THE PREDICTION OF A REGIONAL ECONOMIC RESILIENCE IN THE CONTEXT OF EMPLOYMENT DOWNTURN AND UPTURN

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***Abstract**: The term regional economic resilience has been widely used in recent years, especially in connection with assessment of an impact stemming from the 2008 economic crises. This paper presents an example of a possible quantification of the regional resilience. There are also two hypotheses evaluated in this article. The aim of this paper is to evaluate a relationship of potential determinants of resilience into two indicators of regional economic resilience and also to suggest two models for prediction of type of a region in terms of indicators of regional economic resilience. The analytical part of this paper is based on a dataset NUTS level 2 regions in connection with the economic crisis starting in 2008. Main research methods used are: correlation analysis and decision trees. The period of the recession phase and the first recovery phase were chosen separately for each region according to identification of turning points within business cycle analysis. The results show that human capital significantly influences the growth of employment in the recovery phase. Other results show that the sectorial structure and labour market are the next important factors which are useful for the classification of regions in terms of their resilience.*

Keywords: regional development, resilience, economic crisis, employment

1. Introduction

It can be said that the concept of resilience consists of the region's ability to effectively resist various challenges (such as sudden fluctuations and slow-running processes). Regional resilience is thus seen as the essence of why some regions respond flexibly to economic, social, political or ecological changes, while other regions record deterioration of the existing development in long term. As a result, the regional economic resilience (RER) is often described as a property - more precisely - a process that allows regions to deal appropriately with an adversity. Economic resilience is often defined variously as (1) the ability of a system to recover from severe shock and includes both inherent as well as adaptive resilience [13] and as (2) being composed of people, companies, and institutions that interact in order to accomplish production, distribution, and consumption of goods and services [8]. This article assumes the regional resilience as an ability to reduce decline of some desired variable or ability to increase the desired level in a short time after the beginning of a certain crisis. Based on the NUTS 2 level data (NUTS means Nomenclature of territorial units for statistics), paper describes the relationship between potential determinants and two indexes (F1 and R1 which are described below) and suggests two models for predicting the regional type from the F1 and R1 point of view.

2. Research Methodology

We used results of evaluation of potential determinants from the previous research in this paper [14]. The aim of this research is to evaluate the relationship of RER determinants towards two indicators of RER (F1 and R1) and to suggest two models for prediction of the type of a region in terms of mentioned indicators.

In this study, we use quarterly time series of regional employment level for measurement of economic resilience. We focus on the evaluation of potential determinants of RER in terms of the rate of downturn after the beginning of a crisis (see the index described below - F1) resp. rate of upturn of the employment level in the first recovery phase after the first recession phase (see the index described below - R1). The period of the recession phase and the first recovery phase were chosen separately for each region according to identification of turning points within business cycle analysis (this analysis was based on the methodology described in [11]). HP filter with lambda parameter = 2 was used for turning points identification. Because of the quarterly data, we rearranged the data by the X12-ARIMA method so that we got a seasonally adjusted time series (to remove the seasonal component in the time series).

In accordance with our previous research, we used a set of determinants which showed medium and strong correlation with indicators F1 and R1 from the previous research [14] or were used in the models described below. The regional data was collected from the Eurostat database for the year 2007 (2007 was the last year before the beginning of the economic crisis - according to other studies (e.g. [6])). The indicators resp. potential RER determinants are showed in the Table 1. Mentioned indicators were identified as important determinants of economic resilience of regions in the previous research [15]. This research was based on previous studies of economic resilience of regions - e.g. [1], [2], [3], [5], [10] and [12]. All the data were acquired from the European Statistical Office [4] and [7].

According previous studies (e.g. [10]), we use two indexes of resilience:

- Quarter rate of employment decrease (geometrical average expressing percentage of decrease of regional employment level in the period of decline – symbolised as F1 – where “F” expresses “Fall”, and the number 1 expresses the first period of decline),
- Quarter rate of the employment growth (geometrical average expressing percentage of rise of regional employment level in the period of recovery – symbolised as R1 – where “R” expresses “recovery”, and the number 1 expresses the first period of recovery).

Regions with stronger resilience (compared to others) can be considered as the ones [10], that:

- have a lower rate of decrease of employment level in the recession phase (F1 <= median of F1 for all regions),
- have a higher rate of increase of employment level in the recovery phase (R1 >= median of R1 for all regions).

The research is based on the statistical sample of 175 regions NUTS 2 of 9 countries in the EU (Austria (AT), Czech Republic (CZ), Germany (DE), Spain (ES), France (FR), Italy (IT), Poland (PL), Slovakia (SK), and the United Kingdom (UK)). It represents

about 50 % of all NUTS 2 regions in the European Union (EU). The choice of the above countries is based on the current fulfillment of the following criteria:

- the sample regions has to come from EU,
- the selected regions are from the member state of European Union in the year 2004 (in order to assess the impact of the economic crisis in 2008 and including countries of the latest pre-crisis EU enlargement from 2004).

