# Assessing a Region's Economic Level Using the Regional Economic Development Risk Indicator

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*Abstract:* Assessing the differences between regions within a single country is important not only from the macro-economic perspective, but also in the light of entrepreneurial activities being implemented or intended in a region. Managerial decisions as to whether conditions suit a particular business activity are based on assessments of corporate resources as well as analyses of the environment with respect to future developments. There are a number of indicators whose values are detected by statistical offices at the regional and national level; however, when assessing a region, one must consider the indicators in mutual relations rather than separately. The Regional Economic Development Risk Indicator is synthetic in that it involves not only selected economic criteria, but also social and, to a limited extent, environmental aspects. Its use is presented by a case study which focuses on an assessment of the Hradec Kralove Region.

*Key words:* Regional economic development risk, macro-economic indicators, fuzzy logic

## 1 Introduction

Assessing a region's level is based on economic, social and environmental aspects. It is also closely linked to strategic documents of individual countries, which is also true of the Czech Republic. Assessment indicators are defined in connection to the Czech Republic's Regional Development Strategy and are assigned to information sources [3].

Analyses of macro-economic indicators and consequences of the development have been the core of studies by a number of influential economists in different periods and countries (see e.g. [1], [5], [6]). The macro-economic balance, characterised by the level of the gross domestic product, i.e. by a balance of the aggregate offer and aggregate demand, is constantly disturbed by destabilising influences [7]. Professional literature (e.g. [5], [11]) involves the following basic indicators: annual gross domestic product growth rate, annual inflation rate, annual inflation rate and the percentage of commercial balance (payment balance) against the nominal gross domestic product.

Although full use of all indicators is hardly feasible, it is possible to choose a certain compromise between a higher proportion of an objective and inferior results in another objective or objectives.

Assessing the differences between regions within a single country is important not only from the macro-economic perspective, but also in the light of entrepreneurial activities being implemented or intended in a region. Contrarily to big firms, small firms interact intensively with the territory in which they located, as a signal of their embeddedness. [2].

The aim of this paper is to assess a region's economic development and to predict whether the region will develop along the same lines as other regions, or whether it will be faced with a threat and in need of support. In order to attain this goal, I use the Regional Economic Development Risk Indicator (the fundamental assumptions from which the concept stems are not detailed herein, see [8] for more information).

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# 2 Problem Formulation

## Regional Economic Development Risk Indicator

The synthetic Regional Economic Development Risk Indicator has been compiled using the generally valid criteria defined for the Czech Republic's micro-regions with state support, such as:

- the unemployment rate of the given micro-region is 25% or more higher than the indicator of the region (or the higher administration unit),
- the tax revenue indicator is 90% or less of the indicator of the region,
- the average salary in the micro-region is 95% or less of the indicator of the region,
- the indicator of the relative number of entrepreneurs in the micro-region is 95% or less of the indicator of the region,
- the indicator of the population density in the micro-region is 95% or less of the indicator of the region,
- The indicator of the natural increase of the population in the micro-region is negative.
- The concept also respects some special criteria intended for structurally impaired and economically poor regions in need of focused support, namely:
- the indicator of employment in agriculture is 15% or more higher than the indicator of the region,
- the indicator of employment in industry is 8% or more higher than the indicator of the region.

The percentage values of the indicators in relation to the higher administration unit are not conceived as sharp values, for the use of fuzzy sets enables assessing the risk rate of partial criteria and the extent of their attainment in much greater detail.

The Regional Economic Development Risk indicator involves:

- gross domestic product per capita,
- the number of registered entrepreneurs per 1,000 persons,
- the portion of the population employed in agriculture,
- the portion of the population employed in industry,
- the natural increase of the population,
- the index of the population's financial security.

The index of the population's financial security F is defined as a ratio between the average salary in the region and the number of unemployed in the region (for more detail see [8]).

# 3 Problem Solution

## 3.1 Conception and evaluation of the Regional Economic Development Risk Indicator using fuzzy sets

Fuzzy logic is a sub-field of mathematics and is derived form the fuzzy set theory [9], where logical statements are assigned a relevance grade (on a scale), whose values are within the interval [0, 1]. [12]

In this way fuzzy logic differs from the classical statement and predicate logic, where statements are either true, i.e. are assigned a value of 1 in the binary system, or false, i.e. are assigned a value of 0. [10]

Next, we will describe the individual steps of the process of fuzzy processing of the case study for the Hradec Kralove Region; i.e. we will construct and assess the Regional Economic Development Risk Indicator.

