
The purpose of such a quantitative analysis based on patterns of foreign direct investment, was to identify the two-way relationship, with different intensities from one period to another, of the FDI and their determinants as well as among the indicators of performance of the Romanian economy and foreign direct investment, as a major factor of influence.
We apply the VAR technique to quantify the parameters of elasticity between FDI, as an explained and/or explanatory variable and other factors in the cause-effect relationship.
The VAR analysis was based on data obtained from NOTR (National Office of Trade Registrar), NBR (National Bank of Romania) and NIS (National Institute of Statistics) for FDI, GDP indicators, export and import indicators for the period 1997-2011.

Keywords: foreign direct investment, the method of auto-regressive vectors, gross domestic product, export, import, heteroskedasticity, homoskedasticity, co-integration, auto-correlation.

JEL Classification: C001, C12, C30.
REL Classification: 10B, 10F, 10G, 10H.

Econometric analysis of auto-regressive vectors (VAR) represents a linear system of regressions in which a set of variables are estimated on the basis of past values of the same variable and of other variables in the set. This method is often used for analysing macroeconomic phenomena, since they manifest themselves as complex, dynamic systems with feedback and mutual causality and therefore, only the system type tests are able to capture the relationship between variables (Boţel, 2002).

To identify the relationship between the variables I used the impulse-response function, decomposition of variance of forecasting error and Granger causality tests.

The Cholesky impulse-response function shows further developments in a variable, due to the shock value of other variables, following the trajectory of this effect in time.

A decomposition method of forecast error variance indicates the volume of information with which each variable contributes to the explanation of the other variables, and the causal relationships highlights the studied Granger variables, a variable X is causing a Granger effect in another variable Y if changing the values of X causes changes of Y, and the Y variable can be predicted using the information provided by the variable X.

The identification of the system was made using the recursive decomposition method of Choleski type of the variance-covariance matrix of the residual terms. This method enforces the restriction that a variable cannot be influenced by a shock which affects those variables subsequently ordered to it. This involves the distinction between various behaviors in economy, the studied variables being the results of the interaction between supply and demand on the markets (Zha, 1997).

Taking into account these considerations of the VAR method, we have forecasted a model in which the order of the variables is FDI, GDP, export and import. The reasoning is that FDI is considered predetermined on a short term, because it is very much influenced by investors ' perception of a country's potential on a medium and long term, the market, the stage of development, the risk aversion of global events, but also by subjective shocks, such as political disputes, economic and financial crises in neighbouring countries.

Thus, in this model, the GDP, export and import do not have an immediate impact on FDI, but only with a lag. Thus, the increase or decrease in GDP, export or import should not influence of FDI on the very short term (one year). On the other hand, sudden increase or decrease of FDI can have a strong and immediate impact on the gross domestic product, exports or imports. We consider that this reasoning best characterizes a relatively small, developing economy, exposed to external shocks, such as Romania's economy [(1)].

The VAR analysis was based on data obtained from NOTR (National Office of Trade Registrar), NBR (National Bank of Romania) and NIS (National Institute of Statistics) for FDI, GDP indicators, export and import indicators for the period 1997-2011.

The econometric models have undergone diagnosis analyses for testing their statistical properties, the main steps taken being:

I. Testing the order of integration of the variables of interest;
II. Choosing the of number of lag of the VAR;
III. Testing the stability of VAR;
IV. Testing the properties of "white noise" of residual terms (the normal distribution, the lack of autocorrelation and heteroskedasticity).

I. Testing the order of integration of the variables of interest *(the Augmented Dickey-Fuller Test)*

The test showed, at a significance level of 5%, that the series are not stationary, but are integrated of order I. Thus, in the VAR analysis, we use the first difference of these variables. Unfortunately, I could not test the existence of a relationship of co-integration among the variables used.

