# The regional competitiveness in Romania. A panel multivariate approach

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***Abstract:*** *The main objective of this study is to assess the regional competitiveness in Romania by two alternative and quantitative approaches: the panel data approach and the multivariate analysis. The use of these methods is almost inexistent for Romanian counties, even if there are many studies for other countries. For the 42 Romanian counties a dynamic panel model was estimated for the period from 2006 to 2013, the real GDP rate depending on this variable with 3 lags and by the research and development (R&D) expenses. On the other hand, a principal component analysis was conducted to determine the factors with an important contribution to explaining the regional competitiveness in the Romanian counties. In 2006, 59.93% of the variation in regional competitiveness is explained by aspects related to R&D activities, while aspects related to growth and labour market occupation explain only 29.95% of the variation. In 2013, 62.71% of the variation in regional competitiveness is explained only by aspects of the labour market, the economic growth being independent of this component.*

***Keywords:*** *competitiveness, research and development, dynamic panel, principal component analysis*

***JEL Classification:*** *C23, O11*

## I. Introduction

The main aim of this research is to evaluate the regional competitiveness in Romania. Besides the panel data approach that was previously used by Iordan, Chilian and Simionesu (2014), this study completes the analysis of the regional competitiveness in Romania with a multivariate approach. These two quantitative

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methods are chosen because they have some advantages that exceed the limits of the previous approach. The panel data analysis solves the problem of short sets of data for macroeconomic variables that is specific to the Romanian economy. This approach takes into account at the same time the spatial and the time dimension. The principal component analysis allows us to combine the factors that determine a certain variable. The computation of some indices and rates, like in incipient studies, does not provide us a complete image of regional competitiveness in a country.

In the previous studies for Romanian regional competitiveness, the research and development expenses and occupation rate were not considered as determinants of regional competitiveness. But these variables are considered in our research.

The research and development (R&D) activities are a key element of regional competitiveness, the application of results from this domain having an important contribution to economic revival in a country at national and regional level. Even if in the development strategies for Romania, the innovation and R&D hold an important place, according to Goschin (2013), the lack of development of territorial infrastructure determined a low regional development. Beside the less developed infrastructure, several problems were reported for Romania: a low implication of the economic agents in R&D activities, a low capacity of application of the R&D results in practice, decrease in number of researchers simultaneously with increase in average age, a low degree of scientific collaboration.

The employment rate and number of employees in R&D activities are used as a proxy for describing the labour market dynamics. In previous studies, Chilian (2012), Mereuţă, Albu, Iordan and Chilian (2012), Iordan, Chilian and Simionescu (2014), the unemployment rate, the number of employees and the average number of employed people are utilized.

In this paper, the regional competitiveness is analyzed from the perspective of regional economic growth, by taking into account aspects of the R&D activities and the occupation rate of labour resources in Romania. Two approaches were selected: the panel data model approach and a multivariate analysis based on the principal components analysis. The study is based on the data on real GDP rate, number of employed people, occupation rate, R&D expenses, that were of the Romanian counties over the period from 2006 to 2013. After a short literature review, the empirical results are presented and further some conclusions are drawn.

## II. Literature review

The literature review covers several aspects regarding the regional competitiveness: the concept of competitiveness in literature, types of competitiveness (local, regional, urban competitiveness), methods to evaluate the regional competitiveness and the assessment of regional competitiveness in Romania.

According to Ketles (2006), there are many debates regarding the competitiveness because of the lack of a definition. The competitiveness is judged in the context of a particular research and policy issue. The concept is used in order to understand the main drivers of economic sustainability in a given location. One definition of competitiveness is based on productivity. The competitiveness is related to productivity of a country- the GDP level determined by each unit of input that is available for economic activity at current prices. The macroeconomic, social, political and legal environments are essential in determining the competitiveness. However, without improvements at the microeconomic level, the competitiveness is difficult to achieve. For example, Argentina made huge efforts to improve the macroeconomic policies, increasing the population consumption, but the microeconomic problems determined a low productivity and consequently a low competitiveness.

