THE REAL GDP RATE IN EUROPEAN UNION. A PANEL DATA APPROACH

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Abstract.

The main aim of this article is to explain the evolution of real GDP rate in European Union (EU-28) over the period 2002-2013 using panel data sets. Several dynamic models (6 models) explained the real GDP growth, an increase in the real GDP rate in the previous period with 1% generating an increase in the real GDP rate in the current period with a value between 0.3% and 0.4%. A fixed effects model with individual effects and effects in time explained the real GDP growth using as explanatory variable the employment. Moreover, a panel data model is estimated, but the assumptions related to errors are not checked. Simulations are made for 2014 and 2015 using the dynamic model and the fixed effects model, the latter anticipating higher GDP rate than most of the dynamic models.

Key-words: GDP rate, dynamic model, fixed effects model, employment

JEL Classification: C15, C53

Introduction

In the last 10 years several EU countries had faced a notable economic instability. They have problems on short and long run like low economic growth, unemployment, globalization population ageing. In this study the economic growth in all EU countries is analyzed using the panel data approach.

There are many macroeconomic variables that explain the economic growth, in literature many types of econometric models being proposed. In this study, the panel data approach is used, the real GDP rate being explained by using dynamic and fixed effects models. The real GDP rate is analyzed using the correlation with the employment.

After this introduction, a short literature review is made. The methodology corresponds to dynamic model and fixed-effects model. The economic growth is explained for all the countries in EU-28 over the period 2002-2013 and simulations are built up for 2014 and 2015.

Literature review for modeling economic growth

The Solow's neo-classical growth theory shows that there are two long-term factors that determine growth rate: population growth and total factor productivity rate. On the other hand, on medium-run, the physical capital accumulation and saving rate have a positive impact on GDP rate.

In literature, there are many factors recognized as engines for economic growth:

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- ❖ Human capital is consider a principal source of growth in augmented Solow model and endogenous growth model;
- ❖ Foreign direct investment (FDI) has a positive impact on GDP, as Petrakos, Arvanitidis and Pavleas (2007) stated, because FDI increases trade openness, production internationalization and favorable spillover effect;
- ❖ Investment is essential in endogenous growth models and neoclassical models, according to Workie(2005);
- ❖ Openness ensures the exploitation of comparative advantage, knowledge diffusion, technological transfer, increasing scale economies;
- ❖ Stable macroeconomic conditions and macroeconomic policies that have the following characteristics: predictable and low inflation rates, low departure of real exchange rate from the equilibrium level, sustainable budget deficit;
- ❖ Structural reforms and liberalization for market-oriented countries;
- ❖ Institutional framework that is evaluated using the following indicators: expropriation risk, property rights, government repudiation of contracts, values of country risks;
- ❖ Initial income, especially important for transition countries;
- ❖ Political factors like political regime, political instability and civil and political freedom.

The economic theory showed a positive correlation between GDP rate and employment. If economic growth is analyzed in more states, Chubrik(2005) consider that a separate regression should be run for each country when there are high correlations among regressors. However, recent studies proposed the panel data approach to describe the GDP growth rate in more countries, like European Union. The main advantages of panel data are the more informative data, more variability, higher number of degrees of freedom, less co-linearity between variables and more efficiency.

In the study of Tas, Hepsen and Onder(2013), the gross domestic product in EU countries and several candidates during 2002-2012 is explained in a panel data framework using as regressors: general government gross debt, general government total expenditure, current account balance, gross national savings, inflation (average consumer prices), unemployment rate, general government revenue, population, volume of exports of goods and services, volume of imports of goods and services, total investment. The population number positively influences economic growth, while unemployment rate and total expenditure have a negative impact on economic growth.

Ciftcioglu and Begovic (2008) analyzed the relationship between GDP growth and different economic variables using panel data models for 9 East and Central European Countries during 1995-2003. The selection of the best panel data model is based on F, LR and Hausman tests. Several variables have a positive impact on economic growth: ratio of budget balance to GDP, ratio of the sum of exports and imports to GDP and share of domestic investment in GDP. On the other hand, inflation rate, its volatility and ratio of the stock of external debt to GDP has a negative on real GDP rate. For South-East European countries, Trpkova and Tashevska (2011) developed a panel data analysis to determine the factors that generate economic growth. 7 states were chosen (Romania, Bulgaria, Albania, Bosnia and Herzegovina, Serbia, Macedonia and Croatia) during 1995-2007 and the economic growth was generated by inflation rate, exchange rate, current account/GDP, population growth, general government balance, large scale privatization, and general government expenditure and price liberalization.

Patillo et al. (2004) used a large panel data series for 61 developing countries in the period 1969-1998 and they showed that the increase in “external indebtedness” negatively affected economic growth because of the adverse effects on physical capital accumulation and total factor productivity growth.

Furceri and Karras (2008) studied the impact of changes in taxes on economic growth for 26 countries of OECD using a panel data approach in the period 1965-2007. The increase in taxes with 1 percent generated a decrease in per capita real GDP with a value between -0.5 percent and – 1 percent. The increase in taxes on goods and services or social security contributions has a more intense impact on per capita real GDP than the income tax increase.

A panel data analysis was run for ASEAN countries by Hussin and Saidin (2012) who evaluated the impact on GDP of the following variables: openness, foreign direct investment and gross fixed capital formation. A pooled model, a fixed effects model and a random effects model are estimated over the period from 1981 to 2008. All the macroeconomic variables are positively correlated with GDP, but the results of panel data models indicated that for all four ASEAN countries (Thailand, Philippines, Malaysia and Indonesia) FDI is not correlated with GDP.

Adhikary (2011) observed a positive relationship between economic growth, foreign direct investment (FDI), trade openness and capital formation in USA countries. Hoang, Wiboonchutikula and Tubtimtong(2010).analyzed the impact of FDI on growth rates in Vietnam by using panel data models during 1995-2006. The authors observed that FDI had a significant positive effect on growth rates in Vietnam.