Table 1. *The order of integration*

Series	FDI	GDP	EXPORT	IMPORT
Order of integration	I(1), c	I(1)	I(1),c	I(1), c

Null Hypothesis: **D(PIB) has a unit root**
Exogenous: None
Lag Length: 0 (Automatic based on SIC, MAXLAG=3)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.159878	**0.0344**
Test critical values:	1% level	-2.754993	
	5% level	-1.970978	
	10% level	-1.603693	

*MacKinnon (1996) one-sided p-values. Warning: Probabilities and critical values calculated for 20 observations and may not be accurate for a sample size of 13

Null Hypothesis: **D(ISD) has a unit root**
Exogenous: Constant
Lag Length: 2 (Automatic based on SIC, MAXLAG=3)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.662966	**0.0232**
Test critical values:	1% level	-4.200056	
	5% level	-3.175352	
	10% level	-2.728985	

*MacKinnon (1996) one-sided p-values. Warning: Probabilities and critical values calculated for 20 observations and may not be accurate for a sample size of 11

Null Hypothesis: **D(IMPORT) has a unit root**
Exogenous: Constant
Lag Length: 0 (Automatic based on SIC, MAXLAG=3)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.561098	**0.0236**
Test critical values:	1% level	-4.057910	
	5% level	-3.119910	
	10% level	-2.701103	

*MacKinnon (1996) one-sided p-values. Warning: Probabilities and critical values calculated for 20 observations and may not be accurate for a sample size of 13

Null Hypothesis: **D(EXPORT) has a unit root**
Exogenous: Constant
Lag Length: 1 (Automatic based on SIC, MAXLAG=3)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.295192	**0.0391**
Test critical values:	1% level	-4.121990	
	5% level	-3.144920	
	10% level	-2.713751	

*MacKinnon (1996) one-sided p-values. Warning: Probabilities and critical values calculated for 20 observations and may not be accurate for a sample size of 12.

II. Choosing the number of lags of the VAR

The number of lag sites was determined on the basis of Akaike information criterion and Schwarz information criterion. Tests have shown a maximum number of 2 lags, but, however, in this model, we decided to use a single lag because of the small number of observations, namely 15.

Table 2. *VAR Order Lag Selection Criteria*

VAR Lag Order Selection Criteria
Endogenous variables: ISD PIB IMPORT EXPORT
Exogenous variables: C
Date: 04/10/13 Time: 19:36
Sample: 1997 2011
Included observations: 13

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-498.4096	NA	4.35e+28	77.29378	77.46761	77.25805
1	-435.4820	77.44928	3.76e+25	70.07416	70.94331	69.89551
2	-386.3678	30.22412*	7.02e+23*	64.97967*	66.54414*	64.65810*

***** indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

III. Testing the VAR stability

The stability condition of a VAR is that the characteristic equation roots of the estimated coefficients matrix of VAR should be inside the unit circle. The stability of a system assumes that the shocks are transient and disappear after a certain period of time, and their lack of steadiness implies that certain results, such as the standard errors for the impulse-response function, are not valid. According to tests, the estimated VAR is stationary.

Table 3. *Roots of Characteristic Polynomial*

Roots of Characteristic Polynomial
Endogenous variables: D(ISD) D(PIB) D(IMPORT) D(EXPORT)
Exogenous variables: C
Lag specification: 1 1
Date: 04/10/13 Time: 20:00

Root	Modulus
0.524420 - 0.526322i	0.742988
0.524420 + 0.526322i	0.742988
-0.565088	0.565088
0.398551	0.398551

No root lies outside the unit circle. VAR satisfies the stability condition.

IV. Testing the properties of "white noise" of the residual terms

This stage will be performed using the Lagrange Multiplier in order to see if there is any auto-correlation, the Lutkepol test to check the normality of the series and the White Heteroskedasticity test to detect the existence of heteroskedasticity (the lack of a constant variance).

The test results are not satisfactory, the assumptions of the existence of autocorrelation and existence of homoskedasticity cannot be rejected at the conventional 5% significant level. Although the errors do not have a normal distribution, we chose to ignore this problem considering the appropriate models in terms of theory, and the lack of normality does not mean that the model is invalid, but only that there are other variables which explain the pattern, a reasonable assumption given the multitude of factors that influence foreign direct investment, GDP, export and import.

Table 4. *VAR Residual Serial Correlation LM Tests*

VAR Residual Serial Correlation LM Tests
H0: no serial correlation at lag order h
Date: 04/10/13 Time: 20:09
Sample: 1997 2011
Included observations: 13

Lags	LM-Stat	Prob
1	28.57219	0.0270
2	18.59634	**0.2902**
3	14.70959	**0.5460**
4	36.79062	0.0022
5	22.33316	**0.1328**
6	21.41833	**0.1630**

Probs from chi-square with 16 df.