Huovari, Kangasharju and Alanen (2001) considered four dimensions in describing the competiveness: human capital, innovativeness, agglomeration and accessibility. A proxy for human capital is the participation rate, but we use in our study the occupation rate, because only data on this variable are available for Romanian counties. The dimension of innovativeness is explained by the consideration of the following variables: R&D expenditure, innovative establishments, number of patents and share of value-added of high technology sectors. In our study, we considered R&D expenditure and the number of employees in R&D activities as determinants of regional competitiveness. Many types of models have been proposed in order to explain the research and development (R&D) sector, where RD has an imitative and innovative role. Griffith, Redding and Van Reenen (2004) provided a quantitative analysis in a three-dimensional panel of industries from 12 OECD states starting in 1970. A heavy investment in R&D determined a high increase in competitiveness. The conclusions of several studies were the following: rich regions can take advantage from own R&D activities, but poorer ones benefit more from the imitation. Only for regions that exceeded a certain degree of development, the propensity for achieving a high R&D degree of intensity is specific, as Braconier (2000) explained.

The competitiveness has been analyzed at local, regional and urban levels. In the global economy approach, the regions are considered drivers of the economy. The national competitiveness is analyzed with respect to regional foundations. The activities are coordinated at regional level and the public policy is regionalized. The competeveness of each region is improved by developing new forms of policy interventions, as Melecký (2011) stated. Overall, the national prosperity is achieved by the improvement of regional competitiveness,.

In assessing the regional competitiveness, there are still many difficulties. The most common method, according to Pichierri (2013), implies the decomposition of aggregate indicators at macroeconomic level, in order to determine the factors that generated economic growth, productivity and regional development. On the other hand, Nevima and Kiszová (2013), explaine that there are other approaches for assessing the regional competitiveness like: panel data regression models and DEA method for evaluating the regional efficiency. Multivariate statistical methods like cluster analysis, method of main components or factor analysis are also used to measure the competitiveness factors, as Melecky (2013) showed.

Lately, the panel data models are frequently used to assess the regional competitiveness. The panel data approach provides many advantages in evaluating the regional competitiveness compared to the traditional approach of a linear regression model. The panel data model allows a better assessment of the dynamics of change when the characteristics occur. The model permits the identification of stochastic or fixed effects to diagnose the chronological series and cross-section data. More types of complex models are tested with a suitable number of degrees of freedom. However, the panel data approach eliminates the changes determined by the data aggregation. Panel models employ data from various economic levels (microeconomic, mezzo-economic and macroeconomic level).

Lukáš and Jan (2011) proposed an econometric panel data model to assess the regional competitiveness in EU-15. The productivity and regional competitiveness are analyzed with respect to the theories on economic growth. A nonlinear panel model is estimated for 35 regions at NUT-2 level from EU-15 during 2000-2008. The global competitiveness in EU is approximated by using the average GDP per capita in PPS as volume. The explanatory variables are: gross domestic expenditure regarding R&D, net disposable income and gross fixed capital formation.

The comparison between methods to assess the regional competitiveness is quite difficult. There are linkages between the tools for assessing the competitiveness at regional and national level. The indices and indicators applied to large areas like social, economic and environmental ones.

Romania tries hardly to define its regional strategy regarding the R&D and the suitable priorities and policies regarding the regional innovation. As Ranga (2010) explained, the limited effectiveness of innovation policies in Romania is explained by the lack of coordination between regional policies and the national ones.

In Romania, Iordan, Chilian and Simionescu (2014) evaluated the regional competitiveness using a dynamic panel for the 42 Romanian counties including Bucharest during 2000-2012. The authors show that the GDP at present depends on the average number of workers and on the GDP in the previous period. However, the regional competitiveness was deeper analyzed in our study, the dynamic panel approach being accompanied by the principal component analysis. A panel data model was also proposed by Chilian (2012) for the 8 regions of Romania over 2000-2005 period. The author concluded that investments and employed people dynamics have an important impact on economic growth.