It was necessary to include only the regions that have appeared to be affected by the economic crisis from 2008. The group of 175 regions excluded those for which the following conditions apply:

1. the regions where there was no decrease in the estimated annual real regional gross domestic product (GDP) in at least one of the periods between 2007-2008 and 2008-2009 (real regional GDP was estimated using implicit price deflator),
2. the data on the annual change in regional GDP wasn't available for the 2007-2008 as well as 2008-2009 periods,
3. the regions where there was a decrease in the estimated regional GDP in at least one of the periods (2007-2008 or 2008-2009), but it was not possible to set breakpoints in employment quarterly time series.

After that, 131 regions were considered for further analysis.

The specific objective of this research paper is to test the following hypotheses:

- H1: The diversification of economic activities reduces the size of the decline in regional employment (F1).
- H2: The quality of human capital increases the growth of regional employment in the recovery phase (R1).

The hypothesis H2 will be accepted in the case of finding at least one statistically significant positive correlation relation with at least one of the determinants of human capital.

For the analysis of sectorial structure of a region, output characteristics of regional economy (e.g. regional product) as well as inputs such as employment level and capital costs can be used. The employment level is a good indicator due to its greater stability (compared to others) [9]. The best way to evaluate sectorial structure of a region is an evaluation of diversification, specifically of a specialization. One of the most common measurements of diversification, or specialization, are an adjusted and gross index of diversification. The adjusted index of diversification ($I_d^{(u)}$) is based on a gross index of diversification. The gross diversification index is calculated in the following way [9]:

$$I_d^{(c)r} = S1 + (S1 + S2) + (S1 + S2 + S3) + \cdots + (S1 \ \ldots + Sn), \quad (1)$$

where "S_i" is percentage of the number of employees in a sector in order from largest to smallest according percentages."n" represents a number of units - sectors.

The adjusted index of diversification can be symbolically expressed as following [9]:

$$I_d^{(u)} = \frac{I_d^{(c)r} - I_d^{(c)s}}{I_d^{(c)r}(max) - I_d^{(c)s}} \quad (2)$$

where “s” represents all the regions included in a group of regions, and “r” represents a value of a gross diversification index calculated for a region. $I_d^{(u)r}$ corresponds to a gross index of diversification of a region and $I_d^{(c)s}$ corresponds to a gross index of diversification of a group of regions. If $I_d^{(u)r} = 0$, then the degree of diversification of a region is the same as in a group of regions. If $I_d^{(u)r} = 1$, then it means the absence of any diversification of a set of regions (a region is thus highly specialized). A negative value of an index means that a single region is more diversified than a group of regions.

Another method used in this paper to design the evaluation model of resilience is a classification method, called “a decision tree”. A decision tree is one of the possible ways of representing knowledge. Creating a decision tree includes dividing data into multiple subsets. It includes the use of training data on which the learning process of the model is divided into successively smaller and smaller subsets (tree nodes). The aim of this process is a situation where the same class of samples is divided into its subsets. This procedure is often called a top down induction of decision trees (TDIDT). The aim is to find a tree consistent with the training data.

3. Analysis of Results

To accept or reject the above mentioned hypotheses, it was necessary to perform a correlation analysis. Results presented in the Table 1 demonstrate the fact that hypothesis H1 has been rejected. “The adjusted index of diversification, according to the number of people employed”, showed a very weak and also non-significant correlation relationship with the indicator of decrease of regional employment in the recession phase (F1). Moreover, this result shows that the diversification of economic activities has no positive effect on employment in the recession phase (or the effect is too weak).

The strongest negative correlation relationship (above correlation coefficient 0,4) between potential determinants and the indicator F1 represented the following indicators (these indicators can be seen as a protector of employment resilience in decline): “The job vacancy rate”; “Total intramural research and development (R&D) expenditure (in the Purchasing Power Standard (PPS))”; “Labour productivity (gross value added of the number of persons employed)”; “Number of patent applications per million inhabitants”; “The proportion of people employed in R&D in economically active population”; “The estimate of real gross domestic product at market prices per capita” (expressed in purchasing power standard base year = 2005), “The proportion of researchers employed in R&D in the economically active population”, and “Human Resources in Science and Technology”.

