Application of Econometric Panel Data Model for Regional Competitiveness Evaluation of Selected EU 15 Countries

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Abstract

The aim of the paper is to create an econometric panel data model with techniques using dummy variables for simplification of regional competitiveness evaluation in selected EU 15 countries. The theoretical background of the paper is based on the knowledge of theoretical concept and issues of regional competitiveness and productivity in the context of growth theories. The empirical part of the paper is focused on the application of nonlinear panel data regression model for 35 regions at NUTS level 2 of selected EU15 countries. The level of regional competitiveness is analyzed by selected indicators that evaluate the performance of the objectives of the EU growth strategies. Selection of explanatory variables in the panel data model appropriately reflects the level of competitive potential in NUTS 2 regions of selected EU 15 countries in the reference period 2000 - 2008. The use of econometric panel data model seems to be appropriate, since it better captures the dynamics of changes and the fixed or stochastic effects that have occurred in the proposed explanatory variables. Based on the estimation of the panel data model, econometric and economic verification, the final part of the paper makes a comparison of results for all explanatory variables in NUTS 2 regions, which are cross-sectional and time used to determine the order of influence of each NUTS 2 region of selected EU 15 countries to the overall competitiveness of the European Union. For the purposes of the model, the overall EU competitiveness is approximated with the average volume of GDP per capita in PPS for 271 NUTS 2 regions in EU 27, in accordance with the NUTS 2006 classification methodology.

Key words: competitiveness, EU15, NUTS 2 region, macro econometric modelling, panel data model

1. INTRODUCTION

Competitiveness and its evaluation have a significant position in the European Union (EU) and all over the world. For evaluation of regional competitiveness, we face the problem of the basic concept and definition of competitiveness due to absence of a consistent approach of its definition. Competitiveness has become quite a common term used in many professional and non-specialized publications. The ambiguity in the definition and understanding of competitiveness is associated with numerous problems. Evaluation of the competitiveness issue is not less complicated. In the absence of mainstream views on the assessment of competitiveness, there is sample room for the presentation of *individual approaches* to its evaluation. In our paper we will examine the possibility of evaluation the competitiveness of the regions of selected EU 15 countries at NUTS 2 level in terms of macro econometric modelling methodology (see e.g. Garrat, Lee, Pesaran, Shin, 2006; Šmídková, 1995) which as one of the techniques offers panel data regression models (see e.g. Greene, 2007; Baltagi, 2008). Macro econometric modelling

as a scientific discipline allowing the estimation of the regression model, which would have sufficient economic importance to the appropriate regional indicators, which would be based on economic theories and approaches directly, reflect developments in the regions and their competitive potential.

2. THEORETICAL BASIS OF COMPETITIVENESS IN REGIONAL CONTEXT

2.1 Definition of Competitiveness

The *definition of competitiveness* is a problematic issue because of the *lack of mainstream* view for understanding this term. Competitiveness remains a concept that is not well understood and that can be understood in different ways and levels despite widespread acceptance of its importance. Competitiveness is one of the fundamental criteria for evaluating economic performance, and also reflects the success in the broader comparison. The concept competitiveness is understood at different levels especially at the *microeconomic and the macroeconomic level,* among which is the difference. In original meaning the concept of competitiveness was applied only to companies and corporate strategies. Competitiveness of companies is usually understood as *the ability to provide products and services as well as or more effective than their main competitors* (Porter, 2003).

Nowadays, competitiveness is one of the most monitored characteristic of national economies and is increasingly appearing in the evaluation of their prosperity, welfare and living standards. The need for a theoretical definition of competitiveness at the macroeconomic level, emerged with the development of globalization process in world economy, so because of increased competition between countries. Despite of that, growth competitiveness of the territory belongs to the main priorities of the economic policies of the countries, there does not exist (compared with the competitiveness at the microeconomic level) a uniform definition and understanding of *national competitiveness.* While the concept of competitiveness of companies is not much discussed, the concept of national or regional competitiveness is an object of numerous discussions. One of the most common interpretations of this term understood national competitiveness as the ability to produce goods and services that are able to successfully face international competition, and people can enjoy growing and sustainable living standards (Klvačová, Malý, 2008). The Organization for Economic Cooperation and Development (OECD) defines the national competitiveness as *the degree or extent to which the country, in terms of open and fair trade, produce goods and services which meet the test of international markets while maintaining and increasing the real incomes of its citizens in the long run* (Garelli, 2002). Michael Porter suggests that the best way to understanding competitiveness is through the sources of a nation's prosperity. *"A nation's standard of living is determined by the productivity of its economy, which is measured by the value of its goods and services produced per unit of the nation's human, capital and natural resources. True competitiveness, then, is measured by productivity. Productivity allows a nation to support high wages, a strong currency and attractive returns to capital and with them a high standard of living"* (Porter, 2003). The European Commission offers similar definition of this term in The Sixth Periodic Report on the Social and Economic Situation of Regions in the EU: "*...the ability to produce goods and services which meet the test of interna-*

tional markets, while at the same time maintaining high and sustainable levels of income or more generally, the ability of (regions) to generate, while being exposed to external competition, relatively high income and employment levels" (European Commission, 1999). European Commission presented in the European Competitiveness Report that *the economy is competitive if its population enjoy a high and constantly rising living standards and permanently high employment.*