## III. The determinants of regional GDP growth in Romania

The variables used in this study are:

- Real GDP rate;
- R&D expenses;
- Number of employees in R&D activities;
- Rate of occupation.

The real GDP rate is used as a proxy for regional competitiveness instead of GDP per capita used in other studies like that of Lengyel (2004). We preferred the real GDP rate because of the lack of a good approximation of GDP in comparable prices for Romanian counties. The number of employees in R&D activities and the rate of occupation are selected to define the aspects related to labour market that are correlated with regional competitiveness as Gardiner, Martin and Tyler (2004) mentioned.

The resources that determine the technological process acceleration are important determinants of regional competitiveness: Huovari, Kangasharju and Alanen (2001) consider the R&D expenses and number of patents in the calculation of a regional competitiveness index. Therefore, we consider the R&D expenses as a factor of competitiveness.

The variable values are recorded for each of the 42 Romanian counties (including Bucharest) during 2006-2013. The real GDP rates are provided by the National Commission for Prognosis in “The projection of main social-economic indicators in territorial profile”. The source of data for the rest of the variables (rate of occupation, number of employees in R&D activities and R&D expenses) is the 2013 Statistical Yearbook. The rate of occupation is taken from the section “Labour market” of the Statistical Yearbook. Data on the number of employees in R&D activities and R&D expenses are provided in the chapter called “Science, technology and innovation”.

The number of employees in R&D activities represents the total number of employees that at a certain moment in time participate in a direct or indirect way to solve the problems related to the activity object of that unit. These people are remunerated for their services. There are three categories of employees: personnel in R&D activities that directly participate in these types of activities, personnel in production activities and personnel in annex activities.

The expenses on R&D activities refer to current expenses and capital expenses in that sphere of activity. The current expenses refer to payments that represent the labour cost, materials and other current expenses, while capital expenses have as main purpose building creation, the acquisition of instruments, devices, machines and equipment or other expenses for increasing the volume of fixed means.

The occupation rate of labour resources is computed as:

$$\text{Occupation rate} = \text{The unit cost of the inductor} = \frac{\text{Cost of resources by activities}}{\text{Inductor's volume}} \quad (1)$$

A dynamic panel data was estimated by means of these variables. The demeaning transformation in panel data generates 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 faces 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:

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

Where:

$X_{it}$ - exogenous regressors,

$y_{it}$ - dependent variable,

$u_i$ - unobserved individual effect,

$\varepsilon_{it}$ - error.

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

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

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 2nd and the 3rd lag. If the error is i.i.d., then the lags are correlated with the lagged dependent characteristic, but it is not correlated with the composite error term.

Let us consider the equations:

$$y_{it} = \beta_0 \cdot X_{it} + \beta_1 \cdot W_{it} + v_{it}$$

$$v_{it} = u_i + \varepsilon_{it}$$

Where:

$X_{it}$ - 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 imply 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 the 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 implies supplementary restrictions regarding the initial conditions for generating the dependent variable.

