Theoretical and Applied Economics
Volume XX (2013), No. 7(584), pp. 43-58

Saving and economic growth: An empirical analysis for Euro area countries

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Abstract. *The study consists in analysing the long-run relationship between saving and the real economic growth for Euro area countries. By using annual data series and econometric techniques like Johansen co-integration procedure, Granger causality or panel data models, our findings suggest the existence of a unidirectional causality between the two macroeconomic variables; the sense of this connection is from real GDP growth rate to gross national saving rate, with a delay of, at least, four years.*

Keywords: economic growth; saving; Granger causality; panel data; Euro area.

JEL Classification: E01, E21.
REL Classification: 20A, 20Z.

Introduction

The economic growth has always been the most fascinating and complex macroeconomic issue; the impact of the saving rate, one of the key determinant, on the evolution of GDP, in the very long-run, represents the main subject in various empirical studies. In this way, relevant are the papers of Aghion et al. (2009), Barro and Sala-i-Martin (2004), Mankiw (2003), Acemoglu and Ventura (2000), Romer (1996). By taking into account the neoclassical and enodogenous growth theory's predictions, most of these works, utilizing cross-country regressions, in order to estimate the relationship between saving and the real economic growth, concluded that: *(i)* in Solow's model, a permanent increase in the saving rate leads to faster growth only temporarily – it has only moderate effects on the level of output; *(ii)* in most endogenous models, countries tend to grow faster according to their steady state level of the saving rate – the higher the saving rate the higher growth is; *(iii)* in the long-run, the effects of saving on the economic growth are more strong for the rich economies than for the poor economies.

These studies reveal that there is a significant positive relationship between the two macroeconomic variables, but they don't offer any information about the direction and the sense of the causality link.

To identify the existence of a unidirectional relation, in one sense or the other, or the existence of a bidirectional connection, the most indicated methods are the *Granger causality*, the *Johansen co-integration procedure*, the *vector auto-regressive (VAR) model*, the *vector error correction (VEC) model* or *panel data models.*

Our analysis focuses on the study of long-run interdependence between real GDP growth and the gross national saving rates for Euro-area countries. We intend to investigate two main objectives: the first consists in determining whether saving and GDP are co-integrated, and the second in identifying the direction of causality between the two macroeconomic variables.

The following parts of this paper are organized as: *Section 2* provides an overview of the econometric methodology being used, *Section 3* presents the results obtained from empirical analysis, and *Section 4* highlights the conclusions.

1. Methodology

Before we test if between two or more given time series is a Granger causality, we must check if the data series are stationary and, at the same time, co-integrated. At the formal level, stationarity can be determined by finding out if the time series contains a unit root. The most known test, that can be used for this porpose, is the *Augmented Dikey-Fuller* (ADF) test; this test consists in estimating the following regression:

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta Y_{t-i} + \varepsilon_t ,$$

where Y_t is the variable tested for stationarity, δ represents the lags used to identify the possible auto-correlations of higher order, and ε_t is the white noise error term.

The unit root statistic test is carried out under the null hypothesis H_0: $\delta = 0$ against the alternative hypothesis H_A; $\delta < 1$.

The testing procedure is the same as for Dikey-Fuller (DF) test: once a value for the statistic test $DF\tau = \frac{\hat{\tau}}{SE\left(\hat{\lambda}\right)}$ is computed, it can be compared to the relevant critical value for the DF test. Therefore, the more negative the value of the ADF test is, the stronger the rejection of the null hypothesis is.

Testing the hypothesis that there is a statistically significant connection on long-run between the time series could be donne by proceeding to the *Johansen* (1991) *co-integration procedure*. For modeling co-integration, the basic steps in Johansen's methodology are the following:

1. Specify and estimate the following VAR(p) model for Y_t:

$$Y_t = A_1 Y_{t-1} + ... + A_p Y_{t-p} + \varepsilon_t ,$$

where: Y_t is the vector of the $I(1)$ variables, and ε_t is the vector of innovations.