2.2 Concept of Regional Competitiveness

In last few years the topic about *regional competitiveness* stands in the front of economic interest. The concept of competitiveness has quickly spread into the regional level, but the notion of regional competitiveness is also contentious. Macroeconomic concept of national competitiveness cannot be fully applied at the regional level because the regional competitiveness is much worse and less clear defined; between these two concepts is a big difference (see e.g. Krugman, 1994). In the global economy regions are increasingly becoming the drivers of the economy and generally one of the most striking features of regional economies is the presence of clusters, or geographic concentrations of linked industries (Porter, 2003). Current economic fundamentals are threatened by the shifting of production activities to places with better conditions. The regional competitiveness is also affected by the regionalization of public policy because of the shifting of decision-making and coordination of activities at the regional level. Within governmental circles, interest has grown in the *regional foundations* of national competitiveness, and with developing new forms of regionally based policy interventions to help improve the competitiveness of every region and major city, and hence the national economy as a whole. *Regions play an increasingly important role in the economic development of states.* Regional competitiveness can be understood as the *result of joint efforts on the most productive use of internal resources development in the interaction with the use of external resources and development opportunities focused on sustainable increases in production potential* (Viturka, 2008).

The notion of regional competitiveness is also contentious. There are questions over how regions compete, and the extent to which regions are meaningful economic units to which the concept of competitiveness can be meaningfully applied. To talk of regional competitiveness would seem to imply that regional economies are like firms or nation-states, and are in competition with one another. However, *regions are neither like firms nor nations.* A region is not simply a scaled-up version of the individual micro firm, nor the simple aggregation of many such firms. Regions are not economic 'actors' in the sense that firms are. They have limited direct control of the activities that take place within them, and they have a lower level of organizational identity and, arguably, unity that firms and nation states. But equally, a region is not simply a scaled-down version of the macro- or national economy. Regions do not have their own currencies, and do not set their own interest rates. Rather, their economic prosperity can be significantly influenced by the macro level fiscal and monetary policies pursued by the nation-state (and, of course, supra-national bodies, such as the European Parliament, or the WTO).

The starting point for analyses and comparisons of regional competitiveness would thus seem to be examination of relative *regional aggregate productive performance* – output per head, output per worker, and employment. The latter are what might be termed 'revealed' measures of overall regional competitiveness, themselves the outcome of complex underlying factors and processes. Trends in a region's aggregate performance, relative to trends in other regions, should

reveal something about a region's dynamic competitive advantage (Martin, 2005). Productivity may differ between regions for a host of different reasons (see Fig. 1). But equally important is how such differences are predicted to evolve over time. In the standard neoclassical model the growth of productivity (output per worker) depends on the growth of capital per worker and the (exogenous) rate of technical progress (or total factor productivity). Regional differences in productivity growth are explained by regional differences in the rate of (exogenous) technical progress and by regional differences in the growth of the capital labour ratio. But given that, the model also assumes constant returns to scale, diminishing returns to labour and capital, and complete factor mobility - including the unimpeded diffusion of technological advance – regional productivity disparities are predicted to narrow over time, as initially low productivity regions catch up with initially high productivity ones.