Methodology

We start from a regression model based on spatial and temporal date (pooled ordinary least squares- POLS) without using fixed or random effects from panel techniques:

$$y_{it} = \beta_0 + \sum_j \beta_j \cdot X_{jit} + \varepsilon_{it} \qquad (1)$$

y_{it}- dependent variable for individual unit i and at time t; X_{jit}- the regressor “j” for individual unit i and at time t; β_0- constant (common for all individual units); ε_{it}- errors; i=1,2,…,N; t=1,2,…,T.

This general model will be transformed for estimating the parameters using the fixed-effects panel techniques that test the existence of individual effects. Considering a specific particularity of each individual unit that is constant in time, the unobserved characteristics are modeled as fixed-effects included in different values of β_{0i} for each individual unit. These individual effects show the individual units characteristics that suppose to be constant in the mentioned period that has impact on the dependent variable. Therefore, the unobserved heterogeneity is controlled under the assumption that it is constant in time and, eventually, correlated with regressors. The form of one-way fixed effects model is:

$$y_{it} = \beta_{0i} + \sum_j \beta_j \cdot X_{jit} + \varepsilon_{it} \qquad (2)$$

y_{it}- dependent variable for individual unit i and at time t; X_{jit}- the regressor “j” for individual unit i and at time t; β_{0i}- unobserved individual effect (constant in time for each individual unit); ε_{it}- errors; i=1,2,…,N; t=1,2,…,T.

The model could be extended for including the fixed-effects in time (two-way fixed effects model):

$$y_{it} = \beta_{0i} + \gamma_i + \sum_j \beta_j \cdot X_{jit} + \varepsilon_{it} \quad (3)$$

γ_t- fixed effects in time

The impact of time passage is put into evidence by changes in economic policies, the economic crisis influence or the economic relancement in each individual unit.

The random effects model considers the model constant as a random variable of average β_0 , but the differences between individual units are random deviations from the constant mean β_0:

$$\beta_{0i} = \beta_0 + \varepsilon_i \quad (4)$$

In the case of random effects model, the errors are determined as:

$$u_{it} = \varepsilon_i + e_{it} \quad (5)$$

ε_i- error that is specific to individual unit *i; e_{it}*- random error

The demeaning transformation in panel data generates the problem of unobserved heterogeneity. The dynamic panel models make the first differencing to remove the unobserved heterogeneity. A partial adjustment mechanism is ensured by the lagged variable or lagged variables in the model. The demeaning procedure generates a regressor which is not distributed independently of the error. If the explanatory variables are correlated with the lagged dependent variable, the coefficients are biased. The fixed-effect model has the problem of Nickell bias. This bias appears even if the errors are independent and identically distributed. In order to solve this problem, the first differences of the initial model are considered. If a single explanatory variable and a lagged dependent variable Y are taken, we consider the following model:

$$y_{it} = \beta_0 + \rho \cdot y_{i,t-1} + \beta_1 \cdot X_{it} + u_i + \varepsilon_{it} \quad (6)$$

X_{it}- exogenous regressors; y_{it}- dependent variable; u_i- unobserved individual effect; ε_{it}- error

The construction of the model in first difference will eliminate the constant and the individual effect:

$$\Delta y_{it} = \rho \cdot \Delta y_{i,t-1} + \beta_1 \cdot \Delta X_{it} + \Delta\varepsilon_{it} \quad (7)$$

In this case we still have correlation between disturbances and the lagged dependent variable.

We may build instruments for the lagged dependent variable from the 2^{nd} and the 3^{rd} lag. If the error is i.i.d., then the lags are correlated with the lagged dependent characteristic, but it will not be correlated with the composite error term.

Let consider the equations:

$$y_{it} = \beta_0 \cdot X_{it} + \beta_1 \cdot W_{it} + v_{it} \quad (8)$$

$$v_{it} = u_i + \varepsilon_{it} \quad (9)$$

X_{it}- exogenous regressors; W_{it}- predetermined and endogenous regressors correlated with u_i

The first-differencing equation eliminates the unobserved individual effect, but omitted -variable bias appears.

The Arrelano-Bond (AB) approach and its extension to System GMM (generalized method of moments) is an estimator for the following cases:

- ❖ Many individual units and few time periods;

- ❖ A linear and functional relationship between variables;
- ❖ One left-hand dynamic variable;
- ❖ Not strictly exogenous right-hand variables;
- ❖ Fixed individual effects that suppose unobserved heterogeneity;
- ❖ Autocorrelation and homoskedasticity within individual units.