2. Rewrite the VAR(p) model on order to determine the number of cointegrated vectors, as:

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i Y_{t-1} + \varepsilon_t ,$$

where: $\Pi = \sum_{i=1}^{p} A_i - I$; $\Gamma = -\sum_{j=i+1}^{p} A_i$.

3. Impose normalization and indentifying restrictions on the cointegrating vectors that results from taking a rank $r < k$ for the coefficients of the Π matrix;

4. Estimate the resulting cointegrated *Vector Error Correction* (VEC) model.

In the Granger (1969) approach X is a cause of Y if it is useful in forecasting Y, considering only post values of Y. There are three different types of situations in which a Granger causality test can be applied: *(i)* a simple Granger causality test for no more than two variables and their lags, *(ii)* a multivariate Granger causality test for more than two variables or *(iii)* in a VAR framework for testing the simultaneity of all included variables. For testing if X *Granger cause* Y and vice versa, one can proceed to the estimation of the following OLS regressions:

$$\Delta Y_t = \alpha_0 + \alpha_1 \Delta Y_{t-1} + ... + \alpha_l \Delta Y_{t-l} + \beta_1 X_{t-1} + ... + \beta_l X_{t-l} + \varepsilon_t$$

$$X_t = \alpha_0 + \alpha_1 X_{t-1} + ... + \alpha_l X_{t-l} + \beta_1 \Delta Y_{t-1} + ... + \beta_l \Delta Y_{t-l} + u_t$$

Based on the estimated OLS coefficients for the two equations, one can infer that between the two variables is:

- a unidirectional Granger causality from X to *Y*;
- a unidirectional causality from *Y* to *X*;
- a bidirectional or feedback causality – in this case X cause *Y* and vice versa;
- no Granger causality in any direction.

Another econometric method that one can use for testing the relationship between two variables is *Panel data*. Regarding the choice of using or not panel data, Hsiao (2003) reveals several *advantages* of such regression models:

- unlike time series and cross-section studies, a panel data model assumes that individuals, firms, states or countries are heterogeneous;
- panel data models have a large number of observations, so it carries out *more informative data, more variability, less collinearity among the variables, more degrees of freedom* and more reliable parameter estimates;
- a panel data model is more suitable to study the dynamics of economic policies adjustments;
- by estimating a panel data regression model one can identify and analyse effects that simply cannot be detected in pure cross-section or pure time series data;
- panel data represents an excellent background for constructing and testing more complicated behavioral models, such as economies of scale or technological progress;
- macro panel data implies a longer time series than a pure time series data;
- in panel data the unit root tests have standard asymptotic distribution.

The most significant *limitations* of panel data are related to the problems of data collection – coverage or frequency, distorsions of measurement errors, selectivity problems, short time series dimension and cross-section dependence, which affects inference.

In his study, Gujarati (2004) indicates that the estimation of panel data regression models depends on the *assumptions* we will make about the intercept, the slope coefficients and the error term, as: *(i)* the intercept and slope coefficient are constant across time and space and the error term captures differences over time period and entities, *(ii)* the slope coefficients are constant and the intercept varies over entities, *(iii)* the slope coefficients are constant and the intercept varies over entities and time period, *(iv)* both slope coefficients and the intercept vary over entities or *(v)* all coeficients vary over entities and time.

On way to analyse the impact of variables that may vary over individuals and time, Baltagi (2005) estimates the *Fixed Effects* (FE) model by using differential intercept dummies:

$$y_{it} = \alpha_1 + \alpha_2 D_{2it} + \alpha_3 D_{3it} + \alpha_4 D_{4it} + \beta_2 X_{2it} + \beta_3 X_{3it} + \mu_{it} \ ,$$

where α_1 represents the intercept and α_2, α_3, α_4 are the differential intercept coefficients.