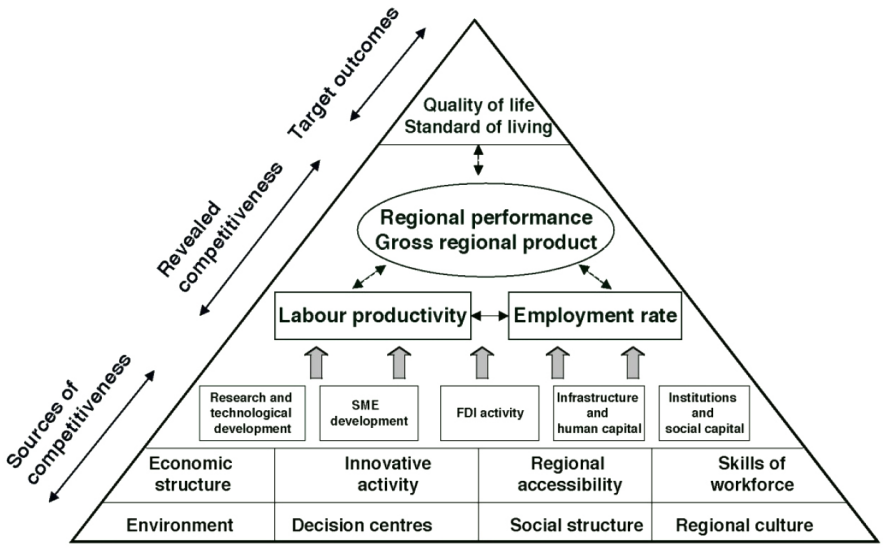

Fig. 1 – Pyramid model of regional competitiveness. Source: Gardiner, Martin, Tyler, 2004

2.3 Approaches to Competitiveness Evaluation

Evaluation of competitiveness is no less complex as the definition and understanding of the concept itself. Creation of competitiveness evaluation system in terms of the EU is greatly complicated by heterogeneity of countries and regions and also by own approach to the original concept of competitiveness. Evaluation of competitiveness in terms of differences between countries and regions should be measured through complex of economic, social and environmental criteria that can identify imbalance areas that cause main disparities. Currently not only quantitative but also qualitative development at the national level, and especially at the regional level, increase socio-economic attraction and create new opportunities that are fundamentals for subsequent overcoming disparities and increasing the competitiveness of the territory.

Competitiveness is most commonly evaluated by *decomposition of aggregate macroeconomic indicators*

of international organizations. Competitiveness of countries is monitored in many institutions, however, two well known international institutes publish most reputable competitiveness reports. To compare a level of competitiveness of countries we can use the databases performed by *Institute for Management Development* (IMD) and *World Economic Forum* (WEF). The World Economic Forum publishes the *Global Competitiveness Report* (GCR) that produces annual competitiveness indices that rank national economies. Global Competitiveness Reports use two main aggregate indexes for measuring the level of competitiveness – the *Global Competitiveness Index* (GCI) and the *Business Competitiveness Index* (BCI). The Institute for Management Development ranking on competitiveness is realized in the *World Competitiveness Yearbook* (WCY) which provides a comprehensive report on the competitiveness of countries assesses and analyzes the national conditions for business competitiveness.

Regional competitiveness and its evaluation are issues constantly in the forefront of economic sciences, which lacks a mainstream method of regional competitiveness monitoring and evaluation. Decomposition of aggregate macroeconomic indicators is most common used approach at the regional level, as well as *comprehensive* (mostly descriptive) analysis aimed at identifying the key factors of regional development, productivity and economic growth (see e.g. Blažek, Viturka, 2008; Martin, 2003). Another approach is presented by EU *structural indicators evaluation*. These indicators are used for the assessment and the attainment of the objectives of the Lisbon Strategy. Finally, we can provide an approach of *macro econometric modelling* and create econometric regression model (see e.g. Melecký, Nevima, 2009). *Evaluation of regional competitiveness* is determined by the chosen territorial region level, especially in terms of the European Union through the *Nomenclature of Territorial Units Statistics* (NUTS). No less importance is the reference period, availability and periodicity of data, and selection of convenient specific factors. For evaluation of regional competitiveness is necessary to note that the data availability decreases in direct proportion to the lower territorial unit.

Comparing instruments for measuring and evaluation of competitiveness in terms of the EU is no simply matter. There is linkages among instruments for measuring the EU competitiveness both national and regional level. There are different time period series at both levels, overlap of indicators of EU's Growth Strategies at national and regional level. Further there is continuity between approach of the World Economic Forum and approach of the EU to measuring and evaluation of EU competitiveness. Between EU Competitiveness and cohesion policy there is a link in terms of Reports on Economic and Social Cohesion – 4th and 5th reports (2007, 2010) articulated a special indices for measuring and evaluation of competitiveness of European regions. Indicators and indices cover a broad area of economic, social and environmental interests, but coverage and reference period decrease in direct proportion to the lower territorial unit. Because of these clear and close link among instruments (indicators and indices) for measuring of competitiveness is difficult to choose just the "best approach" to evaluation.

3. REGIONAL COMPETITIVENESS EMPIRICAL ANALYSIS OF SELECTED EU 15 COUNTRIES

3.1 Methodological Background of the Analysis

If we want to evaluate the degree of regional competitiveness or search for sources of competitiveness on regional level, it is appropriate to use the formulation of regional models. *Regional panel data models,* they form a link between micro and macro components and are constructed mostly ad hoc. The explanatory and interpretive ability is mainly dependent on the fulfilment of the appropriate model and especially the available data and specification of the applied model.