Table 5. *VAR Residual Heteroskedasticity Tests*

VAR Residual Heteroskedasticity Tests: No Cross Terms (only levels and squares)
Date: 04/10/13 Time: 20:04
Sample: 1997 2011
Included observations: 13

Joint test:		**H0: No Heteroskedasticity**
Chi-sq	df	Prob.
89.57477	80	0.2174

Individual components:

Dependent	R-squared	F(8,4)	Prob.	Chi-sq(8)	Prob.
res1*res1	0.711939	1.235742	0.4471	9.255204	0.3212
res2*res2	0.804831	2.061882	0.2529	10.46280	0.2340
res3*res3	0.932416	6.898192	0.0398	12.12141	0.1459
res4*res4	0.928858	6.528225	0.0438	12.07516	0.1479
res2*res1	0.542543	0.592999	0.7548	7.053059	0.5309
res3*res1	0.493541	0.487246	0.8205	6.416027	0.6007
res3*res2	0.884407	3.825539	0.1053	11.49730	0.1751
res4*res1	0.535488	0.576399	0.7650	6.961349	0.5408
res4*res2	0.946510	8.847495	0.0257	12.30463	0.1381
res4*res3	0.970017	16.17596	0.0085	12.61022	0.1260

Table 6. *VAR Residual Normality Tests*

VAR Residual Normality Tests
Orthogonalization: Cholesky (Lutkepohl)
H0: residuals are multivariate normal
Date: 04/10/13 Time: 20:12
Sample: 1997 2011
Included observations: 13

Component	Skewness	Chi-sq	df	Prob.
1	0.275096	0.163969	1	0.6855
2	0.158724	0.054585	1	0.8153
3	0.231081	0.115697	1	0.7337
4	-0.215977	0.101066	1	0.7506
Joint		0.435317	4	0.9795

Component	Kurtosis	Chi-sq	df	Prob.
1	0.851946	2.499324	1	0.1139
2	1.063754	2.030735	1	0.1541
3	1.041256	2.078200	1	0.1494
4	0.658393	2.970024	1	0.0848
Joint		9.578283	4	0.0482

Component	Jarque-Bera	df	Prob.
1	2.663293	2	0.2640
2	2.085320	2	0.3525
3	2.193896	2	0.3339
4	3.071091	2	0.2153
Joint	10.01360	8	0.2641

Table 7. *The correlation Matrix of residual terms*

The correlation Matrix of residual terms

	D(ISD)	D(PIB)	D(IMPORT)	D(EXPORT)
D(ISD)	1.000000	0.075367	0.095842	0.278671
D(PIB)	0.075367	1.000000	0.964500	0.818762
D(IMPORT)	0.095842	0.964500	1.000000	0.898733
D(EXPORT)	0.278671	0.818762	0.898733	1.000000

