

## PARCELA – MATRICA PLANERSKOG PISMA

### SAŽETAK

*Svrha ovog rada je utvrditi strukturna pravila planiranja za kvalitetu življenja stanovnika. Cilj istraživanja je utvrditi diobu parcela i pripadajuću strukturu općih termina u hijerarhiji od četiri razine jedinaca namjene, te matricu oznaka za njihove klasifikacije. Metodologija istraživanja obuhvaća analizu relevantne literature o svojstvima fractala, te iskustvo autora u pripremi, izradi i provedbi planova prostornog uređenja. Utvrđen je ustroj općih termina i oznaka za planiranje prostora na četiri razine uz primjenu hijerarhije namjene za tri skupine parcela i njihovih klasifikacija. Na taj način hijerarhija parcela vrijedi i za upravu i za struku podjednako, a za njihove korisnike pravilo koje se mora poštovati*

**Ključne riječi:** *Hijerarhija, matrica, parcela, planersko pismo, struktura.*

### Endnotes

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1 The length of time includes various generations. One generation of inhabitants is equivalent to twenty years.

2 Please see the authors of the works and the list of their literature: Batty and Longley, 1994; Arlinghaus, 1985; Batty, 2005; Benguigui et al., 2000 L. Benguigui, D. Czamanski, M. Marinov and Y. Portugali, When and where is a city fractal?, Environ. Plann. B 27 (4) (2000), pp. 507–519. Full Text via CrossRef | View Record in Scopus | Cited By in Scopus (30) Benguigui et al., 2000; Frankhauser, 1994; Goodchild and Mark, 1987; Longley and Mesev, 2000; Longley and Mesev, 2002; MacLennan et al., 1991; Schweitzer and Steinbrick, 1998; Shen, 2002; Wentz, 2001; White and Engelen, 1993; <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.33.7130&rep=rep1&type=pdf>.

3 The terms of construction are essentially are: “The Purpose, Size and Construction (Gross) Area of The Building With the Number of Functional Units” (The Act, 76/07, 38/09: article 106, section).

4 “The subject of property rights and other real rights can be any mobile (movable) or immovable property (real estate), except those who are not able to do so. Things in terms of this Act are physical parts of nature other than people that serve to be used by people. It is also considered that things are also all other things that are equivalent to them by law. Real estate is a parcel of the Earth’s surface together with everything that is permanently connected to the surface or below it, if the law does not define it to be otherwise.” (The Ownership and Actual Rights Act, 91/96, 73/00, 114/01, 79/06, 141/06, 146/08, 38/09).

5 See conditions: The Act, 76/07, 38/09, article 305-324.

6 Hierarchy is... a system of inferiority and superiority in institutions and various organizations, (Rječnik, 1998, 290).

7 Conceptually, planning documents for the wide and narrower areas are questionable when they deal with the majority of fields on various planning levels (UPU and DPU) when the areas in the scope of the area are the same or the scope of the superior plan is narrower than that of the subordinate spatial plan which encompasses a wider area. There are great differences in the content of strategic documents (The spatial planning strategy and Spatial planning program of the Republic of Croatia) and spatial plans. It is more objective to use the term subordinate or superior spatial plan.

8 Introduction by Dr. Slavko Kulić, Ph.D. in the book *Teorija planiranja održivog turističkog proizvoda* (The theory of planning a sustainable tourism product) (Karlovac, 2008).

9 In the cases where the adjective ‘construction’ is added to a plot the third dimension (height), which can be above-ground, underground or a combination of these is also added. This is given the term building plot because it regulates design issues for construction on certain land.

10 This is evident in the transport of agro-pollution over long distances (acid rain, radiation, etc.), and soil, groundwater and sea (in recent years in mucilage) pollution. Some extreme conditions in space caused by long-term human effects have been noted, that is the manner in which natural resources are used so that socio-economic components of the system (political, cultural, demographic and economic) indicate the state of natural systems. These are evident in the natural, agricultural and urban-industrial types of ecosystems (Bajagić, S. et al.1990, 36).

11 See, <http://hr.wikipedia.org/wiki/Slovo>.

12 See, [http://hr.wikipedia.org/wiki/Death\\_Note](http://hr.wikipedia.org/wiki/Death_Note).

13 See, [http://www.infoform.co.yu/graviranje/Brajevo\\_pismo.htm](http://www.infoform.co.yu/graviranje/Brajevo_pismo.htm).

14 See, <http://hr.wikipedia.org/wiki/Broj>;

15 See, [http://bs.wikipedia.org/wiki/Mjerna\\_jedinica](http://bs.wikipedia.org/wiki/Mjerna_jedinica)

16 Protection should be implemented through special regulation and standard measures. These include: noise, radiation, environmental pollution, nature reserves, natural disasters, threat of war, health, safety, cultural monuments and others. Protection measures must be included in the development standards for spatial planning documents.

17 Spatial standards must be established scientifically. A possible definition which includes the development of the following is possible: the interdependence of optimal unit of measurement in the balanced function of life or existence of equilibrium of structural purposes: housing, labour, provision, rest, recreation, care, protection and education, collaborative transportation, communication and information for all age groups from conception to eternal rest. At the state-level in Croatia, there are different decrees for spatial standards in the Regulations 1983.-1986.

18 The final proposal of the DPU Saladinka St. Martin was made based on scientific studies (Poropat, et al. 2000) and the scientific articles (Poropat and Ružić, 2003), plans passed for the wider GUP area and the PPUG of the town of Poreč, which supports a small economy. Public media also support the highest political authorities in Croatia. Among others (purposes for existing buildings), the administrative brass of the relevant Ministry refused to give their consent to the said plan (letter of rejection from the Ministry dated 14 August 2008) because plots intended for hospitality-tourism must not have a capacity of less than 80 beds and the tourist resort must be one plot?