Before the panel data model will be defined, let us have the *benefits* of this model compared to conventional linear regression models. In the panel data model, we can concentrate more than a simple classical regression model. We are better able to affect the dynamics of change, to which the individual variables occurred. The main advantage is the detection of fixed, respectively stochastic effects, which we were able to diagnose only cross-application data or time series. Another advantage is to design and test of complex models with an appropriate number of degrees of freedom. Other advantages and disadvantages of macro-econometric modelling states for example Šmídková (1995). When using panel data model, there are also greatly eliminated variations caused by aggregation of data sets used. Panel model is used not only for a mezzo-business applications, but also in areas such as microeconomics and macroeconomics, it is suitable for the analysis of competitiveness.

3.2 Sample of Regions and Data Base for Econometric Analysis

The utilization of panel data model for empirical analysis of regional competitiveness in EU 15 countries was motivated by previous research of the authors. The partial research was concentrated on application of panel data model in analysis and evaluation of competitiveness of 35 NUTS 2 Visegrad Four regions. For more detail of the results see Melecký, Nevima, (2011a, 2011b). The previous panel data model has been established on similar set of indicators and same reference period (2000-2008) in the frame of 35 NUTS 2 regions of Visegrad Countries. In this paper, we want to apply and test panel data model in different sample of observations presented by macroeconomic indicators of 35 selected NUTS 2 regions in several countries of EU 15. The main *selection criterion* for EU 15 countries and their regions is presented by Gross Domestic Product in Purchasing Power Standard (PPS) per inhabitant in percentage of the EU average (EU 27=100). This criterion we found like a "mirror" of competitiveness performance in accordance with economic theory. Testing sample of countries and regions consist of three economically advanced countries with GDP per inhabitant over the EU 27 average – Ireland (2 NUTS 2 regions), Netherlands (6 selected NUTS 2 regions) and Sweden (8 NUTS 2 regions). The average economic performance of EU 27 is presented by Italy (6 selected NUTS 2 regions) and countries with volume of GDP per inhabitant lower than EU 27 average are presented by Greece (6 selected NUTS 2 regions) and Portugal (7 NUTS 2 regions). In the case of Netherlands, Italy and Greece we choose only several NUTS 2 regions. In rest of countries we count with all NUTS 2 regions. The selection of NUTS 2 regions was conducted with the same logic of selection and criterion like in national level.

Data base econometric model for measuring regional competitiveness in 35 NUTS 2 regions of EU 15 countries is made up of regional data, which was taken from the database of the European Statistical Office - module *Regional Statistics* (Eurostat, 2011b). Under regional data has been used time series of four indicators expressed in all volumes per inhabitant. We use annual basis regional data sheets that include: Gross domestic product *(GDP)*, Gross fixed capital formation *(GFCF)*, Gross expenditure on research and development *(GERD)* and Net disposable income of households *(NDI)*. Comparability of data over time was ensured by using time series of the available indicators in PPS. Within each of selected indicators were always counted the average for the EU 27, which was presented by 271 NUTS 2 regions under NUTS 2006 approach (Eurostat, 2011a). The data analysis cover reference period 2000 - 2008.

3.3 The Specification of the Econometric Model of Panel Data for Selected EU 15 Regions

The estimate for each of the regions is the output of generally formulated model of the panel data. Due to it, we obtain the look at the level of competitiveness of each region. The access can be applied also on low number of observing in time, in our case for each NUTS 2 region during period 2000 – 2008 there were 9 observations. The negative of low number of observations in time is eliminated by using panel data and due to technique of *dummy variables* it is possible to observe regional disparities. Non – linear form of the model type LOG – LOG is applied especially because some of the input variables are assigned in absolute monetary units and some of them in percentage. The input variables are numerically stationary by using non-linear form and also explanation ability of the model is increased. Non – linear model type LOG – LOG measures *partial elasticity* of dependent variable regarding explaining variable under ceteris paribus condition.

The logging for the estimate of panel non-linear regression model with using of dummy variables for NUTS 2 regions of selected countries EU 15 is with using above specified data base following (1):

$$\ln GDP_{r,t} = \hat{\alpha} + \hat{\beta}_1 \ln GFCF_{r,t} + \hat{\beta}_2 \ln GERD_{r,t} + \hat{\beta}_3 NDI_{r,t} + \sum_{r=1}^{35} \hat{\gamma}_r D_{r,t} + \hat{\varepsilon}_{r,t} \quad (1)$$

Where:

$GDP_{r,t}$	Gross domestic product;
$GFCF_{r,t}$	Gross fixed capital formation;
$GERD_{r,t}$	Gross domestic expenditures on research and development;
$NDI_{r,t}$	Net disposable income;
α	Constant;
$\beta_{1,\ldots,5}$	Slope parameter of regression model;
γ_r	Differences parameter of fixed effects;
$\varepsilon_{r,t}$	Random error;

$D_{r,t}$ Binary variable for region specification;

$D_{r,t}$ = 1(if it takes data of the region "r" in time "t" ; $D_{r,t}$ = 0 otherwise;

r Indexes sectional characteristics (in our case NUTS 2 regions of EU 15; *basic „region*" is average of EU 27 regions;

r = 1, 2,…, 35 (in our case 35 selected regions of EU 15);

t Indexes time; t = 2000,2001,…,2008.