Creating fuzzy logic systems can be broken down into the following steps:

***1. Basic variable*** **–** depending on the nature of the system, we choose basic variable A, whose value is to be identified in the fuzzy process. In this case, the basic variable equals the Regional Economic Development Risk indicator *R.*

***2. Basic variable attributes*** – this step defines *m* attributes (levels) of the basic variable. The case study contains the following attributes pertaining to risk *R:*

VHR (very high risk), HR (high risk), MR (moderate risk), LR (low risk), VLR (very low risk), ZR (zero risk),
i.e. $m = 6$. (1)

***3. Partial variables*** – according to the nature of the system, we define *n* partial variables of the system, whose values influence the resulting value of the basic variable of the system. As we have said earlier, the Regional Economic Development Risk indicator R involves the indicators of the gross domestic product per capita (GDPC), the number of registered entrepreneurs per 1,000 persons (NRE), the natural increase of population

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(NIP), the number of people employed in agriculture (NPEA), the number of people employed in industry (NPEI) and the standardised Population financial security index *F*. Table 2 shows these values for the Hradec Kralove Region and Table 3 for the Czech Republic.

*Table 2 Values of choice indicators in the Hradec Kralove Region*

| **Year** | **GDPC** (CZK) | **NRE** (number of companies/1,000 citizens) | **NIP**(number of citizens) | **NPEA** (%) | **NPEI** (%) | $F_{norm}$ **(-)** |
|---|---|---|---|---|---|---|
| 1996 | 159,612.17 | 14.43 | -964 | 6.53 | 44.66 | 0.389 |
| 1997 | 174,512.62 | 16.83 | -1045 | 6.41 | 43.54 | 0.248 |
| 1998 | 188,008.58 | 17.84 | -858 | 5.62 | 43.33 | 0.138 |
| 1999 | 195,872.37 | 18.96 | -991 | 7.42 | 42.77 | 0.102 |
| 2000 | 209,862.99 | 19.68 | -830 | 7.44 | 40.28 | 0.188 |
| 2001 | 222,603.21 | 20.29 | -851 | 5.39 | 43.56 | 0.195 |
| 2002 | 227,868.93 | 21.20 | -767 | 5.59 | 43.20 | 0.153 |
| 2003 | 234,508.37 | 22.16 | -921 | 5.50 | 38.31 | 0.149 |
| 2004 | 254,720.71 | 22.35 | -557 | 6.08 | 39.47 | 0.163 |
| 2005 | 264,873.20 | 22.61 | -303 | 4.89 | 43.16 | 0.187 |
| 2006 | 276,868.41 | 22.82 | -200 | 3.92 | 41.70 | 0.257 |
| 2007 | 301,849.48 | 23.10 | 536 | 4.07 | 43.33 | 0.428 |
| 2008 | 313,532.28 | 23.54 | 728 | 3.89 | 45.65 | 0.471 |
| 2009 | 309,570.08 | 23.34 | 350 | 4.03 | 41.92 | 0.251 |

*Source:* [4]

*Table 3 Values of indicators under consideration within the Czech Republic*

| **Year** | **GDPO** (CZK) | **NRE** (number of companies/ 1,000 citizens) | **NIP** (number of citizens) | **NPEA (%)** | **NPEI (%)** |
|---|---|---|---|---|---|
| 1996 | 163,183.00 | 14.25 | -22,336 | 4.97 | 25.88 |
| 1997 | 175,772.00 | 15.80 | -22,087 | 4.70 | 26.52 |
| 1998 | 193,929.00 | 17.31 | -18,992 | 4.25 | 27.58 |
| 1999 | 202,357.00 | 19.10 | -20,297 | 3.97 | 28.86 |
| 2000 | 213,110.00 | 19.98 | -18,091 | 3.72 | 29.83 |
| 2001 | 230,064.00 | 20.79 | -17,040 | 3.64 | 30.98 |
| 2002 | 241,593.00 | 21.79 | -15,457 | 3.65 | 30.71 |
| 2003 | 252,617.00 | 22.78 | -17,603 | 3.51 | 29.68 |
| 2004 | 275,770.00 | 23.02 | -9,513 | 3.27 | 29.50 |
| 2005 | 291,560.00 | 23.30 | -5,727 | 3.21 | 29.53 |
| 2006 | 313,868.00 | 23.63 | 1,390 | 3.09 | 30.54 |
| 2007 | 342,494.00 | 23.91 | 9,996 | 2.89 | 30.68 |
| 2008 | 353,701.00 | 24.38 | 14,622 | 2.82 | 30.91 |
| 2009 | 345,601.00 | 24.47 | 10,927 | 3.12 | 28.50 |
| 2010 | 348,928.00 | 25.04 | 10,309 | 3.10 | 28.47 |
| 2011 | 349,051.00 | 25.14 | 4,890 | 2.94 | 29.34 |

*Source:* [4]

The GDPC, NRE, NIP, NPEA and NPEI help define partial variables *H*, $R_P$, $P_o$, $P_Z$, $P_P$ (respectively) expressing the difference of the percentage of the national and corresponding regional indicator.