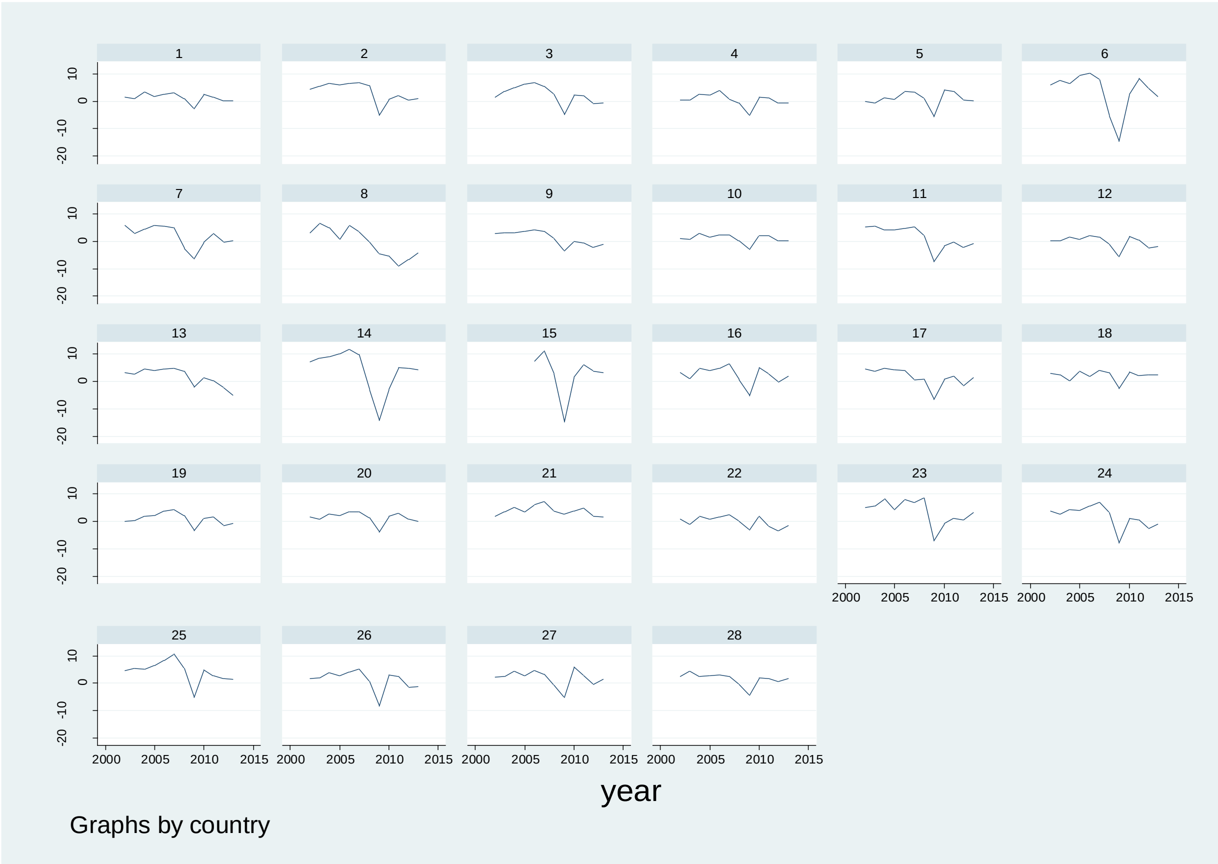
The AB estimator supposes a generalized method of moments' problem. It consists in a model built as a system of equations where the instruments corresponding to each equation are different. The possible weakness of AB estimator is solved by Arrelano-Bond-Blundell-Bond (ABBB) estimator. The lagged levels are in practice poor instruments for the variables in first difference. The new estimator (ABBB one) includes lagged differences and lagged levels. The initial estimator is called difference GMM, but the expanded one is named as System GMM and it supposes supplementary restrictions regarding the initial conditions for generating the dependent variable.

Modeling real GDP rate in EU-28

The variables used in this study are: real GDP growth rate and employment (annual average). The real GDP growth rate is the percentage change on previous year in constant prices. Employed persons are all the people who worked at least one hour for profit and pay during the reference week or were temporarily absent from such work.

The data for these variables are registered for all the European Union countries (EU-28) in the period from 2002 to 2013. First of all, the panel data are stationary, according to several unit root tests (Appendix 4). The evolution of real GDP rate during 2002-2013 for each country in EU-28 is represented in Figure 1. In 2009, many EU-28 countries registered negative values for real GDP rate. Several countries registered very low values for real GDP rate in 2009, these countries being: Estonia (-14.7%), Cyprus (-14.2%) and Latvia (-14.8%).

Figure 1. The real GDP rate in EU-28 in the period 2002-2013



Source: own computations

More dynamic panel models were estimated for GDP rate in EU-28 (Appendix 1) and simulations are made for 2014 and 2015. Only a dummy variable for year 2009 was introduced and a valid dynamic model was obtained. The moment conditions of GMM estimators are valid if there is no serial correlation in the idiosyncratic errors. The first difference of white noise is auto-correlated, only the second and higher autocorrelation must be checked.

The first type of dynamic model uses only the real GDP rate. The Arrelano-Bond and the Arrelano-Bond-Blundell-Bond estimators are computed for a lag equaled to 1 and for two lags. The models with one lag revels a positive impact of GDP rate in the previous period on the economic growth. On the other hand, the models with two lags indicated us a positive influence of the GDP rate in the previous period and a negative impact of the GDP rate with two years ago on economic growth in the current period.

The second type uses the employment as regressor, but 2 lags are used for GDP rate and AB estimator. The positive impact of employment on GDP growth is very low compared to the impact of lagged GDP rate. The GDP rate in the previous period had a positive influence on economic growth, while two years ago rate has a negative impact.

Table 1. Dynamic panel data models for explaining the real GDP rate evolution in EU-28 over 2002-2013

Dynamic model	Variable				
M1 (AB estimator)	GDP rate	Coefficient	Standard error	z	P>|z|
	GDP_rate_{t-1}	0.3906	0.0561	6.97	0.000
	constant	0.9866	0.2284	4.32	0.000
M2 (ABBB estimator)	GDP_rate_{t-1}	0.3749	0.0427	8.77	0.000
	constant	1.0186	0.2149	4.74	0.000
M3 (AB estimator)	GDP_rate_{t-1}	0.3916	0.1344	2.91	0.004
	constant	0.9678	0.3512	2.75	0.006
M4 (ABBB estimator)	GDP_rate_{t-1}	0.3745	0.1021	3.67	0.000
	constant	1.0152	0.2926	3.47	0.001
M5 (AB estimator)	GDP_rate_{t-1}	0.4397	0.0705	6.23	0.000
	GDP_rate_{t-2}	-0.2191	0.0938	-2.34	0.020
	constant	1.2379	0.2796	4.43	0.000
M6 (ABBB estimator)	GDP_rate_{t-1}	0.4038	0.0410	9.84	0.000
	GDP_rate_{t-2}	-0.2618	0.0907	-2.89	0.004
	constant	1.4235	0.2368	6.01	0.000
M7 (AB estimator)	GDP_rate_{t-1}	0.3374	0.0641	5.26	0.000
	Year 2009	-8.2413	0.5768	-14.29	0.000
	constant	1.8391	0.2486	7.40	0.000
M8 (ABBB estimator)	GDP_rate_{t-1}	0.3059	0.0461	6.64	0.000
	Year 2009	-8.9833	0.6935	-12.95	0.000
	constant	1.9869	0.2430	8.18	0.000
M9 (AB estimator)	GDP_rate_{t-1}	0.4402	0.1160	37.94	0.000
	GDP_rate_{t-2}	-0.2526	0.0066	-38.01	0.000
	$employment_t$	0.0000372	$5.02 \cdot 10^{-6}$	7.4	0.000
	constant	1.0115	0.0788	12.83	0.000

Source: author's computations

The zero autocorrelation for errors in first difference is checked starting from the second order. After this test is run, only M4, M6, M7 and M8 models are valid. All in all, we can conclude that we have 6 valid dynamic models for explaining the real GDP rate in EU-28 countries (M1, M2, M4, M6, M7, M8).