The dummy variable technique is known in the literature as the *Least-Squares Dummy Variable* (LSDV) model or as the covariance model. One could test the joint significance of these dummies by performing the restricted F test:

$$F = \frac{(RRSS - URSS)/(N-1)}{URSS/(NT - T - K)} \approx^{H_0} F_{N-1,N(T-1)-K} \ .$$

Although easy to apply the model may suffers from a large loss of degrees of freedom. Also, the estimation of so many variables in the model could cause the problem of multicollinearity among the regressors. Furthermore, if we include variables that are time invariant it is possible that the *FE* estimator may not be able to identify the effect of such variables.

Lancaster (2000) suggests as solutions to this incidental parameter problem the use of instrumental variables, the first differencing or conditioning of the model.

Another important aspect one must take into account is the analyse of the error term variance; we can assume that the error term variance is the same for all cross-section units or it is heteroscedastic and there is no autocorrelation over time.

Brüderl (2005) shows that if in the *FE* model are too many parameters, then the loss of the degrees of freedom can be avoided if we will assume the error term variation across entities as beeing *random*.

Dougherty (2007) indicates that the most known procedure used for choosing between *FE* estimation and *RE* estimation is the *Durbin-Wu-Hausman* test. The null hypothesis underlying the test is that the β_i are distributed independently of the X_i. If the null hypothesis is not rejected, both random and fixed effects are statistically significant, but fixed effects will be inefficient, because its LSDV form involves the estimation of an unnecessary set of dummy variable coefficients. If the null hypothesis is rejected, the conclusion will be that *RE* model is not appropriate and that one may choose to use the *FE* model.

2. Empirical analysis

This analysis uses time series data on gross national saving rate and real economic growth for Euro-area countries. All the data have annual frequency, covering the time period 1960-2011; they are extracted from The World Bank Data website:

- ΔGDP_t - real economic growth (annual %) of the EU-17 countries: Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, Netherlands, Portugal, Slovakia, Slovenia, Spain;
- GNS_t - gross national saving (% of GDP).

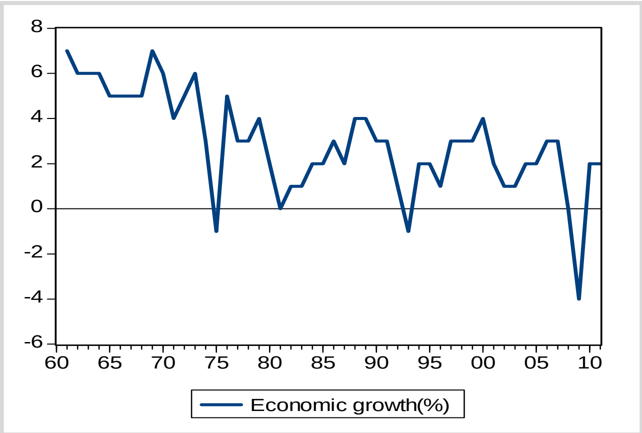

Figure 1. *Evolution of the Euro-area real GDP growth rates*

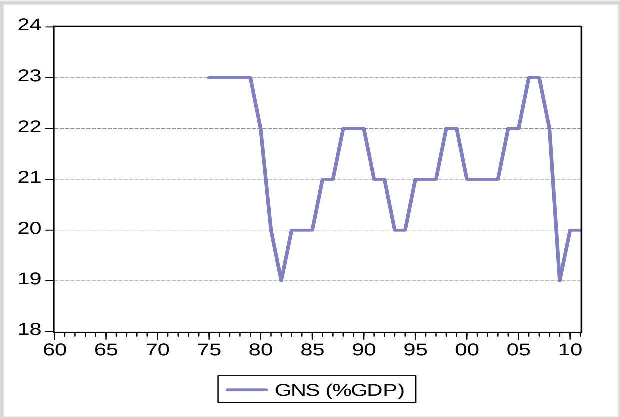

Figure 2. *Evolution of the gross national saving rate*

Stationarity and co-integration tests

For testing the stationarity and, also, to identify the integration order of the two time series, we performed the *Augmented Dikey-Fuller* (ADF) unit root test for the level series and for the order one differences.