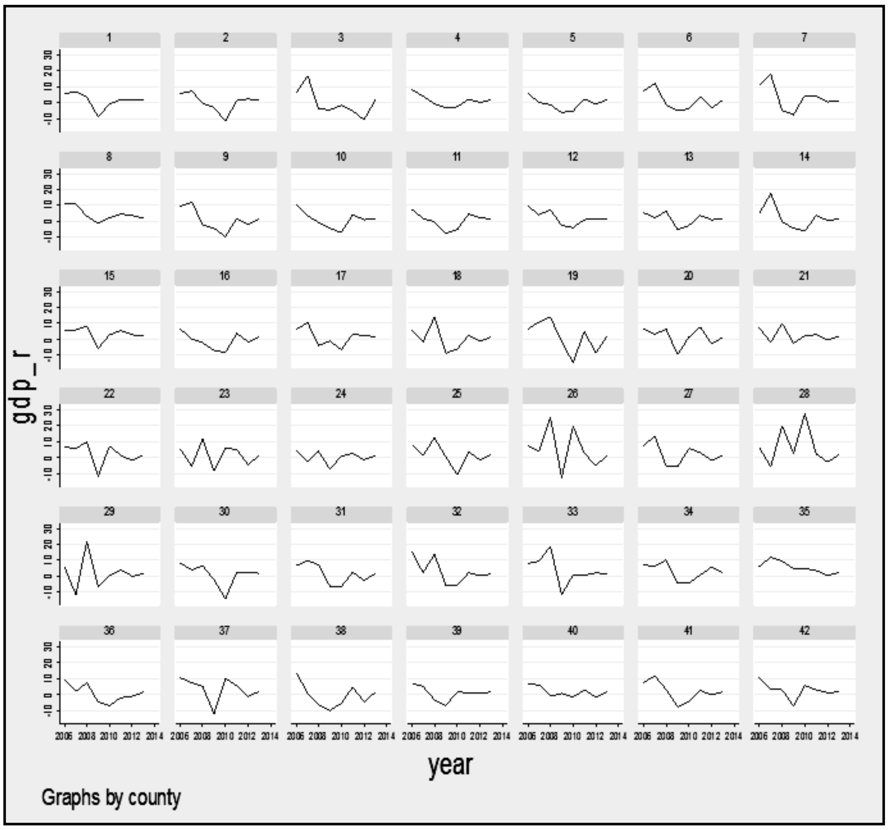
Several panel unit-root tests were applied to check the data stationary. In Appendix 1, the results of the unit root tests for panel data are presented. The GDP rate stationary was checked using Harris-Tzavalis test. The p-value associated to test statistic is 0, under 0.05, which implies the rejection of the null hypothesis H0. So, for a significance level of 5%, we conclude that real GDP data series is stationary. According to the same test, the occupation rate data set presents unit root, the p-value associated to the computed statistic being higher than 0.05 (0.0584). A Fisher-type test was applied in more versions to test the stationary of the employees' data set and %, the data is stationary for a significance level of 5%.

All in all, excepting the rate of occupation, the data for all the other variables are stationary. The logarithm was applied to get a stationary data series for the rate of occupation. Numbers were assigned to counties: 1- Bihor, 2- Bistrita-Nasaud, 3- Cluj, 4- Maramures, 5- Satu-Mare, 6- Salaj, 7- Alba, 8- Brasov, 9- Covasna, 10- Harghita, 11- Mures, 12- Sibiu, 13- Bacau, 14- Botosani, 15- Iasi, 16- Neamt, 17- Suceava, 18- Vaslui, 19- Braila, 20- Buzau, 21- Constanta, 22- Galati, 23- Tulcea, 24- Vrancea, 25- Arges, 26- Calarasi, 27- Dambovita, 28- Giurgiu, 29- Ialomita, 30- Prahova, 31- Teleorman, 32- Ilfov, 33- Bucharest, 34- Dolj, 35- Gorj, 36- Mehedinti, 37- Olt, 38- Valcea, 39- Arad, 40- Caras-Severin, 41- Hunedoara, 42- Timis.

The next figure represents the real GDP rate evolution in each county. There are some differences between Romanian counties regarding the evolution of GDP rate during 2006-2013. For example, the evolution of real GDP rate in

Maramures is almost linear with a slightly negative slope, while GDP rates in Bucharest, Galati, Tulcea, Arges and Giurgiu present significant oscillations.

***Figure 1: The evolution of real GDP rate in the Romanian counties, 2006-2013***




*Source*: own graph.

A fixed or random-effects model that explains the real GDP by R&D expenses or number of employees in R&D was not valid. A dynamic panel model with Arellano–Bover/Blundell–Bond estimators explained the GDP rate using the R&D expenses with one lag and GDP rate with 3 lags in the case of two-step estimators. Previously, a model with one lag and one with two lags were estimated, but these models were not valid, the parameters associated to explanatory variables being insignificant. The estimation results of the dynamic model are presented in Appendix 2. The probabilities associated to the variables in the model are below 0.05. Therefore, the proposed dynamic model is valid. However, the R&D expenses are determined by the number of employees in R&D activities using a fixed-effects or random-effects model, as it was expected.