Given the fact that a growth in the values of the GDPC, NRE, NIP, NPEA and NPEI causes a growth of the value *R*, while an increase of the standardised

Financial security of the population index *F* makes *R* go down, we have, for the purpose of the fuzzy processing, introduced the *Index of the population's financial insecurity G,* determined as

$$G = (1 - F) \cdot 100 \ \ (\%) \qquad (2)$$

Particular values of the partial variables ($n$ = 6) in the Hradec Kralove Region for 1996 to 2011 are listed in Table 4.

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T*able 4 Values of partial variables*

| Year | $H$ (%) | $R_P$ (%) | $P_o$ (%) | $P_Z$ (%) | $P_P$ (%) | $G$ (%) |
|---|---|---|---|---|---|---|
| 1996 | 2.19 | -1.29 | -4.25 | 1.56 | -18.8 | 61.06 |
| 1997 | 0.72 | -6.47 | -2.54 | 1.71 | -17.0 | 75.19 |
| 1998 | 3.05 | -3.07 | -2.93 | 1.36 | -15.8 | 86.18 |
| 1999 | 3.20 | 0.74 | -1.78 | 3.45 | -13.9 | 89.76 |
| 2000 | 1.52 | 1.49 | -2.55 | 3.72 | -10.5 | 81.24 |
| 2001 | 3.24 | 2.40 | -1.20 | 1.75 | -12.6 | 80.48 |
| 2002 | 5.68 | 2.73 | -1.16 | 1.93 | -12.5 | 84.73 |
| 2003 | 7.17 | 2.72 | -0.42 | 1.99 | -8.63 | 85.13 |
| 2004 | 7.63 | 2.91 | 0.87 | 2.81 | -9.96 | 83.67 |
| 2005 | 9.15 | 2.96 | -0.06 | 1.68 | -13.6 | 81.35 |
| 2006 | 11.79 | 3.41 | 4.99 | 0.83 | -11.2 | 74.30 |
| 2007 | 11.87 | 3.37 | -0.08 | 1.19 | -12.7 | 57.19 |
| 2008 | 11.36 | 3.44 | 0.84 | 1.08 | -14.7 | 52.93 |
| 2009 | 10.43 | 4.60 | 4.09 | 0.91 | -13.4 | 74.85 |
| 2010 | 11.46 | 4.68 | 1.35 | 0.37 | -12.8 | 75.91 |
| 2011 | 19.05 | 3.66 | 6.40 | 0.52 | -9.30 | 65.82 |

*Source: Own*

Positive percentage values express a decrease in comparison with the national average; negative values express an increase in comparison with the national average.

***4. Attributes of partial variables*** – the attributes of the partial variables correspond to attributes (1) of the basic variable of the system.

***5. Partial variable transformation matrix T*** – the partial variable transformation matrix is a matrix with $m$ lines and $n$ columns, whose elements $t_{i,j}$, $i = 1, 2,\ldots, m$, $j = 1, 2,\ldots, n$, are numbers corresponding to the limits of the intervals of the attributes of the partial variables pertaining to the issue in question. These interval limits must be determined on the grounds of experience gained by the experts in the given field, as we did in the case study presented. Table 5 contains an overview of the particular attribute interval limits (1) of the partial variables of the system. The transformation matrix **T** (grey background) is a mathematical representation of these limits.