Table 1. *Unit root test results for the level series and for the 1st differences*

	GNS_t	GDP_t	ΔGNS_t	ΔGDP_t
t -statistic	-2.474	-3.790	-5.182	-8.347
ρ value	0.129	0.005	0.000	0.000
critical value (5%)	-2.945	-2.921	-2.948	-2.923
R^2_{adj}	0.127	0.214	0.432	0.691
F - statistic	6.125	14.369	26.860	53.774
Prob F	0.018	0.000	0.000	0.000

The 1st order one differences ρ-value (0.000) associated to t-statistic indicates a clear rejection of the non-stationary hypothesis for both time series, gross national saving rate and real GDP growth rate; thus, we can infer that the two data series are stationary integrated of order one - $I(1)$.

Johansen co-integration test

Due to the fact that the two macroeconomic variables are $I(1)$, one can check if the data series are co-integrated by applying the *Johansen* procedure.

Table 2. *Results of the Johansen cointegration test for the stationary variables*

Data trend	None	None	Linear	Linear	Quadratic
Test type	No Intercept	Intercept	Intercept	Trend	Trend
	No Trend	No Trend	No Trend	Trend	Trend
Trace	1	1	2	0	2
Max-Eig	1	0	2	0	0

The results reveals the existence of at least one and no more than two co-integration connections, in the very long run, between gross national saving rate and the evolution of real GDP.

Granger causality test

In order to determine the existence of a relationship between saving rate and the dynamic of the real economy we tested the bivaried Granger causality by estimating the following OLS regression models:

$$\Delta GDP_t = \alpha_0 + \alpha_1 \Delta GDP_{t-1} + ... + \alpha_l \Delta GDP_{t-l} + \beta_1 GNS_{t-1} + ... + \beta_l GNS_{t-l} + \varepsilon_t$$

$$GNS_t = \alpha_0 + \alpha_1 GNS_{t-1} + ... + \alpha_l GNS_{t-l} + \beta_1 \Delta GDP_{t-1} + ... + \beta_l \Delta GDP_{t-l} + u_t$$

Therefore, we will test, first, if GNS_t Granger cause ΔGDP_t and, second, if ΔGDP_t Granger cause GNS_t.

Table 3. *Granger Causality tests for l=5*

Null hypothesis	F - statistic	P value
ΔGDP_t does not Granger cause GNS_t	2.610	0.054
GNS_t does not Granger cause ΔGDP_t	1.099	0.390

Due to the fact that the *F* value is statistically significant only for the first regression model we can assume that there is a unidirectional causality between the two macroeconomic variables, from the real GDP toward the saving rate for Euro-area countries.

We will estimate the folowing VAR(4) model in order to identify the intensity and the direction of this causal relationship:

$$\begin{cases} \Delta GDP_t = \alpha_{10} + \alpha_{11}\Delta GDP_{t-1} + \alpha_{12}\Delta GDP_{t-2} + \alpha_{13}\Delta GDP_{t-3} + \\ \quad + \alpha_{14}\Delta GDP_{t-4} + \beta_{11} GNS_{t-1} + \beta_{12} GNS_{t-2} + \beta_{13} GNS_{t-3} + \\ \quad + \beta_{14} GNS_{t-4} + \varepsilon_{1t} \\ GNS_t = \alpha_{20} + \alpha_{21}\Delta GDP_{t-1} + \alpha_{22}\Delta GDP_{t-2} + \alpha_{23}\Delta GDP_{t-3} + \\ \quad + \alpha_{24}\Delta GDP_{t-4} + \beta_{21} GNS_{t-1} + \beta_{22} GNS_{t-2} + \beta_{23} GNS_{t-3} + \\ \quad + \beta_{24} GNS_{t-4} + \varepsilon_{2t} \end{cases}$$