19 <http://www.rogoznica.hr/dokumenti/Odluka%20o%20izradi%20PPU-a.doc>.

20 [http://hreak.srce.hr/index.php?show=clanak&id\\_clanak\\_jezik=39351](http://hreak.srce.hr/index.php?show=clanak&id_clanak_jezik=39351)

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## ASSESSMENT OF THE EFFICIENCY OF CROATIAN COUNTIES USING DATA ENVELOPMENT ANALYSIS

### ABSTRACT

*Achieve high rates of economic growth is the government's task of any country because the future world order depends on the own ability to improve the living standards of its citizens. In Croatia, observed at the regional level, is present uneven economic growth according to the GDP per capita, while in line with the nominal growth rate economic development shows uniform movements. In recent years, Croatia has obtained a relatively high growth rates, but they were still below the average rate of other developing countries. Croatia did not follow the global development trends, and the reason for this lies primarily in the uneven economic growth by counties. Using data envelopment analysis, in this paper we determine efficient and inefficient counties, and which resources should be efficiently used to enhance regional production, and then also the total national production.<sup>4</sup>*

Keywords: *economic growth, counties, efficiency, data envelopment analysis*

### 1. INTRODUCTION

Achieve high rates of economic growth is the government's task of any country because the future world order depends on the own ability to improve the living standards of its citizens. From the distant history to the present, many economists have tried to find answers on how to accelerate economic growth, or what are factors that allow some countries achieving higher rates of growth and leadership in the global rankings as measured by national production. Numerous studies have shown that the economic growth is a complex macroeconomic phenomenon, and therefore even today it can not be completely explained what determinants; in what measure and in what way contribute to the growth. The historical survey of theories of economic growth has shown that each theory pointed out one or more determinants which are key ones for the economic growth. Classical economists pointed out natural resources, namely land, and labor, neo-classicists capital and technology, and the new theory of growth stressed human potentials. Besides the mentioned determinants, the theories of growth give the key role in growth also to: innovations, research and development, international trade and export capacity, political and governmental factors, equipment investment, foreign direct investment etc. Therefore, government should design their economic policies to encourage: open markets of goods and service, promotion of liberal capital market, protection of private property rights, reasonable government spending, efficiency of the tax system, incentives for entrepreneurial activity, incentives for investment in human capital (active labor market policies) as well as macro-economic stability.

Considering the fact that economic growth is increase of the national production i.e. the quantity and value of manufactured products and services; economic growth can be identified with the production possibilities frontier. Specifically, a country that has moved its

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production possibilities frontier has achieved a greater level of national production, which is possible using more resources and/or with technological progress. According to the economic theory, equilibrium is established at a point which is on production possibilities frontier (PPF), indicating an efficient economy; while point inside of the PPF means inefficient economy. In this paper we investigate the efficiency of Croatian counties with the goal to assess the efficiency of the development process in the entire country. We construct the production possibilities frontier with two outputs, gross domestic product per capita and gross wages per employee as indicators of achieved living standards of citizens and level of economic growth. Both outputs depend on several inputs, but in line with the theory and facts of insufficient availability of data, we take following inputs:

- Graduated students (Input 1) as indicator of human potential
- Foreign direct investment FDI (Input 2) as indicator of capital and technology
- Equipment investment (Input 3) as indicator of capital
- Exports (Input 4) as indicator of openness
- Active legal entities (Input 5) as indicator of entrepreneurship

Using data envelopment analysis (DEA) we tried to identify efficient and inefficient counties, and how the latter can increase efficiency, which in our case means to accelerate economic growth.

## **2. THE THEORETICAL FOUNDATION OF ECONOMIC GROWTH**

Economic growth means increase in a level of production of one country or some region over a certain period of time. It includes only a positive change in the level of production of goods and services and could be analyzed like nominal growth defined as economic growth including inflation, or real growth which is nominal growth adjusted for inflation. Since the production depends on many factors such as number of inputs and technologies, economic growth is very complex economic phenomenon.

The theoretical foundation of economic growth can be studied from classical economist Smith. One of the biggest Adam Smith's contributions to the economic theory is the introduction of the term increasing returns into economy, based on division of labor, i.e. on specialization. Smith was aware that specialization is stronger in industrial production and, at the same time, very limited in agricultural production, that led to his theses that countries more oriented to industrial production become richer, whilst those oriented to agricultural production, are and remain poor. At the same time, Smith recognized also the importance of international exchange and free trade as engine of economic growth. Only free markets can lead to better country prosperity (Smith, 1776). He also stressed the importance of a stable legal framework in which business sector can operate. Based on the research of Smith, Ricardo deepened the theory of economic growth, formalized decreasing returns, but did not take into consideration innovation.

The following contributions to the theory of growth come from Harrod and Domar (Harrod, 1939; Domar, 1946) who, independently from one another, starting from different positions, came to the same conclusions. The Harrod-Domar model explains economic growth through savings. Savings should be equal investment, and investment leads to capital accumulation. Capital accumulation generates economic growth. This model suggests that the main variable to increase GDP is savings. Harrod-Domar model uses aggregate production function with fixed coefficients, assuming therefore constant returns. Its aggregate production function is linearly homogeneous in the stock of capital. It merges together the physical and human capital with the intellectual capital when the technical progress happens. Through technological progress is neutralized effect of diminishing returns. According to this model

high savings will finance a higher rate of technological progress resulting in faster growth process.

In the 50's of last century, the neo-classical theory of growth was created by Robert M. Solow (Nobel Prize winner in 1987). It is also called the neo-classical model of growth or Solow's growth model. The Solow model (Solow, 1956) emphasizes capital accumulation and exogenous rates of change in population and technological progress. Mentioned model predicts that all market-based economies will eventually reach the same constant growth rate if they have the same rate of technological progress and population growth. Moreover, the model assumes that the long-run rate of growth is out of the reach of policymakers but he stressed that combination of capital deepening & technological improvement explains major trends in economic growth.