Table 2. Arrelano-Bond test for null autocorrelation in first-differenced errors

Model	Order	Z	Prob>z
M3	1	-2.3957	0.0166
	2	-2.743	0.0061
	3	1.3685	0.1712
	4	2.3523	0.0187
M4	1	-2.739	0.0062
	2	-2.7547	0.0059
	3	1.4405	0.1497
	4	2.3691	0.0178
M5	1	-3.1052	0.0019
	2	-0.6528	0.5139
	3	1.4094	0.1587
	4	1.7296	0.0837
M6	1	-3.376	0.0007
	2	-0.3182	0.7503
	3	1.1254	0.2604
	4	1.5168	0.1293
M7	1	-2.7441	0.0061
	2	-2.4313	0.015
	3	0.31767	0.7507
	4	1.6762	0.0937
M8	1	-2.8765	0.004
	2	-2.248	0.0246
	3	0.0332	0.9734
	4	1.4616	0.1439
M9	1	-3.6938	0.0002
	2	-0.5856	0.5581
	3	1.066	0.2864
	4	1.9496	0.0512

Source: author's computations

An increase in the real GDP rate in the previous period with 1% generated an increase of the real GDP rate in the current period with 0.39% (according to M1), 0.37% (according to M2), 0.37% (according to M4), 0.33% (according to M7) and 0.30% (according to M8). According to the estimations based on M6 model, an increase in the real GDP rate in the previous period with 1% generated an increase of the real GDP rate in the current period with 0.4% when the other variables are constant. On the other hand, an increase in the real GDP rate with two years ago with 1% generated a decrease of the real GDP rate in the current period with 0.26% when the other variables are constant.

Moreover, a panel data model with fixed-effects in time and cross-sections was proposed for GDP rate and employment in EU-28 (Appendix 2). In addition to these models, a panel data model was estimated, but the assumptions regarding the errors were not checked and the model was not used in simulations (Appendix 3). In the first period, the variation of the real GDP is entirely due to changes in GDP. Starting from the third lag, around 97% of the variation in reagl GDP rate is determined by the changes in this variables and around 2% of this variation is due to employment changes. In the first period, 1,118% of the variation in employment is due to changes in real GDP rate. Starting from the fourth lag, around 6% of the variation in employment is generated by GDP modifications.

The p-values corresponding to F and Chi-square statistics are 0.00 that provides strong evidence against the assumption that the fixed effects are all equal to each other. This shows that there is unobserved heterogeneity in time and for cross-sections. An increase in employment rate with one unit determines in increase with 0.001 units in the GDP rate.

The equations for fixed-effect model are the following:

R_GDP_1 = 4.43309521026 + PER_EFFECT - 9.08199801476 + 0.00137229576288*EMPL_1

R_GDP_2 = 7.658165837 + PER_EFFECT - 9.08199801476 + 0.00137229576288*EMPL_2

R_GDP_3 = 4.67245655914 + PER_EFFECT - 9.08199801476 + 0.00137229576288*EMPL_3

R_GDP_4 = 5.75568426361 + PER_EFFECT - 9.08199801476 + 0.00137229576288*EMPL_4

R_GDP_5 = -44.9492543867 + PER_EFFECT - 9.08199801476 + 0.00137229576288*EMPL_5

R_GDP_6 = 12.0053156114 + PER_EFFECT - 9.08199801476 + 0.00137229576288*EMPL_6

R_GDP_7 = 8.34205211328 + PER_EFFECT - 9.08199801476 + 0.00137229576288*EMPL_7

R_GDP_8 = 2.48662483678 + PER_EFFECT - 9.08199801476 + 0.00137229576288*EMPL_8

R_GDP_9 = -15.6073403218 + PER_EFFECT - 9.08199801476 + 0.00137229576288*EMPL_9

R_GDP_10 = -26.4604911641 + PER_EFFECT - 9.08199801476 + 0.00137229576288*EMPL_10

R_GDP_11 = 8.56626640366 + PER_EFFECT - 9.08199801476 + 0.00137229576288*EMPL_11

R_GDP_12 = -24.810098326 + PER_EFFECT - 9.08199801476 + 0.00137229576288*EMPL_12

R_GDP_13 = 10.1733337186 + PER_EFFECT - 9.08199801476 + 0.00137229576288*EMPL_13

R_GDP_14 = 11.9244335776 + PER_EFFECT - 9.08199801476 + 0.00137229576288*EMPL_14

R_GDP_15 = 10.7603414248 + PER_EFFECT - 9.08199801476 + 0.00137229576288*EMPL_15

R_GDP_16 = 11.0872645385 + PER_EFFECT - 9.08199801476 + 0.00137229576288*EMPL_16

R_GDP_17 = 4.95570714489 + PER_EFFECT - 9.08199801476 + 0.00137229576288*EMPL_17

R_GDP_18 = 11.1130710974 + PER_EFFECT - 9.08199801476 + 0.00137229576288*EMPL_18

R_GDP_19 = -1.60819404527 + PER_EFFECT - 9.08199801476 + 0.00137229576288*EMPL_19

R_GDP_20 = 5.11783312587 + PER_EFFECT - 9.08199801476 + 0.00137229576288*EMPL_20

R_GDP_21 = -7.26241819572 + PER_EFFECT - 9.08199801476 + 0.00137229576288*EMPL_21

R_GDP_22 = 2.16776989986 + PER_EFFECT - 9.08199801476 + 0.00137229576288*EMPL_22

R_GDP_23 = -0.0244584351446 + PER_EFFECT - 9.08199801476 + 0.00137229576288*EMPL_23

R_GDP_24 = 9.55237930458 + PER_EFFECT - 9.08199801476 + 0.00137229576288*EMPL_24

R_GDP_25 = 10.4168509793 + PER_EFFECT - 9.08199801476 + 0.00137229576288*EMPL_25

R_GDP_26 = 6.96930160579 + PER_EFFECT - 9.08199801476 + 0.00137229576288*EMPL_26

R_GDP_27 = 4.89565642618 + PER_EFFECT - 9.08199801476 + 0.00137229576288*EMPL_27

R_GDP_28 = -29.0888532723 + PER_EFFECT - 9.08199801476 + 0.00137229576288*EMPL_28

The dynamic panel and fixed-effects models are used to make simulations for 2014-2016. The GDP rates for each country are aggregated by computing a mean in order to determine the real GDP rate for entire EU-28. For the employment, the levels from 2013 and 2014 are considered in simulations.