The results of the VAR(4)'s estimates are summarized in the tabel below:

Table 4. *Estimation results of VAR for l=4*

	GNS_t	ΔGDP_t
GNS_{t-1}	0.685	-0.137
GNS_{t-2}	0.186	0.137
GNS_{t-3}	-0.275	-0.679
GNS_{t-4}	-0.205	-0.101
ΔGDP_{t-1}	0.099	0.431
ΔGDP_{t-2}	-0.247	-0.440
ΔGDP_{t-3}	0.607	0.448
ΔGDP_{t-4}	0.055	-0.249
C	12.933	14.362
R^2	0.593	0.396
R^2_{adj}	0.457	0.195
F - statistic	4.378	1.970
AIC	2.590	3.797
SC	2.998	4.205

** statistically significant at 95%.*

According to the estimation results we can observe that there is a strong positive unidirectional causality from real GDP growth rate to the gross national saving rates for Euro-area countries, with a delay of at least four years, as otherwise the impulse response function graph shows.

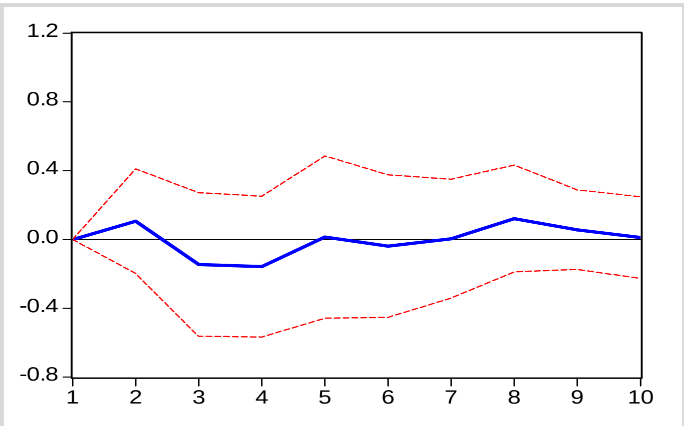

Figure 3. *The saving rate response function to a shock of real economic growth*

The Vector Error Correction (VEC) model

We use the VEC model because *(i)* the unit root test results showed that the data series are not stationary in their levels, but are in their first differences, *(ii)* to test if the $I(1)$ macroeconomic variables are cointegrated and, also, *(iii)* if there is a long-run relationship between them. Thus, introducing the cointegration equation for GDP and GNS, we estimated the VEC model as it follows:

$$\begin{cases} \Delta GDP_t = \alpha_{10} + \left(a + b\Delta GDP_{t-1} + c\Delta GNS_{t-1}\right) + \alpha_{11}\Delta GDP_{t-1} + \alpha_{12}\Delta GDP_{t-2} + \\ \qquad + \alpha_{13}\Delta GDP_{t-3} + \alpha_{14}\Delta GDP_{t-4} + \\ \qquad + \beta_{11}GNS_{t-1} + \beta_{12}GNS_{t-2} + \beta_{13}GNS_{t-3} + \beta_{14}GNS_{t-4} + \varepsilon_{1t} \\ GNS_t = \alpha_{20} + \left(a + b\Delta GDP_{t-1} + c\Delta GNS_{t-1}\right) + \alpha_{21}\Delta GDP_{t-1} + \\ \qquad + \alpha_{22}\Delta GDP_{t-2} + \alpha_{23}\Delta GDP_{t-3} + \alpha_{24}\Delta GDP_{t-4} + \\ \qquad + \beta_{21}GNS_{t-1} + \beta_{22}GNS_{t-2} + \beta_{23}GNS_{t-3} + \beta_{44}GNS_{t-4} + \varepsilon_{2t} \end{cases}$$

The results of the VEC(4)'s estimates are summarized in the tabel below:

Table 5. *Estimation results of VEC model for l=4*

	ΔGNS_t	ΔGDP_t
ΔGNS_{t-1}	0.608	0.954
ΔGNS_{t-2}	0.890	1.420
ΔGNS_{t-3}	0.453	0.447
ΔGNS_{t-4}	0.362	0.395
ΔGDP_{t-1}	0.071	-0.361
ΔGDP_{t-2}	-0.157	-0.776
ΔGDP_{t-3}	-0.289	-0.299
ΔGDP_{t-4}	0.076	-0.139
Intercept	0.001	0.008
Cointegrating eq.	-0.986	-1.343
b	1	
c	0.088*	
a	-21.293	
R^2	0.675	0.528
R^2_{adj}	0.542	0.335
F - statistic	5.092	2.739
AIC	2.156	3.926
SC	2.614	4.384

** statistically significant at 95%.*

The VEC model is statistically significant highlighting that there is a positive direct relationship in the very long run between real GDP growth and the saving rate (Figure 4); furthermore, the value and the sign of the c coefficient indicates that the saving rate has an elasticity higher than one in relation to the evolution of GDP growth rate.

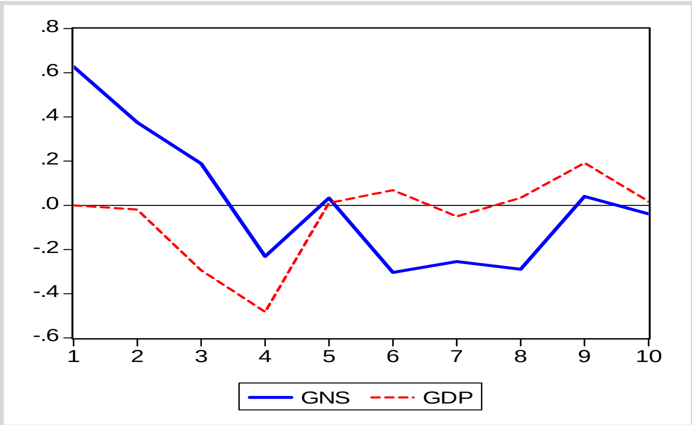

Figure 4. *Combined graphs impulse response function*

Relationship between saving rate and real economic growth using panel data

In order to investigate the interdependence between saving and the economic growth for Euro-area countries, we performed a *panel data analysis*; in this sens, we used the following macroeconomic variables:

- ΔGDP_t – real GDP growth rate (annual %) of the EU-17 countries: Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, Netherlands, Portugal, Slovakia, Slovenia, Spain;
- ΔGNS_t – gross national saving (% of GDP).

Our data series have annual frequency and covers the 2000-2011 time period; they have been provided, for each country, by The World Bank Data.

Panel data models

Using the variables mentioned above, one can estimate the either *Fixed Effects* (FE) or *Random Effects* (RE) models.

The *Fixed Effects (FE) model* has the following expression:

$$y_{it} = (\alpha + u_i) + X_{it}^{'}\beta + v_{it}$$

where y_{it} is the dependent variable, X_{it} is a matrix of explanatory variables, and $\nu_{it} \sim IID(0, \sigma_\nu^2)$.

The *Random Effects (RE) model* could be expressed as:

$$y_{it} = \alpha + X_{it}^{'}\beta + (u_i + \nu_{it})$$

where y_{it} is the dependent variable, X_{it} is a matrix of explanatory variables, and $\nu_{it} \sim IID(0, \sigma_\nu^2)$.

There are major differences between the two models:

- in the *FE model* the intercept is varying across countries or time periods, while in the *RE model* the intercept is constant;
- the variance of the residual term is constant for *FE model*, while in *RE model* the variance is not constant over time or across countries.

For choosing between *FE* and *RE* we use *Hausman test*; therefore, we are testing the null hypothesis that the incercepts are orthogonal to both explanatory variables and residual variable.