New (endogenous) theories of growth are connected to the names of P. M. Romer, R. E. Lucas, E. Helpman and G. Grossmann, who start from the assumption that single decision-makers learn rationally not adaptively. That means that they do not change their behavior gradually, reacting to new information or different circumstances, but they learn new rules quickly and discontinuously. It is assumed that people in decision-making are turned towards future, expectations, not towards history, experience (Romer, 1986; Lucas, 1988). Romer observed that traditional theory failed to reconcile its predictions with the empirical observations that, over the long run, countries appear to have accelerating growth rates and, among countries, growth rates differ substantially. Endogenous growth theory says that government policy to increase capital or foster right kinds of investment in physical capital can permanently raise economic growth. Three main factors of economic growth are labor (increasing rate of population and participating rate of labor force, as well as the quality of labor force); capital (net and gross value of investment as well as quality of investment) and entrepreneurship (quality of entrepreneurs and entrepreneurial ability).

New Economic Geography (NEG) asserts that economic growth tends to be an unbalanced process favoring the initially advantaged economies (Krugman, 1991). According to this theory economic activity tends to concentrate in one region and also choose a location with a significant local demand generating a self-reinforcing process. Distribution of economic activity between regions can be explained by centripetal forces and centrifugal forces. The first include networks between firms, externalities and economies of scale while the second include negative externalities, transport costs and level of competitiveness. Consequently, NEG is mainly concerned with the location of economic activity, concentration and specialization rather than economic growth.

The economic growth is a complex macroeconomic phenomenon, and therefore even today it can not be completely explained what determinants, in what measure and in what way contribute to growth. The historical survey of theories of economic growth has shown that each of the said theories pointed out one or more determinants, which are key ones for the economic growth. Classicists pointed out natural resources and labor, neo-classicists capital and technology, and the new theory of growth stressed human potentials as well as entrepreneurship, while in recent theoretical approaches, economists distinguish location and development of cluster as main determinants of development process.

Besides the mentioned determinants, the theories of growth give the key role in growth also to: innovations, research and development, international trade and export capacity, political and governmental factors, equipment investment, foreign direct investment etc. Some of mentioned determinants we will also include in our research.

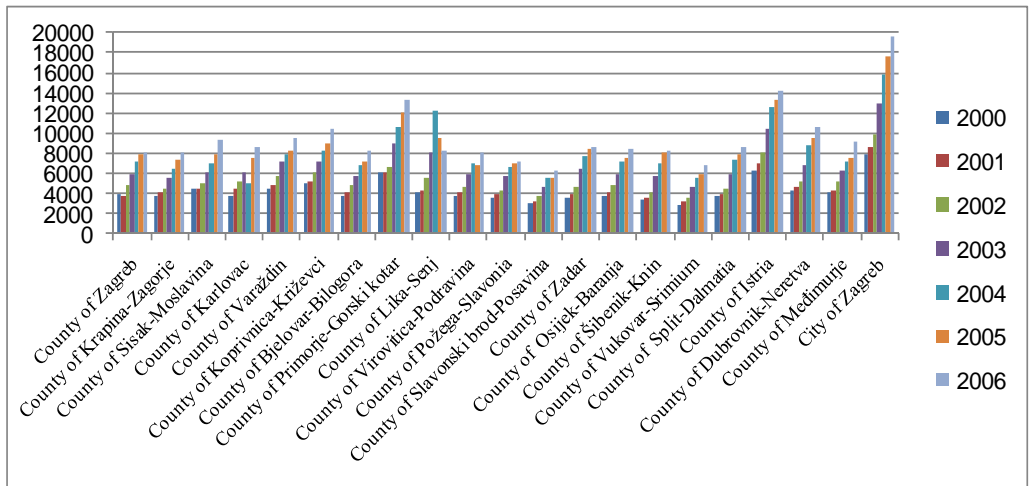
### 3. WHAT ARE THE MOST DEVELOPED COUNTIES IN CROATIA?

Global economic production grew 4 percent a year from 2000 to 2007, led by record growth in low- and middle-income economies. Developing economies averaged 6.5 percent annual growth of GDP from 2000 to 2007, and growth in every region was the highest in three decades. Europe and Central Asia and South Asia had their best decade in the most recent period (2000–07). East Asia and Pacific almost equaled their previous peak, reached before the 1997 crisis. For others the peak was in 1976 – before the oil price shocks of the late 1970s and the debt crisis of the 1980s (WDI, 2009). In light of the transition from planned to market economy, Croatia, like other transition economies faced with the transitional crisis whose bottom was reached somewhere between 1993 and 1995. Croatia has experienced a period of positive change in the economic field since 2000. In the period 2000–2007, Croatia grew 4.48 percent a year, while the reduction in 2008 (2.4%) caused the average rate fell to 4.24%. In accordance with the above, Croatia has grown more slowly than other developing countries in 21st century.

Despite the events on the world economic scene, the recession and the crisis that began in the USA spread to the rest of the world, the data showed that Croatia has its own weaknesses and limitations of economic growth (Škufljić, Šokčević, 2010). Specifically, relatively high growth rate of Croatian GDP was based on personal consumption and partly government spending that was financed by borrowing abroad generating a high level of external debt. At the end of 2008, Croatian external debt was 39 milliard of euro or 8,805 euro per capita; in terms of GDP it was 82% of GDP as well as 196% of export of goods and services. In 2009 external debt only increased and reached amount of 44 milliard of euro. Croatia used external debt to finance the development process, but unequally, and achieved economic growth rates and GDP levels varying by counties, which will be analyzed below. As at the regional level in Croatia the last available data are for 2006, in our paper we analyze the period 2000–2006.