- VAR system Results

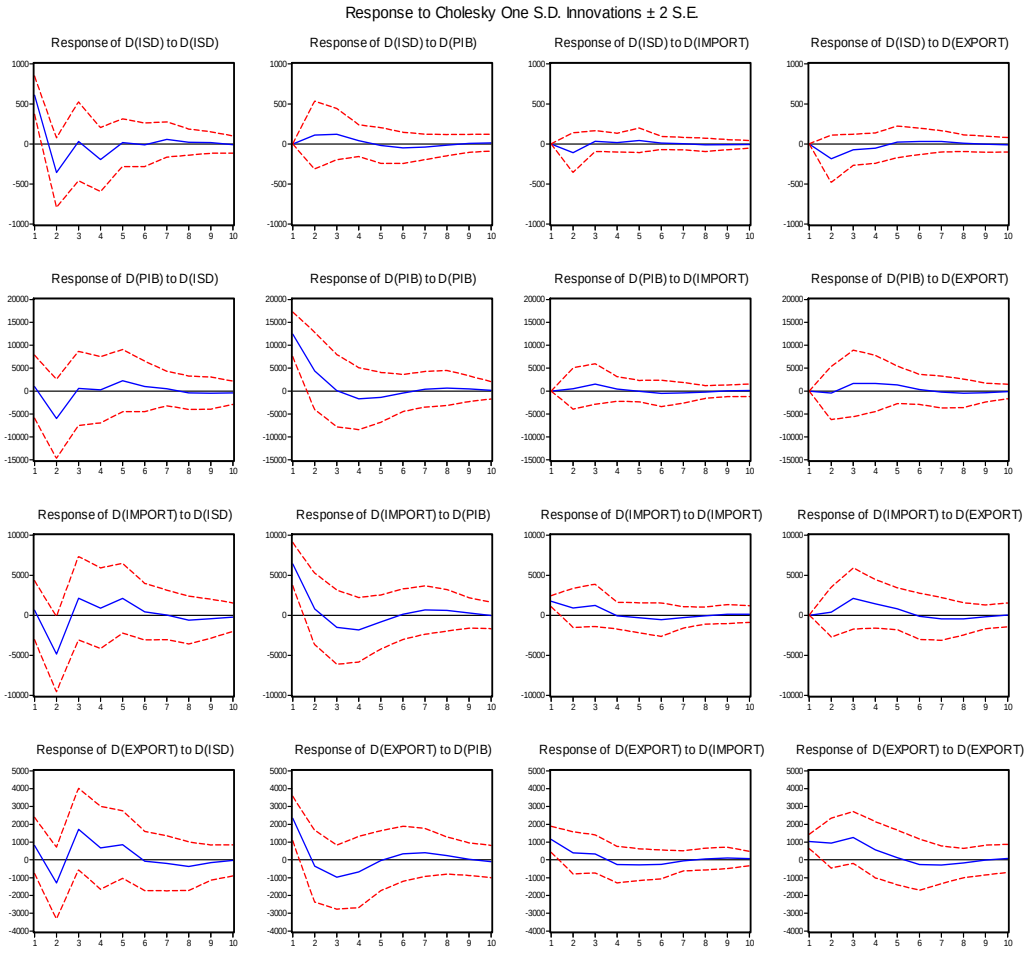
Vector Autoregression Estimates
Date: 04/10/13 Time: 19:59
Sample (adjusted): 1999 2011
Included observations: 13 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	D(ISD)	D(PIB)	D(IMPORT)	D(EXPORT)
D(ISD(-1))	-0.428084	-10.13960	-8.499737	-2.934662
	(0.32059)	(6.53667)	(3.50549)	(1.53015)
	[-1.33531]	[-1.55119]	[-2.42469]	[-1.91789]
D(PIB(-1))	0.013729	0.131924	-0.146097	-0.006772
	(0.04064)	(0.82860)	(0.44436)	(0.19396)
	[0.33783]	[0.15921]	[-0.32878]	[-0.03491]
D(IMPORT(-1))	0.056075	0.586321	0.269233	-0.373760
	(0.09877)	(2.01391)	(1.08002)	(0.47143)
	[0.56773]	[0.29114]	[0.24928]	[-0.79282]
D(EXPORT(-1))	-0.179555	-0.427047	0.377704	0.909230
	(0.13731)	(2.79967)	(1.50141)	(0.65537)
	[-1.30768]	[-0.15253]	[0.25157]	[1.38736]
C	486.3555	8433.600	5208.791	2752.416
	(310.678)	(6334.63)	(3397.14)	(1482.85)
	[1.56546]	[1.33135]	[1.53329]	[1.85616]
R-squared	0.405348	0.277176	0.433164	0.465070
Adj. R-squared	0.108022	-0.084236	0.149745	0.197605
Sum sq. resids	2968277.	1.23E+09	3.55E+08	67620524
S.E. equation	609.1262	12419.89	6660.543	2907.330
F-statistic	1.363312	0.766924	1.528355	1.738807
Log likelihood	-98.64673	-137.8421	-129.7418	-118.9653
Akaike AIC	15.94565	21.97571	20.72951	19.07158
Schwarz SC	16.16294	22.19300	20.94680	19.28887
Mean dependent	211.1923	7223.923	3416.923	2913.385
S.D. dependent	644.9562	11927.67	7223.291	3245.639