Let's introduce single input variables, which are included in the model. GDP is in the position of explained variable. GDP was chosen as it is one of the most important macroeconomic aggregate which is simultaneously suitable basic for competitiveness assessment of the country, but also for the regional level, where also NUTS 2 regions belong.

We come from the OECD competitiveness definition, according to which is competitiveness specified by *ability to produce products and services, which compete in the international competition test*. At the same time it is able to keep or increase real GDP. Simultaneously, by keeping assigned hypothesis, it is valid, that GDP is the *symptom of region competitiveness*, as regions with increasing GDP have ideal presumption for long-term increasing of their competitiveness or otherwise. It is obviously not always valid that with increasing level of GDP (i.e. increasing efficiency of regions) also the rate of obtained competitiveness or competitive advantage grows. However, this presumption is initial for lots of grow theories and theories of regional competitiveness (see e.g. Martin, 2003; Gardiner, Martin, Tyler, 2004; Hančlová et. al, 2010).

Explanatory variables of estimated model fulfil the role of the source base for following growth of GDP. Gross fixed capital formation (GFCF) due to international accounting is a basic part of gross capital (capital investments), in which is also the change of inventories and net acquisition of valuables included. According to ESA 95 methodology GFCF consists of the net assets acquisition minus decrease of fixed assets at residential producers during the time period plus certain increasing towards the value of non-produced assets originated as a consequence of production activity of producers or institutional units. Net fixed capital formation is the difference between gross fixed capital formation and fixed capital consumption. It is estimated in purchase price including costs connected with instalment and other costs on transfer of the ownership. Fixed assets are tangible or intangible/invisible assets produced as the output from production process and are used in production process repeatedly or continuously during the one-year period. However, GFCF sense is much broader. It is an index of *innovating competitiveness* which enables to increase production on modern technical base. Gross domestic expenditures on research and development (*GERD*) are sources for further economic growth increasing as stimulation of basic and applied research creates big multiplication effects with long-term efficiency and presumptions for long-term economic growth in economics. R&D is defined as creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society and the use of this stock of knowledge to devise new applications. Net disposable income (*NDI*) is the result of current receipts and expenditures, primary and secondary disposal of incomes. It explicitly excludes capital transfers, real profits and loss from possession and consequences of the events as disasters. In contrast to gross disposable income it does not cover fixed capital consumption. Disposable income (gross or net) is the source of expenditures on final consumption cover and savings in the sectors:

governmental institutions, households and non-profit institutions for households. In sectors of non-financial enterprises and financial institutions is disposable income equal to savings.

From the explanation of regression non-linear model of panel data theorem is clear that it is necessary to assign dummy variable $D_{r,t}$ for each selected NUTS 2 region of EU 15 before estimate of the model is provided. Overall, the model will content 35 of the dummy variables, which assigning is obvious from the following table 1.

Tab. 1 – Assigning of the dummy variables for selected NUTS 2 Regions. Source: Eurostat, 2011, own elaboration

Dummy variable	Code	Name of the region	Dummy variable	Code	Name of the region
D_{1t}	GR13	Dytiki Makedonia	D_{19t}	NL32	Noord-Holland
D_{2t}	GR21	Ipeiros	D_{20t}	NL33	Zuid-Holland
D_{3t}	GR23	Dytiki Ellada	D_{21t}	PT11	Norte
D_{4t}	GR24	Sterea Ellada	D_{22t}	PT15	Algarve
D_{5t}	GR30	Attiki	D_{23t}	PT16	Centro (P)
D_{6t}	GR41	Voreio Aigaio	D_{24t}	PT17	Lisboa
D_{7t}	IE01	Border - Midlands And Western	D_{25t}	PT18	Alentejo
D_{8t}	IE02	Southern And Eastern	D_{26t}	PT20	Região Autónoma Dos Açores
D_{9t}	ITC4	Lombardia	D_{27t}	PT30	Região Autónoma Da Madeira
D_{10t}	ITE1	Toscana	D_{28t}	SE11	Stockholm
D_{11t}	ITE2	Umbria	D_{29t}	SE12	Östra Mellansverige
D_{12t}	ITE4	Lazio	D_{30t}	SE21	Småland med öarna
D_{13t}	ITG1	Sicilia	D_{31t}	SE22	Sydsverige
D_{14t}	ITG2	Sardegna	D_{32t}	SE23	Västsverige
D_{15t}	NL11	Groningen	D_{33t}	SE31	Norra Mellansverige
D_{16t}	NL12	Friesland	D_{34t}	SE32	Mellersta Norrland
D_{17t}	NL13	Drenthe	D_{35t}	SE33	Övre Norrland
D_{18t}	NL23	Flevoland			