*Table 5 Interval limits of partial system variables´ attributes*

| | $H$ (%) | $R_P$ (%) | $P_o$ (%) | $P_Z$ (%) | $P_P$ (%) | $G$ (%) |
|---|---|---|---|---|---|---|
| **VHR** | 20 | 15 | 5 | 3 | 7 | 50 |
| **HR** | 15 | 10 | 4 | 2 | 4 | 40 |
| **MR** | 10 | 6 | 3 | 1 | 2 | 30 |
| **LR** | 8 | 4 | 2 | 0.5 | 1 | 20 |
| **VLR** | 5 | 2 | 1 | 0.2 | 0.5 | 10 |
| **ZR** | 0 | 0 | 0 | 0 | 0 | 0 |

*Source: own*

***6. Partial variable status matrix*** – the partial variable status matrix is a matrix with $m$ lines and $n$ columns, and is a mathematical representation of the actual status of the system as it is described by the partial variables. Elements $s_{i,j}$, $i = 1, 2,\ldots, m$, $j = 1, 2,\ldots, n$, of matrix **S** represent truth values 0 (the particular value of the partial variable lies beyond the interval subjected to the test) or 1 (the particular value lies within the interval subjected to the test). The testing itself takes place in the following manner (this is an example applying to variable $H$ and the limit values from Table 5):

If $H \geq 20$, variable $H$ is in the state of very high risk VHR,
If $20 > H \geq 15$, variable $H$ is in the state of high risk HR,
If $15 > H \geq 10$, variable $H$ is in the state of moderate risk MR,
If $10 > H \geq 8$, variable $H$ is in the state of low risk LR,
If $8 > H \geq 5$, variable $H$ is in the state of very low risk VLR,
If $5 > H$, variable $H$ is in the state of zero risk ZR.

Regarding 2011, in particular, we obtain the following partial variable states:
$H$…HR, $R_P$…VLR, $P_o$…VHR, $P_Z$…LR, $P_P$…ZR, $G$…VHR,
as is presented in Table 6, containing state matrix **S** (grey background) as a mathematical representation.

*Table 6 Truth values of partial system variables for 2011*

| | $H$ | $R_P$ | $P_o$ | $P_Z$ | $P_P$ | $G$ |
|---|---|---|---|---|---|---|
| **VHR** | 0 | 0 | 1 | 0 | 0 | 1 |
| **HR** | 1 | 0 | 0 | 0 | 0 | 0 |
| **MR** | 0 | 0 | 0 | 0 | 0 | 0 |
| **LR** | 0 | 0 | 0 | 1 | 0 | 0 |
| **VLR** | 0 | 1 | 0 | 0 | 0 | 0 |
| **ZR** | 0 | 0 | 0 | 0 | 1 | 0 |

***7. Basic variable value*** – is a numerical value of basic variable $A$, equal to the dot product of the transformation and status matrix.

$$A = \mathbf{T} \cdot \mathbf{S} = \sum_{i=1}^{m} \sum_{j=1}^{n} t_{i,j} s_{i,j} \qquad (3)$$

In this case, the value of the 2011 Regional Economic Development Risk indicator $R_{11}$ equals 72.5.

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$$R_{11}=\begin{pmatrix}20 & 15 & 5 & 3 & 7 & 50\\ 15 & 10 & 4 & 2 & 4 & 40\\ 10 & 6 & 3 & 1 & 2 & 30\\ 8 & 4 & 2 & 0.5 & 1 & 20\\ 5 & 2 & 1 & 0.2 & 0.5 & 10\\ 0 & 0 & 0 & 0 & 0 & 0\end{pmatrix}\cdot\begin{pmatrix}0 & 0 & 1 & 0 & 0 & 1\\ 1 & 0 & 0 & 0 & 0 & 0\\ 0 & 0 & 0 & 0 & 0 & 0\\ 0 & 0 & 0 & 1 & 0 & 0\\ 0 & 1 & 0 & 0 & 0 & 0\\ 0 & 0 & 0 & 0 & 1 & 0\end{pmatrix} \quad (4)$$

***8. Limits of basic variable attribute intervals*** – the determination of the limits of the intervals of the basic variable attributes is fully in the competence of the expert in the given field. The maximum value of the basic variable, defined as the total of the maximum values in each of the columns in the transformation matrix **T**, determines the upper limit.

$$A_{\max}=\sum_{j=1}^{n}\max\left(t_{i,j}\right)_{i=1}^{m} \quad (5)$$

In the case study $R_{max}$ = 100. The limits of the attribute intervals pertaining to the Regional Economic Development Risk *R*, selected in the case study, are listed in Table 7.

*Table 7 Interval limits of basic variable attributes*

| | ***R*** | | ***R*** |
|---|---|---|---|
| **VHR** | 95 | **LR** | 40 |
| **HR** | 80 | **VLR** | 20 |
| **MR** | 60 | **ZR** | 0 |

***9. Retransforming the basic variable*** – a process which assigns the calculated numerical value the corresponding attribute of the basic variable on the grounds of the retransformation table, i.e. Table 8. The retransformation conditions use the attribute interval limits of the variable from Table 7.