Figure 1

GDP per capita of Croatian counties, 2000–2006 in US \$

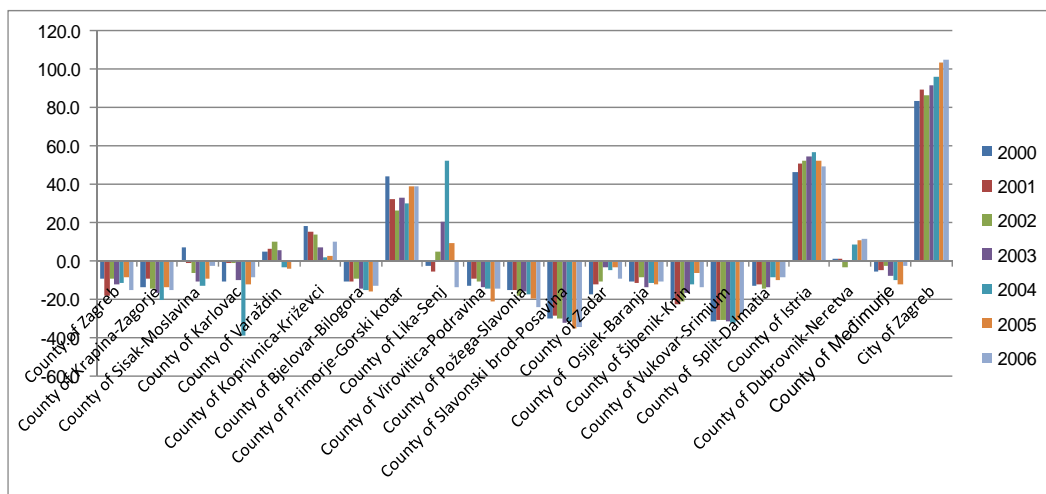


Source: Central Bureau of Statistics, [www.dzs.hr](http://www.dzs.hr)

Figure 1 shows how varied the GDP per capita in the Croatian counties in the period since 2000 to 2006 year (expressed in U.S. dollars). It is obvious that the most developed

county is City of Zagreb with the highest GDP per capita. In that county, in all analyzed period, GDP per capita was between 7,840 USD (2000) to 19,523 USD (2006). The least developed county was Slavonski Brod-Posavina, which in 2006 had only 6,236 USD per capita, which is considerably lower than the average of all counties amounted to 9,532 USD in 2006. City of Zagreb represents the engine of development of the Croatian economy because its GDP per capita is more than twice of the Croatian average. According to the date from 2006, amongst the most developed counties can count those whose per capita GDP was higher than the Croatian average, and they were: Istria (14,267 US \$), Primorje-Gorski kotar (13,242 US \$), Dubrovnik-Neretva (10,636 US \$) and Koprivnica-Križevci (10,515 US \$). If we compare the county with the European average, the most developed City of Zagreb in 2006 reached 65% of EU average while the less developed Slavonski Brod-Posavina recorded only 20.8% of European average.

Figure 2  
Croatian counties according to the achieved GDP per capita in relation to the average, 2000-2006

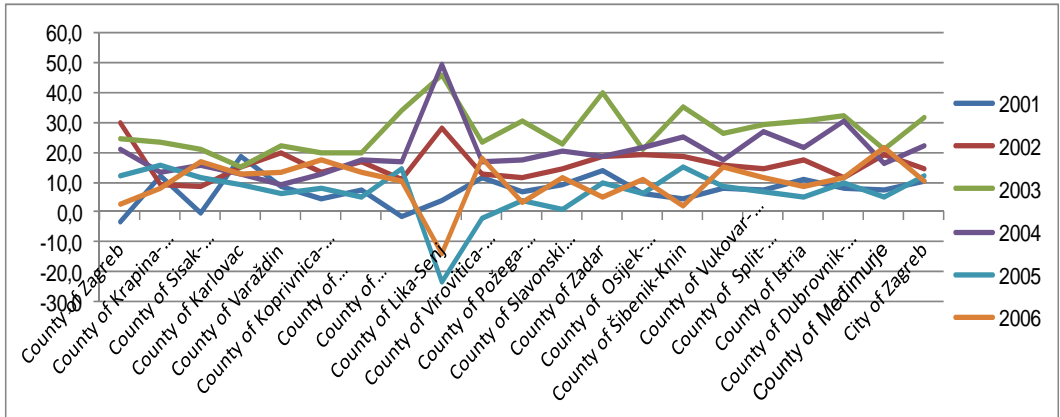


Source: Central Bureau of Statistics, [www.dzs.hr](http://www.dzs.hr)

In 2000, the Croatian average GDP was 4,274 USD per capita. Above the average were the following counties: City of Zagreb, Dubrovnik-Neretva, Istria, Primorje-Gorski kotar, Koprivnica-Križevci. In 2001, the average Croatian GDP per capita amounted 4,581 US \$, but the order of the counties was not significantly changed. In the line with figure 2 can be concluded that the most developed is City of Zagreb with a GDP of \$ 13,210 per capita, followed by County of Istria. Another positive extreme (above the average of actual Croatian development level) are: Primorje-Gorski kotar, Varaždin, Koprivnica-Križevci, Dubrovnik-Neretva but also Lika-Senj. The reason why Lika-Senj is amongst seven most developed Croatian counties is a small number of people since it was taken GDP per capita as indicator of economic growth. At the same time, only that county reported higher fluctuations of the nominal growth rate of GDP which is evident by figure 3. The average growth rate of GDP was ranged between 0 to 30% per year, while the bottom and top are present in the Lika-Senj County.