Table 3. The real GDP rate in EU-28 according to simulations over 2014-2015

Model	2014	2015
M1	0.98	1.02
M2	1.02	1.05
M4	1.01	1.05
M6	1.52	1.42

Model	2014	2015
M7	1.83	1.87
M8	1.98	2.01
Fixed-effects model	1.88	2.1

Source: author's computations

The lowest simulated value for real GDP rate in EU-28 for 2014 is anticipated by M1, while the highest by M8. For 2015, again M1 provided the lowest real GDP rate, while the fixed effects model anticipated the highest economic growth.

Conclusion

There are many determinants of real GDP rate proposed by economic theory. In this study, dynamic panel data models are proposed, because the value of GDP might be determined by the values of the same indicator in previous period. On the other hand, a fixed effect model is proposed with individual effects and time effects to explain the GDP rate using as explanatory variable the employment. Several dynamic models explained the real GDP growth, an increase in the real GDP rate in the previous period with 1% generating an increase in the real GDP rate in the current period with a value between 0.3% and 0.4%.

The models are proposed for EU-28 and simulations are made for 2014 and 2015. Higher GDP rates are anticipated for 2014 and 2015 by the fixed effect model compared to most of the dynamic models in EU-28.

In a further study, the real GDP rate should be explain using other regressors like general government gross debt, general government total expenditure, current account balance, gross national savings, inflation (average consumer prices), unemployment rate, general government revenue, population, volume of exports of goods and services, volume of imports of goods and services, total investment.

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APPENDIX 1

```
. xtabond r_gdp, lags(1) artests(2)

Arellano-Bond dynamic panel-data estimation  Number of obs         =       276
Group variable: country                      Number of groups      =        28
Time variable: year
                                             Obs per group:    min =         6
                                                               avg =  9.857143
                                                               max =        10

Number of instruments =     56               Wald chi2(1)          =     48.55
                                             Prob > chi2           =    0.0000
One-step results
```

r_gdp	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
r_gdp						
L1.	.3906624	.0560655	6.97	0.000	.280776	.5005489
_cons	.9866784	.2284702	4.32	0.000	.5388851	1.434472

```
Instruments for differenced equation
        GMM-type: L(2/.).r_gdp
Instruments for level equation
        Standard: _cons
```

```
System dynamic panel-data estimation         Number of obs         =       304
Group variable: country                      Number of groups      =        28
Time variable: year
                                             Obs per group:    min =         7
                                                               avg =  10.85714
                                                               max =        11

Number of instruments =     66               Wald chi2(1)          =     76.95
                                             Prob > chi2           =    0.0000
One-step results
------------------------------------------------------------------------------
       r_gdp |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       r_gdp |
         L1. |   .3749774   .0427471     8.77   0.000     .2911947    .4587601
             |
       _cons |   1.018673   .2149361     4.74   0.000     .5974057     1.43994
------------------------------------------------------------------------------
Instruments for differenced equation
        GMM-type: L(2/.).r_gdp
Instruments for level equation
        GMM-type: LD.r_gdp
        Standard: _cons


. xtabond r_gdp, lags(1) twostep vce(robust) artests(2)

Arellano-Bond dynamic panel-data estimation  Number of obs         =       276
Group variable: country                      Number of groups      =        28
Time variable: year
                                             Obs per group:    min =         6
                                                               avg =  9.857143
                                                               max =        10

Number of instruments =     56               Wald chi2(1)          =      8.49
                                             Prob > chi2           =    0.0036
Two-step results
                                (Std. Err. adjusted for clustering on country)
------------------------------------------------------------------------------
             |              WC-Robust
       r_gdp |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       r_gdp |
         L1. |   .3916264   .1344157     2.91   0.004     .1281765    .6550763
             |
       _cons |   .9678463   .3513218     2.75   0.006     .2792682    1.656424
------------------------------------------------------------------------------
Instruments for differenced equation
        GMM-type: L(2/.).r_gdp
Instruments for level equation
        Standard: _cons

.
```

Arellano-Bond test for zero autocorrelation in first-differenced errors

Order	z	Prob > z
1	-2.3957	0.0166
2	-2.743	0.0061
3	1.3685	0.1712
4	2.3523	0.0187

H0: no autocorrelation

```
. xtdpdsys r_gdp, lags(1) twostep vce(robust) artests(2)

System dynamic panel-data estimation         Number of obs         =       304
Group variable: country                      Number of groups      =        28
Time variable: year
                                             Obs per group:    min =         7
                                                               avg =  10.85714
                                                               max =        11

Number of instruments =     66               Wald chi2(1)          =     13.45
                                             Prob > chi2           =    0.0002
Two-step results
```

r_gdp	Coef.	WC-Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
r_gdp						
L1.	.374505	.102128	3.67	0.000	.1743378	.5746722
_cons	1.015229	.2926254	3.47	0.001	.441694	1.588764

```
Instruments for differenced equation
        GMM-type: L(2/.).r_gdp
Instruments for level equation
        GMM-type: LD.r_gdp
        Standard: _cons
```

Arellano-Bond test for zero autocorrelation in first-differenced errors

Order	z	Prob > z
1	-2.739	0.0062
2	-2.7547	0.0059
3	1.4405	0.1497
4	2.3691	0.0178