*Table 8 Retransformation table of basic variable*

| **VHR** | **HR** | **MR** |
|---|---|---|
| $100 > R \geq 95$ | $95 > R \geq 80$ | $80 > R \geq 60$ |
| **LR** | **VLR** | **ZR** |
| $60 > R \geq 40$ | $40 > R \geq 20$ | $20 > R \geq 0$ |

If we assign the attribute to value $R_{11}$ = 72.5, it is obvious that in 2011 the region in question was in the moderate risk state.

***10. Trend of the Regional Economic Development Risk indicator*** – for the purpose of prediction or a more detailed evaluation of the Regional Economic Development Risk Indicator *R*, it is suitable to evaluate its value for a longer period of time and apply the regression function to the values acquired.

In the period in question, the values of the Regional Economic Development Risk indicator can be described using attributes ranging from low to moderate risk (Table 9).

*Table 9 Risk of Regional Economics Development – Hradec Kralove Region*

| **Year** | **Value of indicator** | **Attribute** |
|---|---|---|
| 1999 - 2001 | 53 | LR |
| 2002 - 2003 | 58 | LR |
| 2004 | 59 | LR |
| 2005 | 61 | MR |
| 2006 | 66.5 | MR |
| 2007 - 2008 | 63 | MR |
| 2009 | 68,5 | MR |
| 2010 | 65,2 | MR |
| 2011 | 72.5 | MR |

## 3.2 Characteristics of the region assessed

Regarding the geography of the Hradec Kralove Region, we can say that it is a varied area, which, to a certain extent, defines its position among the other regions of the Czech Republic. The historically conditioned structure of industry, agriculture and services enhance the region's stability. This region neighbours with Poland and the border is more than 200 km long, which contributes to the development of cross-border trade, tourism and cooperation.

The Hradec Kralove Region is situated in the north-eastern part of Bohemia and, together with the Liberec and Pardubice regions, forms the North-East Region, which is one of the Czech Republic's three largest, given both the area and the population. Since 2000 the region has consisted of five districts, namely Hradec Kralove, Jicin, Nachod, Rychnov nad Kneznou and Trutnov. The area of the Hradec Kralove Region occupies six per cent of the area of the Czech Republic and is thus the 9th largest. The region is fifth in regards to the portion of agricultural land and eighth in the percentage of forest land. 84% of the agricultural land of the region is used. The region boasts the Krkonose National Park and three nature conservation zones – these protected areas comprised more than a fifth of the area of the region in 2010. The number of inhabitants of

the region represents roughly 5% of the Czech Republic's population. The portion of urban populace reaches 67.6%. In 2010, the region had the lowest portion of inhabitants between 15 and 64 years of age (69.0%) and the highest portion of inhabitants over 65 (16.5%). The density of the population differs across individual districts (highest in Hradec Kralove 183 inhabitants per square kilometre, lowest in Rychnov nad Kneznou (81)). The Hradec Kralove Region is agricultural-industrial with well developed tourism. The industry is situated in large industrial hubs, while intensive agriculture can be found in the Labe Basin. The region, according to the Czech Statistical Office, created 4.5% of the Czech Republic's gross domestic product. The 2010 labour force survey revealed that the total of 253.8 thousand persons were employed in the region (30% of whom worked in the processing industry, 12% in wholesale and retail sale, 9% in the building industry, 7.5% in health and social care, 7% in education, 4% in accommodation, boarding and catering services, and 3.5% in agriculture and forestry act.). The region is not one of the Czech Republic's major industrial areas, as its share of industrial company takings is around 3% [4]. The increase of the revenues in the industry was accompanied by a decrease of the employment rate in the field; however, the efficiency of work is increasing. Unfortunately, the region's average salary lags behind the national average.

## 4 Conclusion

The Regional Economic Development Risk Indicator of the Kralove Hradec Region shows an increase risk trend of from 1996 to 2011, because the gradual decrease of some partial indicators (the gross domestic product per capita, the natural increase of the population) contributed to the region's decreasing position. The gross domestic product per capita has fallen over the last years by 10% or more in comparison with the country's average. It is encouraging that there has not been any major decrease of the number of business subjects in the region, so the number of jobs does not decrease.

An overall assessment using the Regional Economic Development Risk Indicator shows an increase of risk that the region's development will slow down in comparison to the entire Czech Republic. This conclusion is correct given the region's characteristics.

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