Figure 3

The nominal growth rate of GDP in Croatian counties, 2000-2006



Source: Central Bureau of Statistics, [www.dzs.hr](http://www.dzs.hr)

In line with the presented nominal growth rate can be concluded, at this stage of analysis, that the counties equally (effective or ineffective) used their resources, but the reason for the difference in the achieved development level should be in the unequal starting position. We try to confirm or reject our hypothesis using data envelopment analysis.

#### 4. METHODS AND RESULTS

Data Envelopment Analysis (DEA) is a non-parametric linear programming-based technique used for evaluating the relative efficiency of homogenous operating entities / decision-making units (DMUs) on the basis of empirical data on their inputs and outputs. In only thirty years since it has been introduced (Charnes, Cooper and Rhodes, 1978), it has become a central technique in a wide range of productivity and efficiency analysis used when comparing organizations, companies, regions and countries. It was written more than four thousand scientific papers in the field (Emrouznejad, Parker and Tavares, 2008) and developed several models that differ in the choice of returns to scale (constant or variable), orientation toward inputs or outputs, etc.

Advantages over traditional methods of measuring efficiency are also the reason behind choosing this method for purposes of this analysis, and are reflected in the following:

- does not require knowledge of the explicit functional form linking inputs and outputs,
- handles simultaneously multiple inputs and multiple outputs where each of them can be expressed in different units of measure,
- does not require a priori determination of input and output weights, but they represent the variables which are chosen by the method in a manner that assigns the best set of weights to each evaluated DMU thus avoiding the subjective assessment of their importance and contributing to the objectivity of analysis,
- characterizes each DMU by a single result of relative efficiency,
- identifies the sources and amounts of inefficiency in each input and each output,
- proposes improvements to inefficient DMUs based on achieved results of efficient DMUs.

Efficiency assessment in the field of economic growth of Croatian counties using DEA has not been the subject of expert discussions or research which makes it even more interesting.



The Republic of Croatia is administratively divided into twenty counties and City of Zagreb which has status of the county. They represent 21 entities whose relative efficiency is evaluated on the basis of five inputs and two outputs. Inputs included into analysis are the number of graduated students and active legal entities, and the amounts of foreign direct investment (FDI), equipment investment and exports. Outputs are represented by gross domestic product (GDP) and gross wages. To make a comparison reliable, and bearing in mind great differences between counties in population and thus in the number of persons employed resulting in significant differences in all other listed indicators, the gross wages are given per person employed while all other variables are given per capita. All data were taken from the Central Bureau of Statistics (CBS) and the Croatian National Bank (CNB) and relate to the year 2006 as the last available at the Croatian regional level.

Initially collected data presented in appendix 1 needed to be scaled in order to meet DEA requirements for inputs to be exclusively positive and for their smaller amounts to be preferable. That is achieved by adding the same arbitrary number (600) to the amounts of FDI of all counties to make even worst results positive, and then taking the reciprocal of the data of all inputs. The relationships between the data derived by given procedures remained unchanged. The values of output variables are positive and larger amounts are preferable so we use them in their original form.

Thus derived data on inputs and outputs should be included for all the observed DMUs into a linear program that represents the selected DEA model. It derives an empirical efficient frontier (production possibilities frontier) bounding inputs from below and outputs from above, and measures the relative efficiency of each DMU. Since determined by the (best) existing DMUs, the efficient frontier represents an achievable goal that inefficient DMUs should gain on. The relative efficiency value lies between 0 and 1. DMUs identified as "best practice units" are given a rating of 1, whereas the degree of inefficiency of the rest is calculated on the basis of their distance from the efficient frontier and attributed to input excesses and/or output shortfalls which can be overcome by projecting on the efficient frontier.

Basic DEA models commonly used in applications are CCR<sup>5</sup> and BCC<sup>6</sup>, named by initials of their authors.

CCR model is built on the assumption of constant and BCC model on the assumption of variable returns to scale activities. Therefore, knowing the characteristics of the production frontiers of the process to be analyzed is crucial for model type selection. As we could not determine that with certainty, the analysis was carried out under both assumptions. Because of similarity among the results obtained, CCR model is recommended.

In addition, the DEA model can be adjusted to the strategy chosen by management. If the aim is in reducing the input amounts by as much as possible while keeping at least the present output levels, the input-oriented model is used. If the aim is in maximizing the output levels under at most the present input consumption, the output-oriented model is used. Mentioned distinction between the input- and output-oriented model results in different courses and thus in different projection values of inefficient counties on the efficient frontier. Since economic growth is aimed at increasing both the selected outputs, the logical choice is output-oriented model that gives us the ability to explore to what extent we can improve outputs while not worsening the level of inputs used.

The output-oriented CCR model evaluates the efficiency of DMU<sub>0</sub> by solving the following linear program (Cooper, Seiford and Tone, 2006)

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<sup>5</sup> Charnes-Cooper-Rhodes model

<sup>6</sup> Banker-Charnes-Cooper model

$$\begin{aligned}
 & \min \eta = v_1 x_{10} + \dots + v_m x_{m0} \\
 \text{subject to} \quad & u_1 y_{10} + \dots + u_s y_{s0} = 1 \\
 & v_1 x_{1j} + \dots + v_m x_{mj} - u_1 y_{1j} - \dots - u_s y_{sj} \geq 0 \quad (j = 1, \dots, n) \\
 & v_1, v_2, \dots, v_m \geq 0 \\
 & u_1, u_2, \dots, u_s \geq 0
 \end{aligned}$$

where  $n$  is the number of DMUs,  $m$  is the number of inputs,  $s$  is the number of outputs. Variables  $(v_i)$  ( $i = 1, \dots, m$ ) and  $(u_r)$  ( $r = 1, \dots, s$ ) represent input and output weights.