H0: no autocorrelation

```
Arellano-Bond test for zero autocorrelation in first-differenced errors

  +-----------------------+
  |Order |  z     Prob > z|
  |------+----------------|
  |   1  | -2.739  0.0062 |
  |   2  |-2.7547  0.0059 |
  |   3  | 1.4405  0.1497 |
  |   4  | 2.3691  0.0178 |
  +-----------------------+
   H0: no autocorrelation

. xtabond r_gdp, lags(2) twostep vce(robust) artests(2)

Arellano-Bond dynamic panel-data estimation  Number of obs         =       248
Group variable: country                      Number of groups      =        28
Time variable: year
                                             Obs per group:    min =         5
                                                               avg =  8.857143
                                                               max =         9

Number of instruments =     55               Wald chi2(2)          =     40.88
                                             Prob > chi2           =    0.0000
Two-step results
                                (Std. Err. adjusted for clustering on country)
------------------------------------------------------------------------------
             |              WC-Robust
       r_gdp |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       r_gdp |
         L1. |   .4397875   .0705954     6.23   0.000      .301423     .578152
         L2. |  -.2191469   .0938499    -2.34   0.020    -.4030894   -.0352045
             |
       _cons |   1.237918   .2796924     4.43   0.000     .6897311    1.786105
------------------------------------------------------------------------------
Instruments for differenced equation
        GMM-type: L(2/.).r_gdp
Instruments for level equation
        Standard: _cons

.

Arellano-Bond test for zero autocorrelation in first-differenced errors

  +-----------------------+
  |Order |  z     Prob > z|
  |------+----------------|
  |   1  |-3.1052  0.0019 |
  |   2  |-.65282  0.5139 |
  |   3  | 1.4094  0.1587 |
  |   4  | 1.7296  0.0837 |
  +-----------------------+
   H0: no autocorrelation
```

```
. xtdpdsys r_gdp, lags(2) twostep vce(robust) artests(2)

System dynamic panel-data estimation         Number of obs         =       276
Group variable: country                      Number of groups      =        28
Time variable: year
                                             Obs per group:    min =         6
                                                               avg =  9.857143
                                                               max =        10

Number of instruments =     65               Wald chi2(2)          =     97.06
                                             Prob > chi2           =    0.0000
Two-step results
------------------------------------------------------------------------------
             |              WC-Robust
       r_gdp |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       r_gdp |
         L1. |   .4038369   .0410432     9.84   0.000     .3233936    .4842801
         L2. |  -.2618367   .0907283    -2.89   0.004    -.4396609   -.0840124
             |
       _cons |   1.423591   .2368966     6.01   0.000     .9592824      1.8879
------------------------------------------------------------------------------
Instruments for differenced equation
        GMM-type: L(2/.).r_gdp
Instruments for level equation
        GMM-type: LD.r_gdp
        Standard: _cons

.

Arellano-Bond test for zero autocorrelation in first-differenced errors
  +-----------------------+
  |Order |  z     Prob > z|
  |------+----------------|
  |   1  |-3.376  0.0007  |
  |   2  |-.3182  0.7503  |
  |   3  |1.1254  0.2604  |
  |   4  |1.5168  0.1293  |
  +-----------------------+
   H0: no autocorrelation
```

```
. xtabond r_gdp y2009 y2010 y2011 y2012 y2013, lags(1) twostep vce(robust) artests(2)

Arellano-Bond dynamic panel-data estimation  Number of obs         =       276
Group variable: country                      Number of groups      =        28
Time variable: year
                                             Obs per group:    min =         6
                                                               avg =  9.857143
                                                               max =        10

Number of instruments =     61               Wald chi2(6)          =    734.68
                                             Prob > chi2           =    0.0000
Two-step results
                                (Std. Err. adjusted for clustering on country)
```

r_gdp	Coef.	WC-Robust Std. Err.	z	P>|z|	[95% Conf. Interval]	
r_gdp						
L1.	.3414507	.4414209	0.77	0.439	-.5237183	1.20662
y2009	-8.537101	2.840335	-3.01	0.003	-14.10405	-2.970147
y2010	.924439	5.790348	0.16	0.873	-10.42443	12.27331
y2011	-1.251336	2.572484	-0.49	0.627	-6.293311	3.79064
y2012	-3.430657	2.460476	-1.39	0.163	-8.253101	1.391787
y2013	-2.259531	3.384659	-0.67	0.504	-8.89334	4.374278
_cons	2.417138	2.547823	0.95	0.343	-2.576502	7.410779

```
Instruments for differenced equation
        GMM-type: L(2/.).r_gdp
        Standard: D.y2009 D.y2010 D.y2011 D.y2012 D.y2013
Instruments for level equation
        Standard: _cons

.
```

```
. xtabond r_gdp y2009, lags(1) twostep vce(robust) artests(2)

Arellano-Bond dynamic panel-data estimation  Number of obs         =       276
Group variable: country                      Number of groups      =        28
Time variable: year
                                             Obs per group:    min =         6
                                                               avg =  9.857143
                                                               max =        10

Number of instruments =     57               Wald chi2(2)          =    339.20
                                             Prob > chi2           =    0.0000
Two-step results
                                (Std. Err. adjusted for clustering on country)
```

r_gdp	Coef.	WC-Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
r_gdp						
L1.	.3374705	.0641078	5.26	0.000	.2118214	.4631195
y2009	-8.241346	.5768534	-14.29	0.000	-9.371958	-7.110734
_cons	1.839169	.2486374	7.40	0.000	1.351849	2.326489

```
Instruments for differenced equation
        GMM-type: L(2/.).r_gdp
        Standard: D.y2009
Instruments for level equation
        Standard: _cons

.

Arellano-Bond test for zero autocorrelation in first-differenced errors
```

Order	z	Prob > z
1	-2.7441	0.0061
2	-2.4313	0.0150
3	.31767	0.7507
4	1.6762	0.0937

H0: no autocorrelation

Dynamic panel-data estimation — Number of obs = 304

Group variable: country — Number of groups = 28

Time variable: year

Obs per group: min = 7; avg = 10.85714; max = 11

Number of instruments = 67 — Wald chi2(2) = 341.17; Prob > chi2 = 0.0000

Two-step results

(Std. Err. adjusted for clustering on country)

r_gdp	Coef.	WC-Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
r_gdp						
L1.	.3059947	.0460995	6.64	0.000	.2156415	.396348
y2009	-8.983378	.6935064	-12.95	0.000	-10.34263	-7.62413
_cons	1.986905	.2430196	8.18	0.000	1.510596	2.463215

Instruments for differenced equation

GMM-type: L(2/.).r_gdp

Standard: D.y2009

Instruments for level equation

GMM-type: LD.r_gdp

Standard: _cons

Arellano-Bond test for zero autocorrelation in first-differenced errors

Order	z	Prob > z
1	-2.8765	0.0040
2	-2.248	0.0246
3	.03328	0.9734
4	1.4616	0.1439