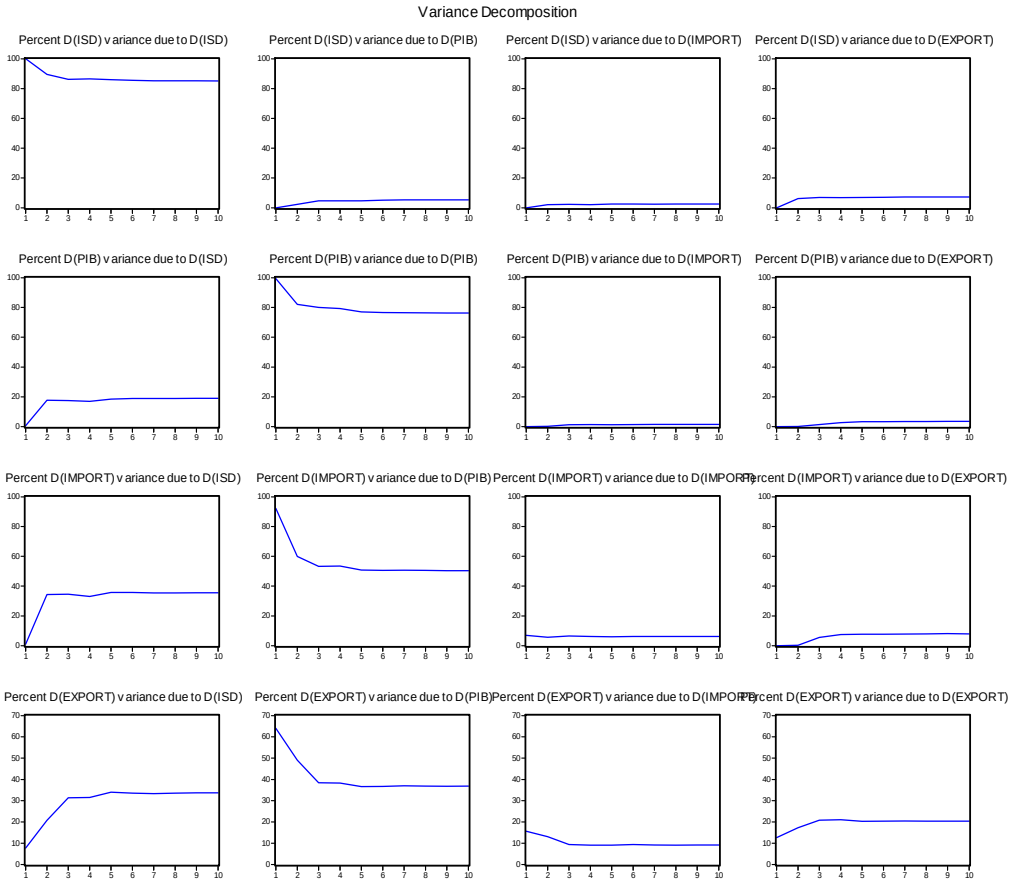
Determinant resid covariance (dof adj.)	1.86E+26
Determinant resid covariance	2.67E+25
Log likelihood	-454.3360
Akaike information criterion	72.97476
Schwarz criterion	73.84392

- Impulse response functions

As expected, due to the fact that the VAR estimated residual terms are not characterized by a normal distribution, the impulse-response functions do not seem to be significantly different from zero. However, we can try a prudent analysis of these results to at least see if the sign of variables for shocks in the other variables in the system, can pinpoint answers or future research topics.



- Decomposition of variance



The interpretation of the results must take into account that we used the first difference of the variables, since the data series were not stationary, so we have to deal with variable growth rates.

- Granger causality

In the table shown below, the values in column "Prob" represent the probability of the null hypothesis: the dependent variable is not caused in a Granger way by the independent variables. It can be seen that the only valid results statistically, at a significance level of 5%, show that only export and import are caused largely by FDI from a Granger point of view. Thus, we can affirm that from a Granger point of view the FDI causes exports and imports. This demonstrates that the FDI generated financial flows, materials, technological and managerial flows which led the development of the production activities which increased on the short term, the demand for both import and export.