In the following only the relevant models (either *RE* or *FE*) are shown, according to *Hausman test.*

Gross national saving rate as a predictor of the real GDP growth rate

In order to asses the connection between saving rate and the dynamic of real economic growth, we have estimated the following *Fixed Effects (FE) model*:

$$\Delta GDP_{it} = (\alpha + \mu_{it}) + GNS_{it-1}^{'}\beta + \nu_{it},$$

where $i = 1...17$ represents the country and t is the time index.

Tabel 6. *Saving rate and the real economic growth*

Variable	Coefficient	St. Error	T-statistic	Prob.
C	-2.302	1.403	-1.640	0.102
GNS ?	0.220	0.068	3.217	0.016
Cross section fixed (dummy variables)				
_Austria_C	-1.533			
_Belgium_C	-1.292			
_Cyprus_C	2.583			
_Estonia_C	1.814			
_Finland_C	-1.134			
_France_C	-0.496			
_Germany_C	-1.260			
_Greece_C	1.432			
_Ireland_C	0.395			
_Italy_C	-1.265			

Variable	Coefficient	St. Error	T-statistic	Prob.
_Luxembourg_C	0.244			
-Malta_C	1.352			
_Netherlands_C	-1.911			
_Portugal_C	-0.191			
_Slovakia_C	2.590			
_Slovenia_C	-0.414			
_Spain_C	-0.187			
Period fixed (dummy variables)				
2000_C	2.159			
2001_C	0.246			
2002_C	0.089			
2003_C	-0.179			
2004_C	0.651			
2005_C	0.951			
2006_C	1.821			
2007_C	1.958			
2008_C	-1.123			
2009_C	-6.364			
2010_C	0.153			
2011_C	-0.365			
R-squared	0.678	Mean dependent var		2.187
Adjusted R-squared	0.624	S.D. dependent var		3.391
S.E. of regression	2.077	Akaike info criterion		4.435
Sum squared resid	725.229	Schwarz criterion		4.918
Log likelihood	-407.904	F-statistic		12.648
Durbin-Watson stat	1.214	Prob(F-statistic)		0.000

As one can observe, the estimated model is not valid for the entire Euro-17 area. Thus, the influence of gross national saving rate isn't statistically significant; yet, for Cyprus, Estonia, Greece, Malta and Slovakia, the coefficient of the cross-section is significant, which means that for these countries there is a causality link between the two variables from the saving rate to the real economic growth.

Real economic growth as a predictor of the saving rate

In order to asses the ability of real economic growth to predict the evolution of the gross national saving rate, we have estimated the following *Random Effects (RE) model*:

$$GNS_{it} = \alpha + \Delta GDP'_{it-1}\beta + (\nu_{it} + \mu_{it}),$$

where $i = 1...17$ represents the country and t is the time index.

Tabel 7. *Real economic growth and the saving rate*

Variable	Coefficient	St. Error	T-statistic	Prob.
C	19.218	1.239	15.502	0.000
GDP ?	0.503	0.056	8.920	0.000
Cross section random effects				
_Austria_C	5.125			
_Belgium_C	4.121			
_Cyprus_C	-8.352			
_Estonia_C	1.444			
_Finland_C	5.001			
_France_C	-0.463			
_Germany_C	2.596			
_Greece_C	-9.031			
_Ireland_C	0.315			
_Italy_C	-0.012			
_Luxembourg_C	3.243			
_Malta_C	-7.194			
_Netherlands_C	5.819			
_Portugal_C	-5.112			
_Slovakia_C	-2.404			
_Slovenia_C	3.776			
_Spain_C	1.125			
R-squared	0.290	Mean dependent var		2.981
Adjusted R-squared	0.286	S.D. dependent var		2.997
S.E. of regression	2.532	Schwarz criterion		1250.239
F-statistic	79.666	Durbin-Watson stat		0.786
Prob(F-statistic)	0.000			

For Euro area as a whole the real GDP growth rate could be seen as a key determinant of the gross national saving rate; there is a positive strong relationship between the two variables, in other words the higher GDP the higher saving is. Again, the impact is not statistically significant for Cyprus, Greece, Malta and Portugal.