H0: no autocorrelation

.

```
. xtabond r_gdp empl, lags(2) twostep artests(2)

Arellano-Bond dynamic panel-data estimation  Number of obs         =       246
Group variable: country                      Number of groups      =        28
Time variable: year
                                             Obs per group:    min =         5
                                                               avg =  8.785714
                                                               max =         9

Number of instruments =     56               Wald chi2(3)          =   3397.95
                                             Prob > chi2           =    0.0000
Two-step results
------------------------------------------------------------------------------
       r_gdp |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       r_gdp |
         L1. |   .4402635   .0116039    37.94   0.000     .4175202    .4630068
         L2. |  -.2526016   .0066464   -38.01   0.000    -.2656283    -.239575
             |
        empl |   .0000372   5.02e-06     7.40   0.000     .0000273     .000047
       _cons |   1.011553   .0788133    12.83   0.000     .8570821    1.166025
------------------------------------------------------------------------------
Warning: gmm two-step standard errors are biased; robust standard
         errors are recommended.
Instruments for differenced equation
        GMM-type: L(2/.).r_gdp
        Standard: D.empl
Instruments for level equation
        Standard: _cons

.

Arellano-Bond test for zero autocorrelation in first-differenced errors
  +-----------------------+
  |Order |  z     Prob > z|
  |------+----------------|
  |   1  |-3.6938  0.0002 |
  |   2  | -.5856  0.5581 |
  |   3  |  1.066  0.2864 |
  |   4  | 1.9496  0.0512 |
  +-----------------------+
   H0: no autocorrelation
```

APPENDIX 2

Dependent Variable: R_GDP?
Method: Pooled Least Squares

Sample: 2002 2013
Included observations: 12
Cross-sections included: 28
Total pool (unbalanced) observations: 330

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-9.081998	3.028497	-2.998846	0.0029
EMPL?	0.001372	0.000379	3.624908	0.0003
Fixed Effects				

(Cross)	
_1—C	4.433095
_2—C	7.658166
_3—C	4.672457
_4—C	5.755684
_5—C	-44.94925
_6—C	12.00532
_7—C	8.342052
_8—C	2.486625
_9—C	-15.60734
_10—C	-26.46049
_11—C	8.566266
_12—C	-24.81010
_13—C	10.17333
_14—C	11.92443
_15—C	10.76034
_16—C	11.08726
_17—C	4.955707
_18—C	11.11307
_19—C	-1.608194
_20—C	5.117833
_21—C	-7.262418
_22—C	2.167770
_23—C	-0.024458
_24—C	9.552379
_25—C	10.41685
_26—C	6.969302
_27—C	4.895656
_28—C	-29.08885
Fixed Effects (Period)	
2002—C	1.472504
2003—C	1.476407
2004—C	2.452885
2005—C	2.042710
2006—C	3.079914
2007—C	2.776754
2008—C	-0.986900
2009—C	-7.764785
2010—C	-0.433615
2011--C	-0.200841
2012--C	-2.220041
2013--C	-1.694992

Effects Specification

Cross-section fixed (dummy variables)

Period fixed (dummy variables)

R-squared	0.678696	Mean dependent var	1.886364
Adjusted R-squared	0.635486	S.D. dependent var	3.822056
S.E. of regression	2.307567	Akaike info criterion	4.623477
Sum squared resid	1544.211	Schwarz criterion	5.083973
Log likelihood	-722.8737	Hannan-Quinn criter.	4.807162
F-statistic	15.70695	Durbin-Watson stat	1.233694
Prob(F-statistic)	0.000000		

Redundant Fixed Effects Tests
Pool: POOL01
Test cross-section and period fixed effects

Effects Test	Statistic	d.f.	Prob.
Cross-section F	4.012352	(27,290)	0.0000
Cross-section Chi-square	104.744862	27	0.0000
Period F	46.674270	(11,290)	0.0000
Period Chi-square	336.267663	11	0.0000
Cross-Section/Period F	15.893216	(38,290)	0.0000
Cross-Section/Period Chi-square	371.500865	38	0.0000

APPENDIX 3

VAR Lag Order Selection Criteria
Endogenous variables: R_GDP EMPL
Exogenous variables: C

Sample: 1 336
Included observations: 309

Lag	LogL	LR	FPE	AIC	SC
0	-4157.491	NA	1.69e+09	26.92227	26.94643
1	-4081.920	149.6743	1.06e+09	26.45903	26.53152
2	-4072.754	18.03564	1.03e+09	26.42559	26.54641
3	-4049.719	45.02563*	9.08e+08*	26.30239*	26.47154*

* 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

Vector Autoregression Estimates

Sample (adjusted): 4 336
Included observations: 309 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	R_GDP	EMPL
R_GDP(-1)	0.443605	-433.4685
	(0.05733)	(194.152)
	[7.73757]	[-2.23262]
R_GDP(-2)	0.127053	-345.1869
	(0.06149)	(208.247)
	[2.06613]	[-1.65758]
R_GDP(-3)	0.201852	749.4577
	(0.05714)	(193.509)
	[3.53251]	[3.87298]
EMPL(-1)	3.04E-05	-0.181377
	(1.6E-05)	(0.05562)
	[1.85022]	[-3.26124]
EMPL(-2)	3.40E-05	-0.060012
	(1.7E-05)	(0.05685)
	[2.02293]	[-1.05567]
EMPL(-3)	-3.38E-05	-0.145161
	(1.7E-05)	(0.05661)
	[-2.02460]	[-2.56425]
C	0.180243	11495.65
	(0.33252)	(1126.08)
	[0.54205]	[10.2086]
R-squared	0.439073	0.109859
Adj. R-squared	0.427928	0.092174
Sum sq. resids	2642.348	3.03E+10

S.E. equation	2.957955	10017.12
F-statistic	39.39903	6.212034
Log likelihood	-770.0216	-3281.435
Akaike AIC	5.029266	21.28437
Schwarz SC	5.113840	21.36895
Mean dependent	1.802589	8334.814
S.D. dependent	3.910807	10513.36

Determinant resid covariance (dof adj.)	8.68E+08
Determinant resid covariance	8.29E+08
Log likelihood	-4049.719
Akaike information criterion	26.30239
Schwarz criterion	26.47154

VAR Residual Serial Correlation LM Tests
Null Hypothesis: no serial correlation at lag order h

Sample: 1 336
Included observations: 309

Lags	LM-Stat	Prob
1	2.120264	0.7137
2	21.03724	0.0003
3	17.70365	0.0014
4	7.964354	0.0929
5	41.31523	0.0000
6	19.33863	0.0007
7	20.88251	0.0003
8	27.19041	0.0000
9	8.913925	0.0633
10	11.09257	0.0255
11	16.62593	0.0023
12	7.647243	0.1054

Probs from chi-square with 4 df.