The results presented in the Table 1 also demonstrate the fact that hypothesis H2 has been verified. The group of indicators named "Human Capital" showed a moderate positive correlation relationship with the indicator of growth of regional employment levels in the recovery phase (R1). Even though it is a relatively weak correlation, these results cannot be considered as insignificant (with the exception of people aged between 25-64 with upper secondary education according to ISCED-97 (level from 3 to 4) – ISCED means The International Standard Classification of Education).

The strongest correlation relationship (above correlation coefficient 0,4 in the absolute value) between the potential determinants and indicator R1 was represented by these indicators: “Public administration and defence, compulsory social security, education, health and social care (O, P, Q)”; “Wholesale and retail trade, transportation and storage, accommodation and food service activities (G, H, I)”; “Information and communication (J)” and “People aged between 25-64 with tertiary education according to ISCED-97 (level from 5 to 6)”.

Table 1: Results of correlation anal. - Spearman's coefficient (significant values are in bold)

Factor	*Variable*	*F1*	*R1*
Human Capital	Human Resources in Science and Technology	**-0,299**	**0,331**
Human Capital	People aged 25-64 with upper secondary education according to ISCED-97 (level from 3 to 4) (Pr-use25-64)	**-0,213**	0,090
Human Capital	People aged 25-64 with tertiary education according to ISCED-97 (level from 5 to 6) (Pr-te25-64)	0,029	**0,402**
Human Capital	People aged 25-64 with upper secondary or tertiary education according to ISCED-97 (level from 3 to 6)	**-0,215**	**0,237**
Sectoral Structure	The adjusted index of diversification - according to the number of people employed (UID-EM)	0,209	-0,109
Sectoral Structure	Wholesale and retail trade, transportation and storage, accommodation and food service activities (G, H, I)	-0,071	**0,496**
Sectoral Structure	Information and communication (J) (EM-J-r)	-0,121	**0,442**
Sectoral Structure	Public administration and defence, compulsory social security, education, health and social care (O, P, Q)	0,130	**0,608**
Innovation and R&D	Total intramural R&D expenditure (in PPS)	**-0,470**	0,105
Innovation and R&D	Number of patent applications per million inhabitants	**-0,437**	**0,314**
Innovation and R&D	The proportion of persons employed in R&D in the economically active population	**-0,426**	-0,034
Innovation and R&D	The proportion of researchers employed in R&D in the economically active population	**-0,332**	0,120
Economic Perform.	Labour productivity (gross value added of the number of people employed) (GVA/EM)	**-0,446**	0,121
Economic Perform.	The estimate of real gross domestic product at market prices per capita, expressed in purchasing power standard (base year = 2005)	**-0,402**	0,088
Labour Market	The job vacancy rate (JVr)	**-0,513**	0,211
Socio-demogr. Charact.	People at risk of poverty or social exclusion (RPr)	**0,436**	0,312

Source: authors, according data from [7] and [4]

4. Models for prediction

To fulfil the aim of this research, it was necessary to create a valid model to predict regional type according to the size of employment downturn and upturn as an effect of the economic crisis. More specifically, this part of the research study presents a set of rules used for classification of regions into a group of resilient or non-resilient regions (according to the F1 and R1 indicators). For this purpose, a decision tree algorithm was used. A decision tree was created in the programming environment SPSS Clementine 10.1. It was necessary to perform data transformation for the successful application of the decision tree algorithm. This transformation was based on the conversion of a continuous variable (indicators F1 and R1) to a discrete type (new indexes F1_2c and R1_2c were set). Each region has obtained two values in terms of the F1 indicator and in terms of the R1 indicator. These two values were either 1 (resilient region in terms of the F1 resp. in terms of the R1 indicator) or 2 (non-resilient region in terms of the F1 resp. in terms of the R1 indicator). For the purposes of the decision tree method the input data was divided into two parts - a training set and a test set at a ratio of 3:1. The regions included in the test group were used to evaluate the quality of the found rules.