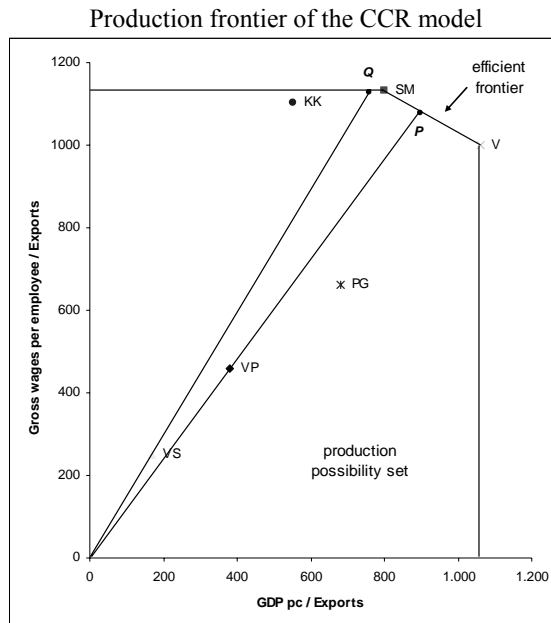
The dual envelopment form of this linear program is expressed as (Cooper, Seiford and Tone, 2006, 58)

$$\begin{aligned}
 & \max \eta \\
 \text{subject to} \quad & x_0 - X\mu \geq 0 \quad (1) \\
 & \eta y_0 - Y\mu \leq 0 \quad (2) \\
 & \mu \geq 0 \quad (3)
 \end{aligned}$$

Condition (1) consists of  $m$ , condition (2) of  $s$ , and condition (3) of  $n$  constraints. In this case,  $n = 21$ ,  $m = 5$ ,  $s = 2$ . The optimal objective value  $\eta^*$  is the reciprocal of the efficiency result, and for inefficient DMU<sub>0</sub> also the output enlargement rate.

Efficient frontier of the output-oriented CCR model will be illustrated by the example of six counties in the model with one input (exports) and two outputs (gross domestic product and gross wages). In order to be able to plot it (figure 4), exports is unitized to 1 under the constant returns-to-scale assumption. Among selected counties, only Sisak-Moslavina (SM) and Varaždin (V) are efficient. Points P and Q represent projections of Virovitica-Podravina (VP) and Vukovar-Sirmium (VS) against the efficiency frontier. Positions of these projections show that both efficient counties are references to Virovitica-Podravina, while only Sisak-Moslavina is reference to Vukovar-Sirmium.

Figure 4



Source: Author's work

Inputs and outputs should be classified as controllable and non-controllable. Controllable are those which management can control and change, while non-controllable are given and can not be influenced by management. In this analysis we consider FDI as non-controllable output. This means that the constraint in condition (1) relating to FDI becomes equality while all remaining constraints and conditions do not change.

The assessment of Croatian counties relative efficiency was carried out using described DEA model based on empirical data computed by DEA-Solver-Pro software.

According to the analysis of the obtained results, average relative efficiency is 0.8492. This means that an average county, should only combine 84.92% of the currently available quantity of inputs and produce the same quantity of the currently produced outputs, if it wishes to reach the efficiency frontier. In other words, if it wishes to do business efficiently, should produce  $(1-0.8492)/0.8492 = 17.76\%$  more output with the same input level. Minimum efficiency result is 0.5057 obtained by County of Vukovar-Sirmium. Seven more counties showed below average efficiency. Those are County of Slavonski Brod-Posavina (0.5065), Krapina-Zagorje (0.6177), Požega-Slavonia (0.6472), Osijek-Baranja (0.6545), Zadar (0.7012), Bjelovar-Bilogora (0.7603) and Virovitica-Podravina (0.7906).

Table 1 The reference set frequency

Efficient county	Frequency
County of Zagreb	6
County of Dubrovnik-Neretva	3
County of Sisak-Moslavina	1
County of Karlovac	3
County of Istria	10
County of Koprivnica-Križevci	12
County of Lika-Senj	0
City of Zagreb	3

Source: Author's calculations

Eight counties proved to be relatively efficient which makes 38% of the total number. It is known that counties that were rated efficient appear in reference sets of inefficient counties, and the frequency of occurrence can be considered an indication of whether they are a role model that other counties should achieve. Table 1 displays for every efficient county the frequency in reference sets of inefficient counties. County of Koprivnica-Križevci can be considered the most efficient as a reference for the most, as many as twelve inefficient counties.

Among a number of results are the projections of all counties against the efficiency frontier, i.e. the values of inputs and outputs that they should come up with to achieve relative efficiency. When it comes to efficient county, empirical data and their projections do not differ. Bearing in mind executed scaling of original data, differences between empirical and projected values in every input and output and their averages for all counties are displayed in table 2.

Table 2

Sources and amounts of inefficiency

Inefficient county	Input and output improvements					
	I1	I3	I4	I5	O1	O2
Krapina-Zagorje	8.18%	0.00%	0.00%	97.04%	61.89%	67.76%
Varaždin	33.20%	0.00%	0.00%	31.18%	6.51%	50.51%
Bjelovar-Bilogora	0.00%	60.85%	14.06%	0.00%	31.53%	115.23%
Primorje-Gorski kotar	0.00%	82.41%	0.00%	40.62%	0.11%	13.91%
Virovitica-Podravina	30.72%	0.00%	0.00%	30.46%	26.49%	101.21%
Požega-Slavonia	0.00%	7.80%	4.96%	21.27%	54.52%	110.07%
Slavonski Brod-Posavina	0.00%	63.68%	96.54%	23.87%	97.44%	97.44%
Zadar	0.00%	0.00%	14.64%	22.28%	42.62%	42.62%
Osijek-Baranja	0.00%	10.35%	24.85%	31.13%	52.79%	97.78%
Šibenik-Knin	0.00%	45.74%	53.30%	18.55%	16.07%	30.81%
Vukovar-Sirmium	0.00%	0.00%	26.54%	15.93%	97.73%	129.32%
Split-Dalmatia	0.00%	37.63%	0.00%	20.87%	2.26%	2.26%
Međimurje	17.72%	29.57%	0.00%	0.00%	14.64%	62.18%
Average per county	6.91%	26.00%	18.07%	27.17%	38.81%	70.85%

Source: Author's calculations

Significantly greater average influence of outputs rather than inputs is predetermined by selection of model orientation.