VAR Residual Portmanteau Tests for Autocorrelations
Null Hypothesis: no residual autocorrelations up to lag h

Sample: 1 336

Included observations: 309

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	df
1	0.198183	NA*	0.198826	NA*	NA*
2	3.359378	NA*	3.380615	NA*	NA*
3	6.616281	NA*	6.669449	NA*	NA*
4	13.54819	0.0089	13.69227	0.0083	4
5	46.62324	0.0000	47.31131	0.0000	8
6	61.04480	0.0000	62.01845	0.0000	12
7	77.53572	0.0000	78.89161	0.0000	16
8	99.11694	0.0000	101.0464	0.0000	20
9	106.6425	0.0000	108.7978	0.0000	24
10	116.2275	0.0000	118.7033	0.0000	28
11	130.7851	0.0000	133.7982	0.0000	32
12	137.0055	0.0000	140.2700	0.0000	36

*The test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for (approximate) chi-square distribution

VAR Residual Normality Tests
Orthogonalization: Cholesky (Lutkepohl)
Null Hypothesis: residuals are multivariate normal

Sample: 1 336
Included observations: 309

Component	Skewness	Chi-sq	df	Prob.
1	-0.374849	7.236349	1	0.0071
2	1.356059	94.70315	1	0.0000
Joint		101.9395	2	0.0000

Component	Kurtosis	Chi-sq	df	Prob.
1	4.610096	33.37725	1	0.0000
2	4.231633	19.53034	1	0.0000
Joint		52.90760	2	0.0000

Component	Jarque-Bera	df	Prob.

1	40.61360	2	0.0000
2	114.2335	2	0.0000
Joint	154.8471	4	0.0000

VAR Residual Heteroskedasticity Tests: No Cross Terms (only levels and squares)

Sample: 1 336
Included observations: 309

Joint test:

Chi-sq	df	Prob.
123.8805	36	0.0000

Individual components:

Dependent	R-squared	F(12,296)	Prob.	Chi-sq(12)	Prob.
res1*res1	0.189895	5.782046	0.0000	58.67743	0.0000
res2*res2	0.124528	3.508613	0.0001	38.47917	0.0001
res2*res1	0.092121	2.502899	0.0038	28.46552	0.0047

Variance Decomposition of R_GDP:

Period	S.E.	R_GDP	EMPL
1	2.957955	100.0000	0.000000
2	3.237196	99.12581	0.874193
3	3.379147	97.67033	2.329675
4	3.560616	97.62608	2.373921
5	3.674930	97.76406	2.235942
6	3.767966	97.84963	2.150369
7	3.823686	97.86718	2.132825
8	3.865721	97.90470	2.095298

9	3.898389	97.93750	2.062504
10	3.922996	97.95913	2.040872

Variance Decomposition of EMPL: Period	S.E.	R_GDP	EMPL
1	10017.12	1.118523	98.88148
2	10236.94	2.204795	97.79520
3	10328.80	3.785627	96.21437
4	10607.69	6.642603	93.35740
5	10633.16	6.616301	93.38370
6	10640.18	6.610267	93.38973
7	10640.92	6.619657	93.38034
8	10642.71	6.631535	93.36847
9	10643.73	6.648829	93.35117
10	10644.04	6.650776	93.34922

Cholesky Ordering: R_GDP EMPL

APPENDIX 4

Pool unit root test: Summary
Series: R_GDP_1, R_GDP_2, R_GDP_3, R_GDP_4, R_GDP_5, R_GDP_6,
R_GDP_7, R_GDP_8, R_GDP_9, R_GDP_10, R_GDP_11,
R_GDP_12, R_GDP_13, R_GDP_14, R_GDP_15, R_GDP_16,
R_GDP_17, R_GDP_18, R_GDP_19, R_GDP_20, R_GDP_21,
R_GDP_22, R_GDP_23, R_GDP_24, R_GDP_25, R_GDP_26,
R_GDP_27, R_GDP_28

Sample: 2002 2013
Exogenous variables: Individual effects
Automatic selection of maximum lags
Automatic lag length selection based on SIC: 0 to 1
Newey-West automatic bandwidth selection and Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-9.06484	0.0000	28	299
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-4.15101	0.0000	28	299
ADF - Fisher Chi-square	102.275	0.0002	28	299
PP - Fisher Chi-square	112.079	0.0000	28	304

** Probabilities for Fisher tests are computed using an asymptotic Chi
-square distribution. All other tests assume asymptotic normality.

Pool unit root test: Summary
Series: EMPL_1, EMPL_2, EMPL_3, EMPL_4, EMPL_5, EMPL_6, EMPL_7,
EMPL_8, EMPL_9, EMPL_10, EMPL_11, EMPL_12, EMPL_13,
EMPL_14, EMPL_15, EMPL_16, EMPL_17, EMPL_18, EMPL_19,
EMPL_20, EMPL_21, EMPL_22, EMPL_23, EMPL_24, EMPL_25,
EMPL_26, EMPL_27, EMPL_28

Sample: 2002 2013
Exogenous variables: Individual effects
Automatic selection of maximum lags
Automatic lag length selection based on SIC: 0 to 1
Newey-West automatic bandwidth selection and Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-7.12794	0.0000	28	271
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-2.96969	0.0015	28	271
ADF - Fisher Chi-square	86.4208	0.0056	28	271
PP - Fisher Chi-square	80.5338	0.0175	28	278

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.