One of the main components of FDI is represented by the net credit granted by non-residents to enterprises with FDI, which means that this component of FDI has stimulated the activity of production destined for export/import.

Table 8. *VAR Granger Causality/Block Exogeneity Wald Tests*

VAR Granger Causality/Block Exogeneity Wald Tests
Date: 04/10/13 Time: 17:24
Sample: 1997 2011
Included observations: 13

Dependent variable: D(ISD)

Excluded	Chi-sq	df	Prob.
D(PIB)	0.114132	1	0.7355
D(IMPORT)	0.322318	1	0.5702
D(EXPORT)	1.710024	1	0.1910
All	3.163884	3	0.3670

Dependent variable: D(PIB)

Excluded	Chi-sq	df	Prob.
D(ISD)	2.406181	1	0.1209
D(IMPORT)	0.084760	1	0.7709
D(EXPORT)	0.023267	1	0.8788
All	2.554823	3	0.4655

Dependent variable: D(IMPORT)

Excluded	Chi-sq	df	Prob.
D(ISD)	5.879136	1	0.0153
D(PIB)	0.108095	1	0.7423
D(EXPORT)	0.063286	1	0.8014

All	6.013297	3	0.1110

Dependent variable: D(EXPORT)

Excluded	Chi-sq	df	Prob.
D(ISD)	3.678320	1	0.0551
D(PIB)	0.001219	1	0.9721
D(IMPORT)	0.628566	1	0.4279
All	6.758120	3	0.0800

The results of the econometric analysis are developed and supported by Acaravci and Ozturk, Ilhan who, in their study "Foreign direct investment, export and economic growth: empirical evidence from new EU countries" have researched the relationship of causality between FDI, exports and GDP in ten developing countries, members of the European Union, including Romania.

The relationship between FDI and GDP is analyzed in terms of:
- the factors that determine economic growth;
- the factors that encourage FDI flows;
- the role of multinational corporations in the host country;
- the relationship of causality between FDI and GDP.

In the specialized literature there are numerous techniques, tools and methods for determining the character of the relations between the three variables mentioned, in the sense of alternating their quality according to the dependent and independent variable on short, medium and long term (co-integration and Engle and Granger causal models).

The work is based on two-step procedure in the Engle and Granger model. In a first stage, considering long-term relationship between the three variables, and in the second stage the VEC dynamic model is used, based on Granger causality to test the causal relationship between the variables.

The results of Acaravci and Ozturk research show a causal relationship in one sense, between FDI and GDP growth in the Czech Republic and Slovakia; in Latvia between GDP and FDI, in Poland between FDI and exports. A two-way causation, resulted between GDP and exports in Latvia and Slovakia and between

FDI and export for Latvia. There is a unique relationship on the medium term and long term or balance between real GDP, real exports and FDI in Bulgaria, Estonia, Hungary, Lithuania, Romania and Slovenia.

Econometric analysis suggests that any causal relationships in the dynamic VEC model for these countries, including Romania, cannot be estimated.

The causal relationship of GDP, exports of goods and services, and FDI, acquires particular meanings from one country to another, depending on its level of economic and social development, competitiveness, in a broad and narrow sense, the micro and the macro-economic and structural peculiarities of the respective economies, levels of technological, territorial, spatial distribution and endowment with natural factors of production.

The results of calculations, confirmed as well by other investigations abroad, reveal the lack of relevance of one way and two way links of different intensities between FDI, exports and GDP growth. Even empirical data show, for example, that in the peak of the economic crisis in Romania, 2009 and 2010, characterized by the negative evolution of GDP, exports have exceeded in 2010 the highest level recorded in the year of crisis, even though GDP had fallen two years in a row.

Note

(1) A second possible model that could be tested, is that in which the order of the variables is GDP, export, import, FDI. We start from the assumption that the economy is characterised mainly by foreign direct investment aimed at making a profit as soon as possible. Thus, the investments are elastic to the evolution of production, exports and imports, foreign investors are greatly influenced by supply and demand in the short term that characterize the market on which they want to invest. For this reason, in this model, the variable is placed last, FDI and GDP first, because, of all the variables used, the production is the one that most depend on factors that are not included in the model, such as: the rate of savings, labour, domestic demand, inflation etc.

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