Gross wages per employee (O2) have far the strongest influence on inefficiency, almost twice stronger than gross domestic product per capita (O1). At the same time, the leading source of inefficiency among inputs are active legal entities (I5) with equipment investment (I3) very close behind it. Exports (I4) and graduated students (I1) have significantly lower impact on inefficiency, while FDI (I2) as non-controllable input does not change. The major modifications are needed in County of Varaždin (number of graduated students), Primorje-Gorski kotar (amount of equipment investment), Slavonski Brod-Posavina (amount of exports), Krapina-Zagorje (number of active legal entities), while Vukovar-Sirmium has relatively worst gross domestic product per capita and gross wages per employee. These facts indicate the need for deeper consideration of the causes of such devastating results and urgent measures to improve them.

Sources and amounts of relative inefficiency and the proposed improvements are extremely valuable information on which authorities can set goals that should be achieved and make decisions that will lead to them.

Since in described model gross wages per employee affect inefficiency significantly stronger than all the other inputs and outputs, we are interested to explore how their omission as output reflects the results of efficiency.

In new model with the same five inputs and gross domestic product per capita as the only output, the average relative efficiency decreased by 0.89% and now stands at 0.8416. Only three counties changed their relative efficiency amounts. In all three cases the amounts are reduced, and that is for 0.07% in County of Slavonski Brod-Posavina, 6.55% in Split-Dalmatia and 13.45% in Zadar whose efficiency amount is lowered to 0.6069. From this we can conclude that gross wages per employee favorably affect the amounts of efficiency of these counties which means that they are high comparing to average gross wages in other counties observed through selected inputs and outputs.

When it comes to amounts of (in)efficiency and number of efficient counties, the differences between models with and without gross wages per employee are not considerable. However, sources and amounts of inefficiency shown in table 3 are significantly different.

Table 3

Sources and amounts of inefficiency in the model without gross wages per employee

Inputs / Outputs	Average difference (%)	Most significant difference			
		County	Empirical value	Projection value	Difference (%)
I1	6.91%	Varaždin	303	403	33.20%
I2	0.00%	/	/	/	/
I3	41.94%	Split-Dalmatia	7,922.47	18,547.94	134.12%
I4	33.73%	Split-Dalmatia	9,423.83	29,947.14	217.78%
I5	39.99%	Zadar	1,836	4,075	121.90%
O1	41.08%	Vukovar-Sirmium	33,385	67,001	97.73%

Source: Author's calculations

Inefficiency is now most affected by equipment investment and little less by gross domestic product per capita and active legal entities which are followed by exports. Influence of graduated students on the efficiency results remained unchanged, while FDI is left uncontrollable and as such has no impact. The counties with major modifications needed, except for number of graduated students and gross domestic product per capita, have changed. Thus Split-Dalmatia has relatively worst amounts of equipment investment and exports, while Zadar has relatively worst number of active legal entities.

## 5. CONCLUDING REMARKS

Economic growth is always present issue in the scientific research as well as in political discussions. Economic theory has not reached consensus about the determinants of economic growth, but various theorists distinguish different factors. Relevance of some factor depends on the time and circumstances in which some economist operates. What we can say with certainty is that all countries want to achieve the higher growth rate and their paths in achieving this goal differ. In recent years, Croatia has obtained a relatively high growth rates, but they were still below the average rates of other developing countries. This is explained by the fact that Croatia belongs to countries with medium – high income, and according to the theory, level of economic growth and the growth rate are in inverse relationship. It can be concluded that Croatia did not follow the global development trends, and the reason for this lies primarily in the uneven economic growth by county.

Economic growth of Croatian counties was analyzed through the use of data envelopment analysis output-oriented CCR model on selected five inputs (number of graduate students and active legal entities, the amount of FDI, investment and exports) and two outputs (amount of gross domestic product and gross wages). FDI is classified as non-controllable input. It should be noted that we are dealing with relative efficiency which results are obtained by comparing all the counties exclusively on the basis of empirical values of their inputs and outputs.

Analysis revealed that eight counties are efficient. These are County of Istria, Dubrovnik-Neretva, Koprivnica-Križevci, Lika-Senj, Zagreb, Karlovac and Sisak-Moslavina and City of Zagreb. Using statistical and historical methods we get an almost identical result regarding the development level of counties in Croatia. For the remaining thirteen counties, we listed sources and amounts of inefficiency, i.e. inputs and outputs that cause inefficiency and their quantities that are used more (for inputs) and produced less (for outputs) then necessary compared with the efficient counties.

Among the thirteen inefficient counties, four are efficient in only one input while the other nine are efficient in just two inputs. In order to achieve efficiency, number of graduated students should be increased in four, exports in seven, equipment investment in eight and number of active legal entities in eleven counties. In comparison with efficient, all of thirteen inefficient counties could achieve higher gross domestic product per capita and higher gross wages per employee without affecting their input levels. Based on these results, guidelines for implementing necessary improvements to achieve efficiency are given. Those improvements are attainable because they are based on the results achieved by efficient counties, while mentioned guidelines provide support to the competent authorities, both at county and state-level decision-making.