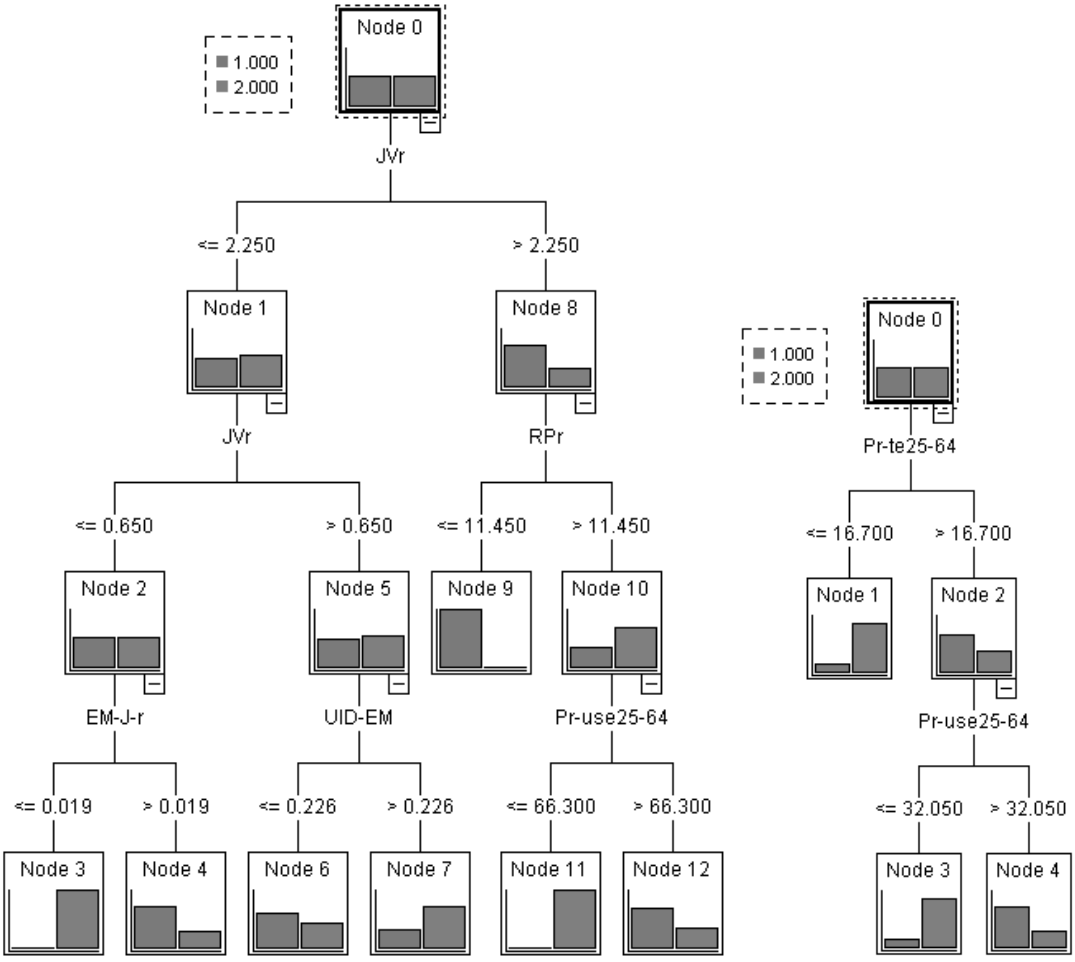

Figure 1: Models for prediction – of F1_2c (on the left side), of R1_2c (on the right side)
Source: Own construction from the programming environment Clementine 10.1

The figure 1 shows two decision trees as a visualization of rules obtained by the use of the decision tree method (the method of the CRT decision tree was especially used). The left side of the Figure 1 shows a decision tree for resilient regions by F1 and the right side is for a decision tree for resilient regions by R1. Abbreviations of all used indicators are explained in the Table 1. The model on the left side of the Figure 1 classifies regions with a reliability of 78.75 % (on the set of test data). Relationships within the model correspond to the relationships found in the correlation analysis (except for the indicators "The adjusted index of diversification - according to the number of people employed" and "The proportion of people employed in the sector information and communication (J)" – there was insignificant relationships found with the indicator F1).
The model on the right side of the Figure 1 classifies regions with a reliability of 70.35 % (on the set of test data). Relationships within the model correspond to the relationships found in the correlation analysis (except for "People aged between 25-64 with upper secondary education according to ISCED-97 (level from 3 to 4)" – there was an insignificant relationship found with the indicator R1). Indicators used in the structure of the decision tree are suitable for the prediction of economic resilience and also for supporting effective decision making concerning the implementation of regional policy.

5. Conclusions

This paper evaluates the relationship between the potential determinants for RER and indicators F1 (rate of decline of employment in the first recession phase) as well as R1 (growth of employment level in the first recovery phase). Although the correlation analysis showed an insignificant relationship between the diversification of economic activities of a region and the indicator F1 (due to that the first hypothesis was not accepted), this indicator of diversification was used in the model for predicting the F1_2c indicator (accuracy of model was 78.35 %). The second hypothesis was accepted – human capital has a decent impact on the growth of regional employment in the recovery phase (moreover, the suggested model for predicting the category of regions in terms of R1 uses two of the determinants related to human capital - the accuracy of the model was 70.35 %). Indicators used in both models show the relevance of the importance of human capital, labour market, sectorial structure and socio-economic characteristics of regions.
Limits of the presented results and models are influenced by the fact that only one shock was researched (the economic crisis of 2008). Further research would enrich the research attitude with the focus on sensitivity analysis of determinants used in both models.

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