The model conception unambiguously determines which regions contribute to total average output of EU 27 by its economic level, which is approximated in endogenous variable by GDP. Average value then presents an arithmetic average calculated from 271 NUTS 2 regions of EU 27 according to NUTS 2006 classification, valid in years 2008 – 2011. According to the *hypothesis*, that average of EU 27 stands for *ideal region* – the most competitive region, it will be valid: the higher value of γ_r, the higher contribution of each NUTS 2 region to average level of economic output of whole EU 27. The regions with the highest contribution will be currently considered as the most competitive. This aspect is crucial for the model.

4. THE RESULTS AND DISCUSSION

4.1 The Estimate of Econometric Paned Data Model and Results Interpretation

The panel non-linear regression model will be estimated on method of least squares (OLS). The statistical verification will be evaluated on 5 % level of statistic significance. For calculation SPSS software for Windows (15.0 version) has been used. The detailed analysis of statistic and econometric verification is not included in the paper. In fact, the paper is oriented on factual economic results from the introduced model. At the same time, we cannot omit statistic and econometric verification.

Economic verification deals with the explanation of the meaning and formulating of the conclusions on economic behaviour. The formula (2) is the result of (the first) estimate of panel non-linear model by dummy variables technique included all regions:

$$\ln \hat{GDP}_{r,t} = 0.665 + 0.157 \ln GFCF_{r,t} + 0.002 \ln GERD_{r,t} + 0.844 \ln NDI_{r,t} + \\ - 0.191 D_{1,t} + ... + 0.173 D_{35,t} \qquad (2)$$

When we look at the formula, it is evident that all 3 explanatory variables have a *different partial influence* on the development of average GDP for EU 27. It is valid, at the same time, that relations in formula (2) are inter-dependent, i.e. their significance, respectively their economic influence can mutually overlap. Indicator of net disposable income (*NDI*) has the highest partial influence. The second partial influence on economic growth has increasing of gross fixed capital formation (*GFCF*). The lowest impact has parameter of gross domestic expenditures on research and development (*GERD*).

After providing brief economic verification, *statistic* and *econometric verification* follows. The *F–test* for evaluation of model significance as whole was used. At testing of model significance the model is statistically significant (level of significance 5 %). T-test for testing of partial regression coefficients was used. Some of regression coefficients (parameters) are not statistically significant (lower than 5 % level of significance). Following parameters are statistically insignificant: $\gamma_4;\gamma_5;\gamma_9;\gamma_{12};\gamma_{16};\gamma_{22};\gamma_{25};\gamma_{27};\gamma_{29};\gamma_{30};\gamma_{31}$ It means that 13 NUTS 2 regions of EU 15 i.e. GR24; GR30; ITC4; ITE4; NL12; NL13; PT11; PT15; PT18; PT30; SE12; SE21; SE22, presented by dummy variables, are not subjects to further evaluation of contribution to GDP formation of EU 27 in reference period and fall out from the econometric model.

After statistical verification view phase of *econometric verification* follows. Econometric verification consists of testing of presence/absence of autocorrelation, heteroscedasticity and multicolinearity in the model. The *autocorrelation* was tested mathematically by Durbin – Watson (D–W) test and graphically by using autocorrelation (ACF) and partial autocorrelation (PACF) function. The value at D–W test at estimated model is 1.227. The value acts for evaluation of autocorrelation presence (serial dependency of residual components connected with sectional and time influences of panel model). According to critical values of D-W test, the presence of autocorrelation was proved. It was acknowledged by orientation graphical test which verifies D-W test validity (D-W test identifies autocorrelation of residues of the first order). The test identified presence of autocorrelation, especially of the first order and confirmed also autocorrelation of higher orders. However, this is not systematic. The fact led us to removing of

autocorrelation of residues or to reduction of their influence.

In the view of these facts (statistically insignificant parameters and presence of autocorrelation in model) we provide corrections of econometric model.