### **BIBLIOGRAPHY**

- Central Bureau of Statistics, (2009), "Statistical Yearbook of the Republic of Croatia 2009"
- Cooper, W. W., Seiford, L., Tone, K., (2006), *Introduction to Data Envelopment Analysis and Its Uses: With DEA-Solver Software and References*, (New York: Springer).
- Domar, E., (1946), "Capital Expansion, Rate of Growth and Employment", *Econometrica*, (April 1946)
- Emrouznejad, A., Parker, B. R., Tavares, G., (2008), "Evaluation of research in efficiency and productivity: A survey and analysis of the first 30 years of scholarly literature in DEA", *Journal of Socio-Economic Planning Sciences*, (42), 3: 151–157.
- Harrod, R., (1939), "An Essay in Dynamic Theory", *Economic Journal*, (May 1939)
- Krugman P., (1991), "Increasing returns and economic geography", *Journal of Political Economy*, 99
- Lucas, R. E., (1988), "On the Mechanics of Economic Development", *Journal of Monetary Economics*, Vol. 22
- Romer, P., (1986), "Increasing Returns and Long Run Growth", *Journal of Political Economy*, Vol. 94
- Smith, A., (1776), *An Inquiry into the Nature and Cause of the Wealth of Nation*, (Glasgow Edition, Book IV).
- Solow, R.M., (1956), "A Contribution to the Theory of Economic Growth", *The Quarterly Journal of Economics*, Vol. 70, No. 1 (February 1956), The MIT Press
- Škuflić, L., Šokčević, S., (2010), "Determinants of the Economic Growth in Western Balkans Countries", *Fifth International Conference (ICES2010)* with the central theme "Economic Development Perspectives of SEE Region in Global Recession Context", in the process
- World Bank, (2009), World Development Indicator, [www.worldbank.org](http://www.worldbank.org) (15.03.2010.)

## PROCJENA EFIKASNOSTI HRVATSKIH ŽUPANIJA PRIMJENOM ANALIZE OMEDIVANJA PODATAKA

### SAŽETAK

Postizanje visokih stopa gospodarskog rasta je zadaća vlade svake zemlje jer budući svjetski poredak ovisi o sposobnosti unapređenja životnog standarda građana svake zemlje. U Hrvatskoj je, gledano na regionalnoj razini, prisutan neravnomjeran gospodarski rast gledajući BDP per capita, dok prema nominalnoj stopi rasta gospodarski razvoj pokazuje ujednačena kretanja. U posljednjih nekoliko godina Hrvatska je ostvarila relativno visoke stope rasta, ali su one još uvijek ispod prosjeka stopa drugih zemalja u razvoju. Hrvatska nije slijedila globalne trendove razvoja, a razlog tome leži prije svega u neravnomjernom gospodarskom rastu županija. Primjenom analize omeđivanja podataka, u ovom smo radu utvrdili koje su županije efikasne, koje resurse neefikasne županije trebaju efikasnije koristiti za povećanje regionalne, a time i ukupne nacionalne proizvodnje.

Ključne riječi: ekonomski rast, županije, efikasnost, analiza omeđivanja podataka

Appendix 1 Initial data on inputs and outputs

County	Inputs					Outputs	
	I1	I2	I3	I4	I5	O1	O2
Zagreb	357	-565.49	5,152.25	4,225.65	2,016	39,724	61,625
Krapina-Zagorje	328	962.61	9,429.47	12,696.63	1,351	39,723	52,973
Sisak-Moslavina	336	155.85	3,571.04	17,105.25	1,319	46,675	66,126
Karlovac	403	-199.71	4,411.51	8,122.67	1,687	43,836	63,884
Varaždin	303	638.87	7,004.19	21,864.11	1,749	48,485	45,752
Koprivnica-Križevci	349	107.00	5,465.59	10,129.59	1,573	54,586	108,844
Bjelovar-Bilogora	307	-9.58	2,982.47	5,155.93	1,541	43,323	47,930
Primorje-Gorski kotar	461	3,726.15	11,721.21	10,151.39	3,275	66,993	65,233
Lika-Senj	297	-52.11	6,561.62	771.54	1,648	50,153	45,034
Virovitica-Podravina	275	64.27	5,695.97	9,200.51	1,293	41,255	49,908
Požega-Slavonia	331	17.64	3,962.20	7,512.96	1,185	35,912	45,914
Slavonski Brod-Posavina	304	63.23	2,393.08	3,630.49	1,068	30,513	52,871
Zadar	433	3,005.77	8,357.87	6,394.03	1,836	41,592	63,136
Osijek-Baranja	336	796.14	6,601.74	10,353.79	1,533	42,738	52,771
Šibenik-Knin	448	232.81	5,720.97	9,865.54	1,982	39,779	61,956
Vukovar-Sirmium	273	127.97	3,439.59	5,005.56	1,017	33,885	49,750
Split-Dalmatia	521	739.21	7,922.47	9,423.83	2,474	43,766	67,293
Istria	369	1,608.43	19,714.03	28,551.17	4,455	71,727	82,973
Dubrovnik-Neretva	637	2,012.74	10,377.19	1,619.37	2,811	53,522	60,900
Međimurje	350	394.80	6,322.50	13,746.80	2,322	44,662	52,453
City of Zagreb	633	18,922.83	56,623.23	28,499.41	4,610	104,039	96,386

I1 – graduated students (per 100.000 population), kuna

I2 – FDI (per capita), kuna

I3 – equipment investment (per capita), kuna

I4 – exports (per capita), kuna

I5 – active legal entities (per 100.000 population)

O1 – gross domestic product (per capita),

O2 – gross wages (per employee), kuna

Source: CBS ([www.dzs.hr](http://www.dzs.hr)), CNB ([www.hnb.hr](http://www.hnb.hr)) and author's calculations