All in all, the GDP rate at county level in Romania was determined by this variable with a lag of 3 periods and R&D expenses after one period. The R&D expenses have a positive but quite low impact on regional GDP in Romania for a significance level of 5%. GDP tended to decrease during 2006-2013; the economic crisis caused this trend (Appendix 2). In Romania a dynamic panel model was developed by Iordan, Chilian and Simionescu (2014) who also identified the GDP in the previous period as a determinant of the GDP in the current period. The lagged GDP rate was also an important determinant of real GDP rate in our study.

**Table 1: The estimation of a dynamic panel model for explaining GDP rate in Romanian counties during 2006-2013**

| gdp_rate | Coefficient | Std. error | z | P>\|z\| |
|---|---|---|---|---|
| L1. | -0.3361 | 0.0180 | -18.60 | 0.000 |
| L2. | -0.2366 | 0.0108 | -21.80 | 0.000 |
| L3. | -0.1430 | 0.0112 | -12.74 | 0.000 |
| R&D expenses | 0.000012 | 0.000005 | 2.25 | 0.025 |
| Constant | -0.6598 | 0.2764 | -2.39 | 0.017 |

*Source*: author's computations.

A multivariate analysis was conducted to identify the determinants of economic prosperity in Romania in 2006 and 2013 respectively in the Romanian counties. The principal components method replaces the initial variables $x^1$, $x^2$, ..., $x^p$ (p-number of initial variables), which are correlated, with new variables, called principal components $c^1$, $c^2$, ... that are linear combinations of the initial variables with the following properties:

1. The principal components are not inter-correlated;
2. The principal components have maximal variance;
3. The principal components are correlated with the initial variables in order to keep the information as much as possible.

Firstly, the principal components analysis was applied. The results of this method are presented in Appendix 3, where the eigenvalues and eigenvectors are computed for each year (2006 and 2013).

**Table 2: The principal component analysis for economic competitiveness in 2006 and 2013 in Romanian counties**

| 2006 | | |
|---|---|---|
| **Component** | **Eigenvalue** | **Proportion** |
| 1 | 2.35337 | 0.5993 |
| 2 | 1.15405 | 0.2995 |
| 3 | 0.47977 | 0.1197 |
| 4 | 0.01390 | 0.0035 |
| **2013** | | |
| 1 | 2.5085 | 0.6271 |
| 2 | 0.8883 | 0.2221 |
| 3 | 0.5701 | 0.1425 |
| 4 | 0.0330 | 0.0083 |

*Source*: author's computations.

For 2006, there are two principal components with eigenvalues higher than 1. The first component explains 59.93% of the variation in regional competitiveness, while the second one explains only 29.95% of the variation. For 2013, only one eigenvalue is higher than 1 and there is only one principal component. However, for economic reasons two components will be considered. 62.71% of the variation in regional competitiveness is explained by the first component.

The first component is related to the number of employees in R&D activities in 2006, while the second one refers to GDP rate and rate of occupation in 2006:

The principal components are determined as it follows:

$$comp\,1_{2006} = 0.5863 \cdot employees_{2006} + 0.6093 \cdot R \wedge D_{expenses 2006} \quad (2)$$

$$comp\,2_{2006} = 0.4497 \cdot occupa\,tion_{rate 2006} + 0.7439 \cdot r_{GDP 2006} \quad (3)$$

$$comp\,1_{2013} = 0.5904 \cdot employees_{2013} + 0.5988 \cdot R \wedge D_{expenses\,2013} + 0.4707 \cdot occupation_{rate 2013} \quad (4)$$

$$comp\,2_{2013} = 0.9582 \cdot r_{GDP 2013} \quad (5)$$

The first principal component in 2006 synthesizes aspects regarding the R&D activities, while the second one states macroeconomic aspects regarding economic growth and occupation. In 2013, the first component synthesizes aspects regarding the labour market occupation and R&D activities while the second one refers only to economic growth. So, it is important to emphasize that in 2013 the R&D expenses and the occupation did not determined higher GDP rates in Romanian counties (see Appendix 3).