The correct estimate of the model was realised by Cochrane-Orcutt (CO) Method. CO method is de facto algorithm for estimation of regression model by GLS method in case of autocorrelation of first order residues. It subsists in transformation of the original model when using Rho $\hat{\rho}$ parameter and its estimation by OLS method. In fact, correct estimation negated all above presented results of verifications. However, by CO method application we removed autocorrelation of first and higher orders from the model. The formula (3) shows the form of corrected estimation:

$$\ln \hat{GDP}_{r,t} = 0.39 + 0.12 \ln GFCF_{r,t} + 0.017 \ln GERD_{r,t} + 0.863 \ln NDI_{r,t} + \\ - 0.193 D_{1,t} + ... + 0.18 D_{35,t} \tag{3}$$

All the parameters of regression model are statistically significant, except for γ_{17} and γ_{21} i.e. regions NL13 and PT11. Next, it was necessary to use second correction of the model and exclude regions NL13 and PT11. The form of final corrected estimation is in formula (4):

$$\ln \hat{GDP}_{r,t} = 0.412 + 0.151 \ln GFCF_{r,t} + 0.021 \ln GERD_{r,t} + 0.871 \ln NDI_{r,t} + \\ - 0.197 D_{1,t} + ... + 0.111 D_{35,t} \tag{4}$$

The estimate of formula signalizes that change of statistical significance of the model has not occurred as whole and simultaneously all parameters of the corrected model are statistically significant. Then we can continue in economic verification tests. Autocorrelation in corrected model was not proved. The value of D-W test is 2.022. It means that also according to critical values of D-W statistics as well as according to orientation graphical test autocorrelation of first order was removed.

The next part of econometric verification covers testing on heteroscedasticity and multicolinearity presence. The final corrected model can be considered as homoscedastic on selected level of significance, which was verified by graphical test. The graph could be constructed which could evaluate development in each region. However, for purpose of the paper, the graph which evaluates development of standardised value of residua of corrected model against predicted value (*GDP for all regions*) was constructed. By evaluating the presence of multicolinearity in the model we have to consider eventuality of inner-cohesion of explanatory variables. For the purpose of the work multicolinearity was orientation tested only by pair correlation coefficient. The test proved that multicolinearity is not present in the model. The mean value of random error is zero.

After brief econometric verification we can verify the model from *economic point of view*. When interpreting corrected estimate we have to emphasize that all 3 explanatory variables *have different partial influence* on development of average *GDP* of EU 27. Simultaneously it is valid that relations in the formula (4) are inter-dependent, i.e. their significance, respectively economic influence can overlap and depends on explanatory variables selection. *NDI* has higher partial

influence, which was proved again (when increasing *NDI* by 1 %, ceteris paribus condition, the change of average level of expected *GDP* EU 27 can be expected by about 0.871 %). *GFCF* has the second higher partial influence on next economic growth, here by increasing by 1 % the change of average level of expected *GDP* EU 27 can be expected at approximately 0.151 %, ceteris paribus. It was found out, that increasing of *GERD* by 1 % can generate in average level of expected *GDP* EU-27 of 0.021 % ceteris paribus, so *GERD* has the lowest partial influence.

It is necessary to emphasize that above interpreted results depend on partial contribution of 22 NUTS 2 regions of EU 15 to overall EU 27 output in reference period 2000 – 2008. The dummy variables in the panel model show, which regions *have the highest contribution to GDP formation* of EU 27 in time and section of each NUTS 2 region. The complex results of econometric model estimation in software SPSS 15.0 are introduced in appendix 1. The final order of NUTS 2 regions from their contribution view, respectively their influence on EU 27 global competitiveness measured by average level of *GDP* is given in appendices 2 and 3.

Among regions, which have the highest *positive impact* on GDP formation of EU 27 belong regions in Netherlands - *Groningen* (NL11), Sweden - *Stockholm* (SE11) and Ireland - *Southern and Eastern* (IE02). On the other hand, the *negative impact* on GDP formation have following regions in Greece - *Dytiki Makedonia* (GR13), *Ipeiros* (GR21) and Netherlands - Flevoland (NL23). The final order of top and last three regions according their impact on the overall EU 27 competitiveness is highlighted in appendices 2 and 3. Thus we can consider the region as most (positive impact) or less (negative impact) competitive in relation to EU 27 average.