Conclusions

This paper's sample is based on annual observations within the entire Euro-area, of variables such as gross national saving rate and real GDP growth rate, before and after the actual financial crisis. Our main findings reveals that there is a significant unidirectional causality between the two macroeconomic variables from real GDP to the saving rate, with a delay of at least four years. This result is in line with the existing literature, which underlines a strong positive connection in the very long run between the two of them in the case of developed economies.

We choose to estimate a panel data models for each country in order to observe the differences in the direction and sense of the causality linkage. Thus, for countries like Cyprus, Greece, Malta and Portugal the intensity of this unidirectional causal relationship from GDP growth rate to the saving rate is low. Possible explanations for this would be that these countries do not have the same structural parameters, like the others Euro-area economies, so the real convergence conditioning hypothesis is valid from the economic development perspective and, also, from the political stability view.

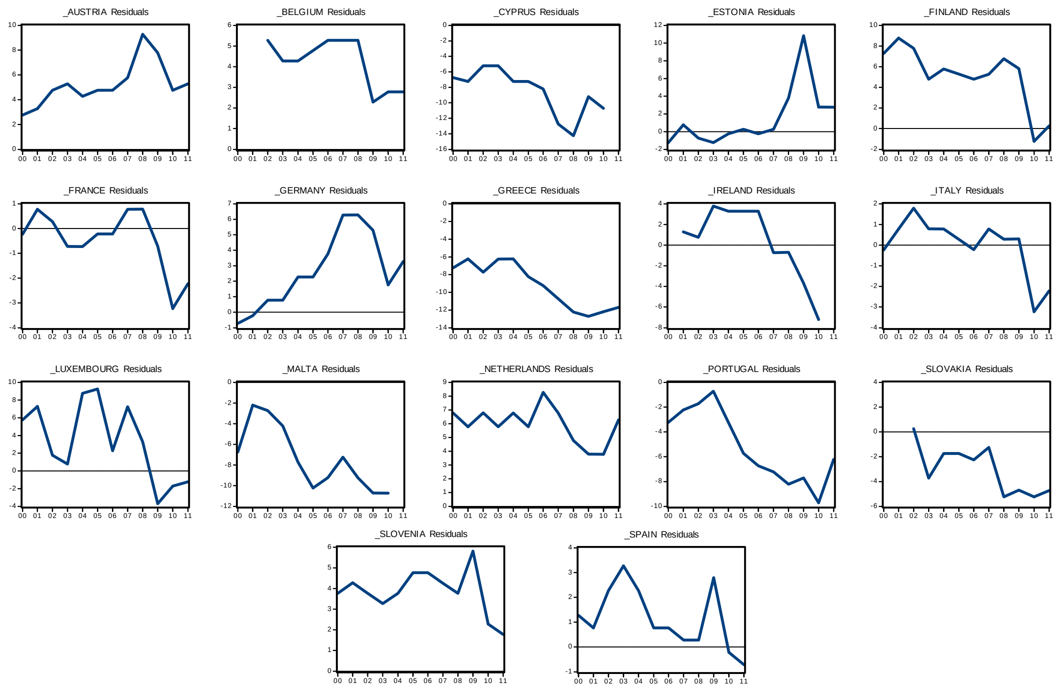

Figure 5. *Residual graphs evolutions for Euro-area coutries*

We did not test *Granger causality in panel data* because this is going to be the next step of our research, when we intend to capture the relationship for all EU-27 economies, before and after the financial crisis, taking into consideration other key determinant of real economic growth, like capital accumulation, population growth rate or technological progress, as well as other methodology, such *Autoregressive and distributive-lag (ARDL) models.*

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