## IV. Conclusions

A large number of governmental programs in Romania includes the R&D activities as key elements for social and economic policies that ensure the territorial development. Many studies consider the expenses in R&D activities as essential for generating GDP growth. A dynamic panel model was estimated in this context, but the expenses in R&D field have not a very high influence on economic growth in Romania during 2006-2013. The principal components analysis showed that in 2006 GDP growth and occupation rate were essential for regional competitiveness, but they were not influenced by R&D expenses. However, in 2013, the economic growth was seen independent of all the other variables (occupation rate, expenses and number of employees in R&D activities).

This research has limits since only few variables are used in the analysis. The calculation of a competitiveness index would include more aspects of the regional competitiveness like those mentioned by Huovari, Kangasharju and Alanen (2001): human capital, innovativeness, agglomeration and accessibility. The previous study of Iordan, Chilian and Simionescu (2014) which developed also a dynamic panel model, concluded that GDP in the previous period was determinant for the GDP in the current period for the period from 2000 to 2012. We used the GDP rate instead of GDP, but this proxy (GDP rate) in the previous periods is a determinant of regional competitiveness. Iordan, Chilian and Simionescu (2014) also used the average number of workers as independent variable which might be considered by us in a further study. Other relevant variables that might be considered are: number of patents, investments and gross domestic product.

## Appendix 1

```
. xtunitroot ht gdp_r

Harris-Tzavalis unit-root test for gdp_r
----------------------------------------
Ho: Panels contain unit roots           Number of panels  =     42
Ha: Panels are stationary               Number of periods =      8

AR parameter: Common                    Asymptotics: N -> Infinity
Panel means:  Included                               T Fixed
Time trend:   Not included
------------------------------------------------------------------------------
                    Statistic         z         p-value
------------------------------------------------------------------------------
 rho                 -0.0759      -14.4371       0.0000
------------------------------------------------------------------------------
```

```
. xtunitroot ht r_ocup

Harris-Tzavalis unit-root test for r_ocup
----------------------------------------
Ho: Panels contain unit roots           Number of panels  =     42
Ha: Panels are stationary               Number of periods =      8

AR parameter: Common                    Asymptotics: N -> Infinity
Panel means:  Included                               T Fixed
Time trend:   Not included
------------------------------------------------------------------------------
                    Statistic         z         p-value
------------------------------------------------------------------------------
 rho                  0.5860       -1.5686       0.0584
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for employees
Based on augmented Dickey-Fuller tests
----------------------------------------
Ho: All panels contain unit roots          Number of panels       =     42
Ha: At least one panel is stationary       Avg. number of periods =   7.74

AR parameter: Panel-specific               Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Not included
Drift term:   Not included                 ADF regressions: 0 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(84)   P       334.2960       0.0000
 Inverse normal            Z        -6.1992       0.0000
 Inverse logit t(214)      L*      -11.6155       0.0000
 Modified inv. chi-squared Pm       19.3108       0.0000
------------------------------------------------------------------------------
```

```
Fisher-type unit-root test for rd_exp
Based on augmented Dickey-Fuller tests
----------------------------------------
Ho: All panels contain unit roots          Number of panels       =     42
Ha: At least one panel is stationary       Avg. number of periods =   7.74

AR parameter: Panel-specific               Asymptotics: T -> Infinity
Panel means:  Included
Time trend:   Not included
Drift term:   Not included                 ADF regressions: 0 lags
------------------------------------------------------------------------------
                                  Statistic      p-value
------------------------------------------------------------------------------
 Inverse chi-squared(84)   P       278.6119       0.0000
 Inverse normal            Z        -8.1899       0.0000
 Inverse logit t(214)      L*      -10.5393       0.0000
 Modified inv. chi-squared Pm       15.0146       0.0000
------------------------------------------------------------------------------
 P statistic requires number of panels to be finite.
 Other statistics are suitable for finite or infinite number of panels.
```

```
Harris-Tzavalis unit-root test for ln_rocup
___________________________________________

Ho: Panels contain unit roots             Number of panels  =     42
Ha: Panels are stationary                 Number of periods =      8

AR parameter: Common                      Asymptotics: N -> Infinity
Panel means:  Included                                 T Fixed
Time trend:   Not included
```

| | Statistic | z | p-value |
|---|---|---|---|
| rho | 0.0808 | -11.3897 | 0.0000 |