5. CONCLUSION

Presented non-linear regression model of panel data by using technique of dummy variables was based on original concept of econometric model specification. Average value of *GDP* for EU 27 in period 2000 – 2008 is dependent variable at considering 3 independent variables (*GFCF, GERD, NDI*) which were chosen arbitrary. The basic hypothesis assumes, that average value of EU 27 GDP is considered as an ideal region, it means the most competitive region. In the paper we have observed contributions of each statistically significant 22 NUTS 2 regions to the average level of whole EU 27 performance approximated by GDP per inhabitant in PPS. The regions with a positive score of parameter γ_r have a positive impact to overall competitiveness of EU 27 because they contribute to average value of EU 27 GDP per inhabitant. The higher positive score of parameter γ_r , the higher positive impact of NUTS 2 region on the overall competitiveness of EU 27. On the basis of the above, between three the most competitive regions belongs *Groningen* (NL11) in Netherlands, *Stockholm* (SE11) in Sweden and *Southern and Eastern* (IE02) in Ireland. All these regions are simultaneously highly developed according to value of their GDP per inhabitant that is higher than EU 27 average in all reference period. All ten NUTS 2 regions of selected EU 15 countries with positive impact on the overall EU 27 competitiveness are stated in appendix 2. On the other hand, the regions with a negative score of parameter γ_r have a negative impact to overall competitiveness of EU 27 because they reduce the average value of EU 27 GDP per inhabitant. The higher negative score of parameter γ_r , the higher negative impact of NUTS 2 region on the overall competitiveness of EU 27. Between three the least competitive regions belongs *Dytiki Makedonia* (GR13), *Ipeiros* (GR21) in Greece

and *Flevoland* (NL23) in Netherlands. All three regions are also less developed according to value of their GDP per inhabitant that is lower than EU 27 average in all reference period. All twelve NUTS 2 regions of EU 15 selected countries with negative impact on the overall EU 27 competitiveness are documented in appendix 3.

The paper outlined and verified possible way for competitiveness analysis at regional level but let's simultaneously remind that above mentioned model is not model of economic growth, but by contrast to model of competitiveness, it has explicitly defined form of input variables. Meanwhile, in this case we partially look for suitable factors which contribute to competitiveness growth by means of GDP formation.

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Appendices

Appendix 1 – Output of the final estimation of the corrected model (equation 4). Source: SPSS 15.0; Own calculations and elaboration, 2011

Model	Non-standardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta	B	Std. Error
D1	-,197	,034	-,113	-5,782	,000
D2	-,169	,033	-,097	-5,153	,000
D3	-,104	,033	-,060	-3,132	,002
D6	-,139	,035	-,080	-4,027	,000
D7	-,121	,034	-,070	-3,517	,001
D8	,198	,034	,114	5,750	,000
D10	-,093	,033	-,054	-2,829	,005
D11	-,163	,032	-,094	-5,037	,000
D13	-,168	,033	-,097	-5,116	,000
D14	-,168	,034	-,097	-4,943	,000
D15	,462	,033	,265	14,076	,000
D18	-,169	,036	-,097	-4,704	,000
D19	,191	,034	,110	5,667	,000
D20	,131	,033	,075	3,936	,000
D23	-,101	,034	-,058	-2,975	,003
D24	,085	,032	,049	2,628	,009
D26	-,098	,032	-,056	-3,022	,003
D28	,224	,033	,129	6,763	,000
D32	,092	,032	,053	2,869	,004
D33	,112	,033	,065	3,437	,001
D34	,077	,033	,045	2,320	,021
D35	,111	,034	,061	3,226	,001
ln_GFCF	,151	,022	,191	6,892	,000
ln_GERD	,021	,006	,085	3,521	,000
ln_NDI	,871	,038	,570	22,997	,000
(Constant)	,412	,312	-,113	1,320	,042

Note: The Cochrane-Orcutt estimation method is used.

Appendix 2 – Positive impact of selected NUTS 2 regions on the overall competitiveness of EU 27. Source: Own calculations and elaboration, 2011

Dummy variable	Name of region	Rank
D15	Groningen	1.
D28	Stockholm	2.
D8	Southern and Eastern	3.
D19	Noord-Holland	4.
D20	Zuid-Holland	5.
D33	Norra Mellansverige	6.
D35	Övre Norrland	7.
D32	Västsverige	8.
D24	Lisboa	9.
D34	Mellersta Norrland	10.

Note: 1. – the highest positive impact, 10. – the lowest positive impact

Appendix 3 – Negative impact of selected NUTS 2 regions on the overall competitiveness of EU 27. Source: Own calculations and elaboration, 2011

Dummy variable	Name of region	Rank
D1	Dytiki Makedonia	1.
D2	Ipeiros	2.
D18	Flevoland	3.
D13	Sicilia	4.
D14	Sardegna	5.
D11	Umbria	6.
D6	Voreio Aigaio	7.
D7	Border - Midlands and Western	8.
D3	Dytiki Ellada	9.
D23	Centro (P)	10.
D26	Região Autónoma Dos Açores	11.
D10	Toscana	12.

Note: 1. – the highest negative impact, 10. – the lowest negative impact