## Appendix 2

```
. xtdpdsys gdp_r rd_exp, lags(3) maxlags(1) twostep artests(2)

System dynamic panel-data estimation        Number of obs        =       201
Group variable: county                      Number of groups     =        42
Time variable: year
                                            Obs per group:    min =         1
                                                              avg =  4.785714
                                                              max =         5

Number of instruments =     25              Wald chi2(4)         =   1160.12
                                            Prob > chi2          =    0.0000
Two-step results
```

| gdp_r | Coef. | Std. Err. | z | P>\|z\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| gdp_r | | | | | | |
| L1. | -.3361338 | .0180754 | -18.60 | 0.000 | -.3715609 | -.3007067 |
| L2. | -.2366625 | .0108554 | -21.80 | 0.000 | -.2579387 | -.2153863 |
| L3. | -.143049 | .0112324 | -12.74 | 0.000 | -.1650642 | -.1210339 |
| rd_exp | .0000129 | 5.74e-06 | 2.25 | 0.025 | 1.64e-06 | .0000242 |
| _cons | -.6598899 | .2764807 | -2.39 | 0.017 | -1.201782 | -.1179978 |

## Appendix 3

```
Principal components/correlation                 Number of obs    =        42
                                                 Number of comp.  =         4
                                                 Trace            =         4
    Rotation: (unrotated = principal)            Rho              =    1.0000
```

| Component | Eigenvalue | Difference | Proportion | Cumulative |
|---|---|---|---|---|
| Comp1 | 2.35337 | 1.19932 | 0.5883 | 0.5883 |
| Comp2 | 1.15405 | .675272 | 0.2885 | 0.8769 |
| Comp3 | .478777 | .46497 | 0.1197 | 0.9965 |
| Comp4 | .0138076 | . | 0.0035 | 1.0000 |

| Variable | Comp1 | Comp2 | Comp3 | Comp4 | Unexplained |
|---|---|---|---|---|---|
| employe~2006 | 0.5863 | -0.3900 | 0.1345 | 0.6971 | 0 |
| rd_exp2006 | 0.6093 | -0.3037 | 0.1637 | -0.7140 | 0 |
| r_ocup2006 | 0.4531 | 0.4497 | -0.7695 | 0.0190 | 0 |
| r_gdp2006 | 0.2822 | 0.7439 | 0.6025 | 0.0626 | 0 |

```
Principal components/correlation                 Number of obs    =        40
                                                 Number of comp.  =         4
                                                 Trace            =         4
    Rotation: (unrotated = principal)            Rho              =    1.0000
```

| Component | Eigenvalue | Difference | Proportion | Cumulative |
|---|---|---|---|---|
| Comp1 | 2.50854 | 1.6202 | 0.6271 | 0.6271 |
| Comp2 | .888334 | .31822 | 0.2221 | 0.8492 |
| Comp3 | .570114 | .537097 | 0.1425 | 0.9917 |
| Comp4 | .0330166 | . | 0.0083 | 1.0000 |

Principal components (eigenvectors)

| Variable | Comp1 | Comp2 | Comp3 | Comp4 | Unexplained |
|---|---|---|---|---|---|
| employe~2013 | 0.5904 | 0.2228 | -0.3391 | -0.6978 | 0 |
| rd_exp2013 | 0.5988 | 0.1744 | -0.3150 | 0.7154 | 0 |
| r_ocup2013 | 0.4707 | 0.0423 | 0.8811 | -0.0164 | 0 |
| r_gdp2013 | -0.2671 | 0.9582 | 0.0973 | 0.0328 | 0 |

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